Department of Water Resources
Testimony for SWRCB Hearing on Cease and Desist Order

Investigation of the Factors affecting Water Quality at Brandt Bridge, Middle River at Union Point, and Old River at Tracy

1 Introduction

To gain a better understanding of how the San Joaquin River, in delta uses, the Sacramento River, exports, and temporary barriers affect water quality at Brandt Bridge, Middle River at Union Point, and Old River at Tracy, several analyses using field data and Delta Simulation Model 2 (DSM2) simulation results were made. These analyses include:

- an evaluation of water quality degradation due to in Delta sources using field data at Vernalis, Brandt Bridge, and Mossdale;
- an evaluation of source water at Brandt Bridge, Old River at Tracy and Middle River at Union Point using DSM2 simulations of historical conditions; and
- an evaluation of the effects of State Water Project pumping on water quality at Brandt Bridge, Old River at Tracy, and Middle River at Union Point by varying pumping in DSM2 simulations of otherwise historical simulations.

The results of the studies show that the three locations are heavily dependent on San Joaquin River water and in Delta returns. It can be shown, from the DSM2 historical simulations that water at the Brandt Bridge location is composed entirely of San Joaquin River water and in Delta returns unless there is reverse flow at Brandt Bridge. Analysis using field data indicates the average degradation from Vernalis to Brandt Bridge is approximately 8%. For the Middle River at Union Point Station and the Old River at Tracy Station, the DSM2 historical simulations demonstrated that unless San Joaquin flow is low, the water at those two locations consist entirely of San Joaquin water and in Delta returns when the barriers are not installed. When the barriers are installed, there are a number of factors that potentially can affect the improvement or degradation in water quality and large changes in exports do not always result in a large change in water quality.

2 Historical Simulations and Field Data

2.1 Water Quality Field data and Explanation of Fingerprinting

Water quality and the effects of project operations at Brandt Bridge, Middle River at Union Point and Old River at Tracy (Figure 1) are evaluated in the various sections that follow. The analysis uses both measured field data and DSM2 model simulations. Information about DSM2 and its calibration and validation can be found in Appendix A

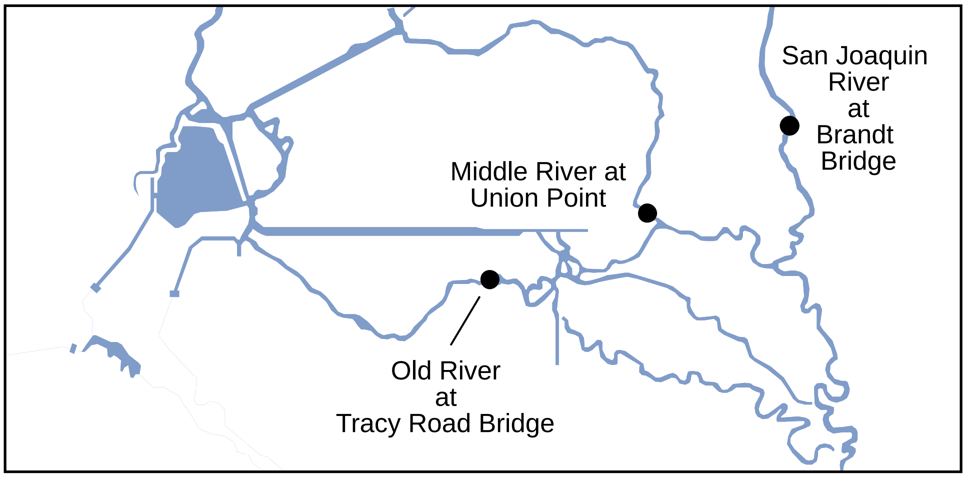


Figure 1. Locations of Water Quality Standards Sites as Modeled by DSM2

Figure 2 shows the field measured electrical conductivity (EC) at the three locations and Vernalis. This report, through various methods will demonstrate the strong effect that the Vernalis water quality and in-Delta returns have on the water quality at the three locations. As Figure 2 indicates, the water quality at the three locations and Vernalis follow predominately similar patterns. Figures 3, 4, and 5 show 30-day running average field measured water quality and DSM2 modeled San Joaquin River and agricultural returns at Brandt Bridge, Middle River at Union Point, and Old River at Tracy Road respectively. Field measured values were obtained from DWR Division of Planning and Local Assistance, Central District and are plotted against the 2005 agricultural standard.

The percentage volume contributions were determined by running historical simulations with the DSM2 Fingerprinting Methodology (Anderson, 2002). By using this method, relative contributions of water sources to the volume can be estimated at any location. Volumetric fingerprinting can be thought of as taking a bucket of water at a particular location and being able to know what percentage of that water came from each source. For the Delta waterways, the sources include the Sacramento River, the ocean, the San Joaquin River, agricultural drainage, or other inflows. Figure 6 shows the historical volumetric fingerprint for Clifton Court Forebay for the period of 2001 through 2002. In this particular plot all sources of water are plotted and all sources sum to 100%. This graph shows that during some months in the spring and early summer, the San Joaquin River dominates and later the Sacramento dominates. In Figures 3, 4 and 5, only the volumetric fingerprint for the combined San Joaquin River and agricultural drainage are shown.

2.2 Brandt Bridge Source Water and Water Quality

Figure 3 shows that there were several periods in the early 1990s when the percentage of San Joaquin River water and agricultural drainage water at Brandt Bridge dropped to approximately 30%. Historically during this time period, reverse flow occurred in the San Joaquin River at Brandt Bridge and other water sources such as the Sacramento River contributed to the volume at Brandt Bridge. Figure 3 also shows that from 1996 through 2004, the water at Brandt Bridge consisted entirely of water from the San Joaquin River passing by Vernalis and agricultural returns. To further show that the source of water at Brandt Bridge is from Vernalis and other in-Delta sources, DSM2 modeled daily average flow at the head of Old River is always flowing away from the San Joaquin River; old River Flow does not contribute to the flow at Brandt Bridge.

Since the historical period covers a variety of different pumping rates, tides, and inflows, it can be concluded from this analysis that unless there is reverse flow in the San Joaquin River, the Brandt Bridge station is fully dependent on Vernalis Water Quality and other returns along the San Joaquin river such as agricultural drainage.

2.3 Degradation of Water Quality from Vernalis to Brandt Bridge

Since the Brandt Bridge water quality is dependent upon the Vernalis water quality and other returns along the San Joaquin River, an analysis was completed quantifying the degradation of water quality from Vernalis to Mossdale and to Brandt Bridge from in-Delta sources. The analysis also provides a relationship to estimate target San Joaquin River EC at Vernalis to ensure that a Brandt Bridge EC standard of 700 μS/cm be met during April - August and 1000 μS/cm be met during September - March. The relationship was developed using monthly averaged historical EC data from year 1994 to 2002. The historical EC data were obtained from the Interagency Ecological Program (IEP) and California Data Exchange Center (CDEC) databases. USBR and DWR are the major collection agencies for EC data at Vernalis, Mossdale and Brandt Bridge.

Figure 7. shows boxplots of monthly averaged historical EC data at Vernalis, Mossdale and Brandt Bridge. Table 1 summarizes some of the basic descriptive statistics of the historical EC data at those periods. Monthly EC data at all three locations showed similar statistical characteristics. Spreads are fairly large and distributed evenly both at lower and higher EC values. There are no outliers.

As shown in the scatter plots Figure. 8, monthly EC at Vernalis and Brandt Bridge are strongly correlated (Pearson's correlation[1] 0.97). The regression analysis of EC showed that Brandt Bridge EC is estimated 1.08 x Vernalis EC, indicating about 8% water quality degradation (measured in term of EC) between Vernalis and Brandt Bridge. Although, the United States Bureau of Reclamation (USBR) cannot control the in-Delta returns, in order to meet the objectives at Brandt Bridge, the Vernalis water quality, in the vast majority of cases would have to be better than the objective.

Using standard error of regression and sum of squares, one can predict the Brandt Bridge EC at a given level of confidence level as a function of Vernalis EC. Figure 9 shows the required Vernalis EC to ensure target Brandt Bridge EC (700 μS/cm during

---

[1] The Pearson correlation r, measures the strength of the linear relationship between the X and Y variables. R^2, the coefficient of determination (a popular measure in regression analysis) is the fraction of the variance explained by the regression. In the least square regression, $R^2 = r^2$.

Apr-Aug and 1000 EC for the rest of the months) at different confidence levels. The numerical values are provided in Table 2.

In general, Vernalis EC can be represented by a dilution mass-balance approach. If additional water were used for dilution purposes between Vernalis and Brandt Bridge, the required volume of water needed would be dependent on the source quality. As a result, lesser volumes of dilution water would be required from a high quality source than from a relatively lower-quality dilution source. The amount of dilution water that would be required to be added to Vernalis flow to conform to the numerical values in Table 2 from a high quality source, such as Goodwin Releases from the Stanislaus River, is probably not insignificant but has not been analyzed.

An attempt was made to break down the salinity (EC) degradation estimate into two components:

a) From Vernalis to Mossdale
b) From Mossdale to Brandt Bridge

Initial analysis indicates an average EC degradation of 7% between Vernalis and Mossdale and 1% between Mossdale and Brandt Bridge. (Figure 10 shows the strong correlation between Vernalis EC and Mossdale EC, with Pearson's correlation of 0.98.)

Upon closer examination, during certain periods EC at Brandt Bridge was actually lower than Mossdale. Typically the only time that one expects lower EC at Brandt Bridge is when there is a reverse net flow at Brandt Bridge. Under this condition, better quality water from the North travels upstream in San-Joaquin River as far as the head of Old River. Reverse net flow at Brandt Bridge usually occurs during low San Joaquin River flows at Vernalis (below 1000 cfs) and high pumping rates. At times field data suggests that EC at Brandt Bridge was lower than the EC at Mossdale even when the San Joaquin River flow at Vernalis was 2000 cfs or higher. This was especially noticeable for the years 1999 and later.

In a separate analysis, the data was divided into two parts, one for the years prior to 1999 and the other for year 1999 and afterwards. The first analysis suggested an average of about 4% EC degradation occurs between Mossdale and Brandt Bridge (which is about half of the total EC degradation between Vernalis and Brandt Bridge). The second data set suggested an average of about 1% EC improvement at Brandt Bridge compared to Mossdale. Developing an accurate estimate for the degradation of water quality in individual reaches requires a fairly accurate data set to within a few percent. Based on the analysis mentioned above, the EC data sets may not have the level of accuracy required for a break-down of the degradation quantity in individual reaches.

However, given the fact Mossdale is about 2.8 miles upstream of the head of Old River, it can be concluded the EC degradation between the head of Old river and Brandt Bridge is less than half the total degradation between Vernalis and Brandt Bridge, and possibly much smaller. The reasons may be attributed to higher tidal flows in the San-Joaquin River downstream of the head of Old River.

From the analysis of field data at Vernalis, Mossdale and Brandt Bridge, there is approximately an average of 8% degradation in EC from Vernalis to Brandt Bridge and the majority of that degradation occurs between Vernalis and Mossdale.

2.4 Middle River at Union Point Source Water and Water Quality

Figure 4 shows the field measured EC and DSM2 simulated percent of water from agricultural diversions and the San Joaquin River at Middle River at Union Point. The water at this station is also heavily dependent upon the flow in the San Joaquin River and in-Delta return sources. Times when the percentage shown in the figures is less than 100% reflect times with the agricultural barriers and/or the Old River at Head fish barrier are installed in the South Delta. Design and timing of the installation of the barriers have varied historically.

Even when the Old River at Head Barrier is installed, San Joaquin River source water can reach this site. Some San Joaquin flow may pass through the barrier culverts or over barrier weir if barrier design allows for it. San Joaquin River flow may be directed into the central Delta and down towards Middle River at Union Point via Turner Cut or Columbia Cut.

Figure 4 shows that the sourcewater makeup at Middle River at Union Point is changed to a small degree by the installation of the temporary barriers; however, the water quality is predominately controlled by the water quality at Vernalis and the water quality of other in-Delta returns. The South Delta Improvements Program, by having the flexibility of operating gates, can change the amount of source water at this location so that this location is not as dependent on Vernalis and agricultural drainage water quality.

2.5 Old River at Tracy Source Water and Water Quality

Figure 5 shows the 30-day running average field measured EC values and DSM2 simulated percent of water from agricultural diversions and the San Joaquin River at Old River at Tracy. This station is further away from the San Joaquin River and is more strongly influenced by the operation of the barriers. When the barriers are not installed, the water quality is primarily a reflection of the Vernalis water quality and the agricultural drainage water quality[2].

As Figure 5 shows, the period of 2001 – 2004 has seen yearly periods when the contribution from the San Joaquin River and agricultural returns dropped to about 20 percent of the source of the water at Old River at Tracy Road. These were times when the agricultural barriers were installed. It may be noticed that the 30-day running average EC does not immediately decrease to coincide with the decrease in San Joaquin River water as the dominant source. This is due to the effect of averaging the EC values over 30 days and because the EC contribution to agricultural returns significantly increases with the installation of the barriers.

[2] Another DSM2 simulation was made using the historical hydrology but removing all barriers. There were a few time periods where some Sacramento flow was occurring at Old River at Tracy and Middle River at Union Point. These periods reflected times when the San Joaquin River flow was below 1000 cfs.

Since the historical period covers a variety of different pumping rates, tides, and inflows, it can be concluded from this analysis that unless there are barriers in the South Delta or the San Joaquin River Flow is below 1000 cfs, the Middle River at Union Point and the Old River at Tracy station is dependent on Vernalis Water Quality and other returns such as agricultural drainage.

3 Modified Historical Simulations

3.1 Reduction and Increase in State Water Project Exports by 500 CFS

To gain a better understanding of the flow and water quality dynamics in the South Delta, a series of simulations were made to see if the water quality at the three inner Delta locations could be controlled by varying the State Water Project's export rate. In one simulation, the exports were reduced by 500 cfs over the entire historical time period, to a minimum of zero. To keep the same net delta outflow and more importantly the same historical Martinez boundary salinity, the Sacramento River was also reduced by 500 cfs over the entire time period. In the second simulation, state exports and Sacramento flows were increased by 500 cfs.

Figures 11, 12, and 13 show the results of these simulations. The Figure 11 shows DSM2 simulated monthly averaged historical EC at Brandt Bridge and changes from this EC due to changes in pumping. Except for a few time periods in the early 1990's, the differences in monthly average EC were less than 2 μS/cm. (For a 700 μS/cm objective, the change is less than 0.3%. The change is less than 0.2% for a 1000 μS/cm objective). Additionally, the reduction in exports didn't always result in better water quality and the increase in exports didn't always result in a degradation of water quality.

Figures 12 and 13 show the results of the simulations at Middle River at Union Point and Old River at Tracy Road. Similar to the modeling results at the Brandt Bridge station, the reduction in exports didn't always result in better water quality and the increase in exports didn't always result in a degradation of water quality. The largest difference observed for these two stations occurred at the Middle River station in the winter of 2004. This difference was 45 μS/cm. (For a 1000 μS/cm objective, a 45 μS/cm change is 4.5%). The volumetric fingerprints for this station during the winter of 2004 for the increase and decrease in SWP pumping revealed that the volume was made up of only San Joaquin River water and agricultural drainage water. The relative proportions of those two sources changed.

The conclusions drawn from performing these studies were;

- *Modifying the pumping rate by 500 cfs resulted in at most a 5% change in water quality.*
- *Modifying the pumping rate by 500 cfs had a small effect (less than 5 uS/cm) on the water quality at Brandt Bridge unless there was reverse flow in the San Joaquin River.*
- *There is not a simple relationship between state water project export operations and water quality improvement.*
- *By changing the export level during times without barriers, the relative proportion of San Joaquin River water and agricultural drainage water changes; however, the total volume is still only made up of those two sources.*

3.2 No State Water Project Exports

Two simulations looked at more drastic changes to operations. In these simulations, the SWP exports were eliminated (Figures 14 and 16) during several months in 2002 and 2003. The Sacramento flow was correspondingly adjusted to maintain the same net delta outflow and more importantly the same Martinez salinity boundary condition. Figures 15 and 17 show EC results for two different time periods for Middle River at Union Point, Old River at Tracy, and Brandt Bridge. On each of these graphs, the 2005 agricultural standard is plotted along with the DSM2 modeled historical EC, and the EC as simulated with the State Water Project exports eliminated. During some of this time period, the modeled historical EC tends to under predict the field data at the three locations (Figure 2). Since observed water quality field data is used for the Vernalis boundary in DSM2 and the water at the locations is a combination of San Joaquin River water and in-Delta returns, it appears that the impact of agricultural returns is under represented in the modeling during this period. DSM2 does not have measured consumptive use data as boundary data for the model; instead, consumptive use is determined using the Delta Island Consumptive Use (DICU) model (Mahadevan,1995) which utilizes crop type, precipitation, seepage, evapotranspiration, irrigation, soil moisture storage, leach water, runoff and acreage.

The SWP export reduction ranges from over 8,000 cfs to approximately 1000 cfs between January 6, 2002 and September 9, 2002 and from over 7500 cfs to approximately 1000 cfs between January 4, 2003 and May 30, 2003. For both Figure 15 and Figure 17 and for both Middle River at Union Point and Brandt Bridge, the no SWP export run results follow the electrical conductivity results of the historic runs. There are small differences between the runs that are consistent with the magnitude of differences shown in Figures 11 and 12; however, they are difficult to discern with the scale used.

3.2.1 Old River at Tracy Road No SWP Exports

3.2.1.1 2002 No SWP Export Simulation

The discussion that follows will focus on the results at Old River at Tracy Road and will look at differences between the two simulations. The differences between the no SWP pumping simulation and the historical simulations start to become visible in May of 2002. The larger cuts in exports shown in Figure 14 don't have a significant effect prior to the middle of April 2002 when three of the temporary barriers have been installed (Table 3). The volumetric fingerprint for the late April time period in Figure 18 shows that some Sacramento source water makes it to Old River at Tracy. The EC fingerprint for the no SWP export shown on the same page indicates that the EC primarily comes from agricultural drainage and San Joaquin River water. Figure 19 indicates that during this time period in the historical simulation, the source water was primarily the San Joaquin River. The slight degradation in water quality shown in Figure 14 is a reflection of the reproportioning of agricultural drainage to San Joaquin water brought on by changes in the exports. Any freshening of the water due to the Sacramento River source was offset by the agricultural drainage source.

Even with the model underpredicting the field EC at Old River at Tracy, the 700 μS/cm 2005 agricultural standard would have been violated with no State Water Project Exports.

Towards the end of June, the water quality improved for the no export simulation. This occurred about the time that the Central Valley Project pumping was increasing, the Grant Line Canal Barrier was installed, and the Old River at Head barrier was removed.

3.2.1.2 2003 No SWP Export Simulation

In the 2003 no export simulation, the water quality started to visibly degrade in late April 2003 (Figure 17) after the barriers were installed. The fingerprinting results during that time period show that some Sacramento water makes it to Old River at Tracy but that proportionally there is more agricultural drainage at that location than in the historical simulation for those stations.

3.2.1.3 Factors controlling the Sacramento Flow into Old River

From these studies, it could not be determined how to operate the SWP exports to improve Water Quality at Old River at Tracy. These studies also demonstrated that drastic reductions in exports did not effectively change the water quality at Brandt Bridge and Middle River, leading to the conclusion that water quality cannot be simply controlled through modifying exports.

To try and develop a better understanding of what might be affecting the water quality at Old River at Tracy, a further examination of the historical hydrology and barrier configuration during a time that a large portion of Sacramento flow made it to Old River at Tracy. (The graphs in Figure 5. showing the percent volume contributions indicate times when the Sacramento River is influencing the water quality at Old River at Tracy). These periods include September 91, May – October 92, April – October 94, September – November 01, October – November 02, and September – October 03. In all periods three of the barriers, Old River near Tracy, Old River at Head, and Middle River were installed either entirely or partially during the time mentioned. In one period the Grant

Line Canal was installed. Looking at the averaged hydrology over the different periods did not reveal a explanatory factor. Total Exports ranged from 2500 – 7300 cfs. The SJR flow ranged from 600-2000 cfs. The Sacramento River flow ranged from 8000 – 11000 cfs. Outflow ranged from 3500 – 6400 cfs. Consumptive use varied from 900 – 2500 cfs. More investigation is needed to determine what combination of factors affect the water quality at Old River at Tracy.

Several factors can influence the flow of Sacramento River water into the southern Delta. The opening of Reclamation's Delta Cross Channel gates allows for Sacramento River water to flow into the interior Delta before being influenced by saltier conditions to the west. Then the interior Delta water is effectively drawn toward the pumping facilities and carrying Sacramento River water quality into the southern Delta environment.

The conclusions drawn from this analysis are

- *Large reductions in SWP exports did not effectively change water quality at Brandt Bridge and Middle River at Union Point.*
- *Large reductions in SWP exports did not effectively change water quality at Old River at Tracy when the temporary barriers were not installed.*
- *Large reductions in SWP exports did not consistently improve water quality. In some situations, water quality was degraded.*
- *More investigation is needed to determine what combination of factors affects the water quality at Old River at Tracy.*

4 Summary and Conclusions

This report contained analyses of water quality and flow in the South Delta using field data and Delta Simulation Model 2 (DSM2) modeled data. From the analysis, the following conclusions were drawn;

- The water quality degradation from Vernalis to Brandt Bridge is on average approximately 8%.
- From DSM2 historical modeling simulations, the makeup of water at Brandt Bridge, Middle River at Union Point, and Old River at Tracy consists of water

coming from the San Joaquin River at Vernalis and in-Delta returns. The only exceptions to this are when there is reverse flow in the San Joaquin River at Brandt Bridge, low San Joaquin River flow, or the temporary barriers are installed.

- Because of the temporary barriers, water at Middle River at Union Point and at Old River at Tracy at times consist of other water sources in addition to water from the San Joaquin and in Delta returns.
- During the times when the volumetric makeup of water consists of only San Joaquin water and in Delta returns, changing State Water Project pumping by 500 cfs results in small changes in water quality. The changes in water quality are primarily a result of a changing proportion of San Joaquin water and in-Delta returns at the three interior Delta locations.
- During the times when the volumetric makeup of water consists of other water sources in addition to the San Joaquin and in-Delta returns, reducing or cutting SWP exports does not always improve the water quality. In some situations, the water quality is degraded.

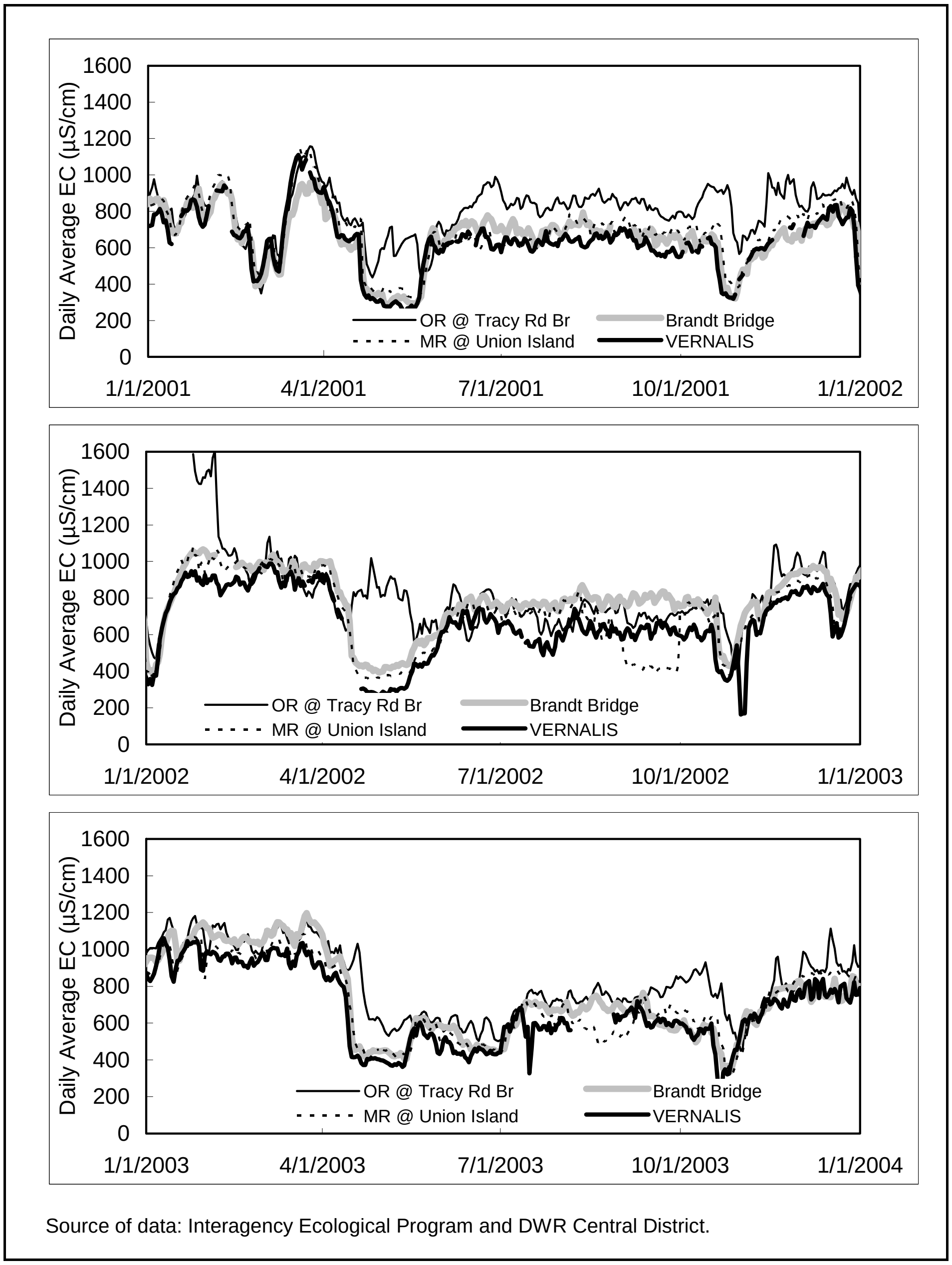


Figure 2. Historical EC at Vernalis, Brandt Bridge, Middle River at Union Point, and Old River at Tracy Road Bridge.

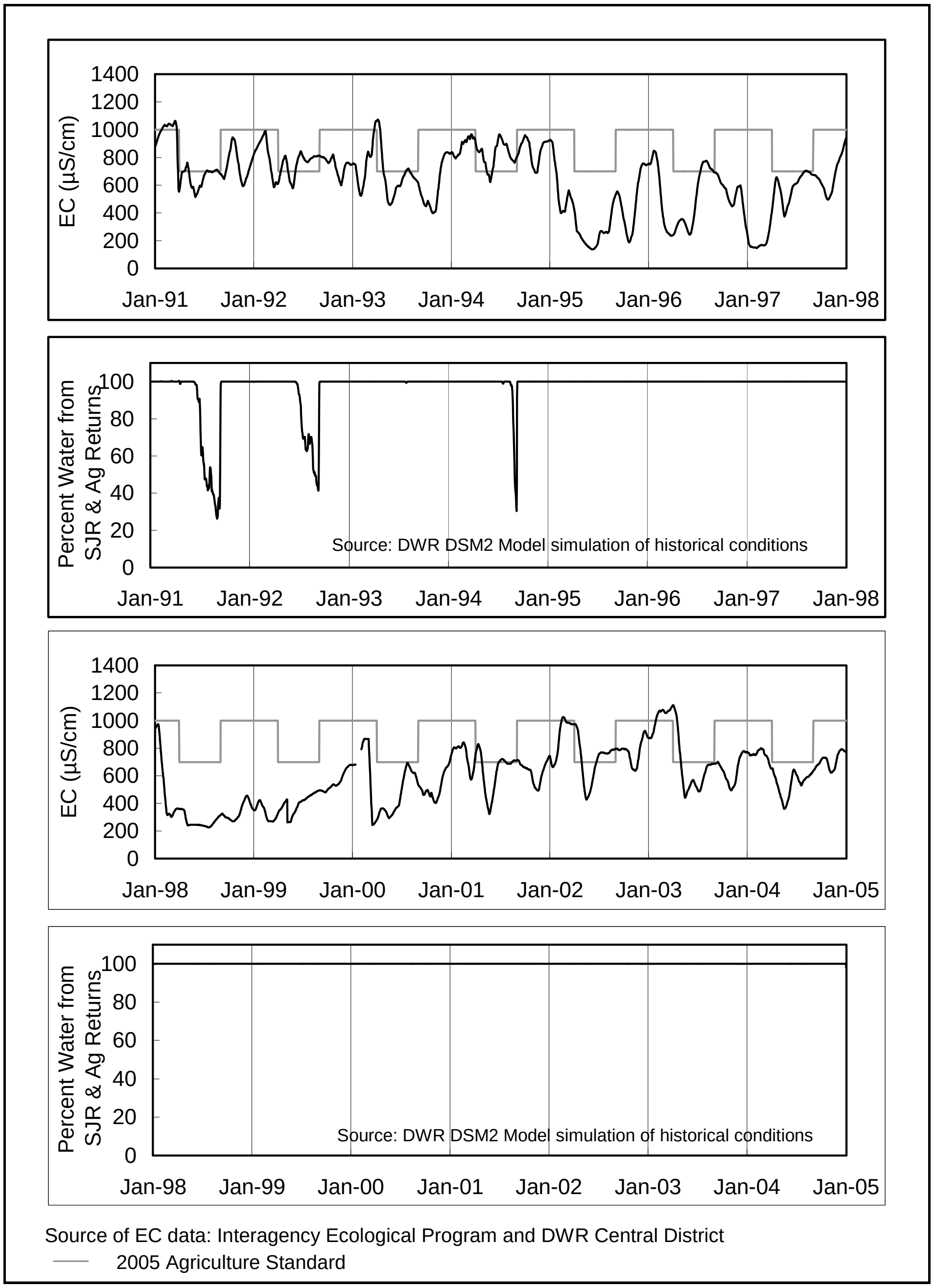


Figure 3. San Joaquin River at Brandt Bridge 30-Day Running Average EC and Percent Water from San Joaquin River and Agriculture Returns.

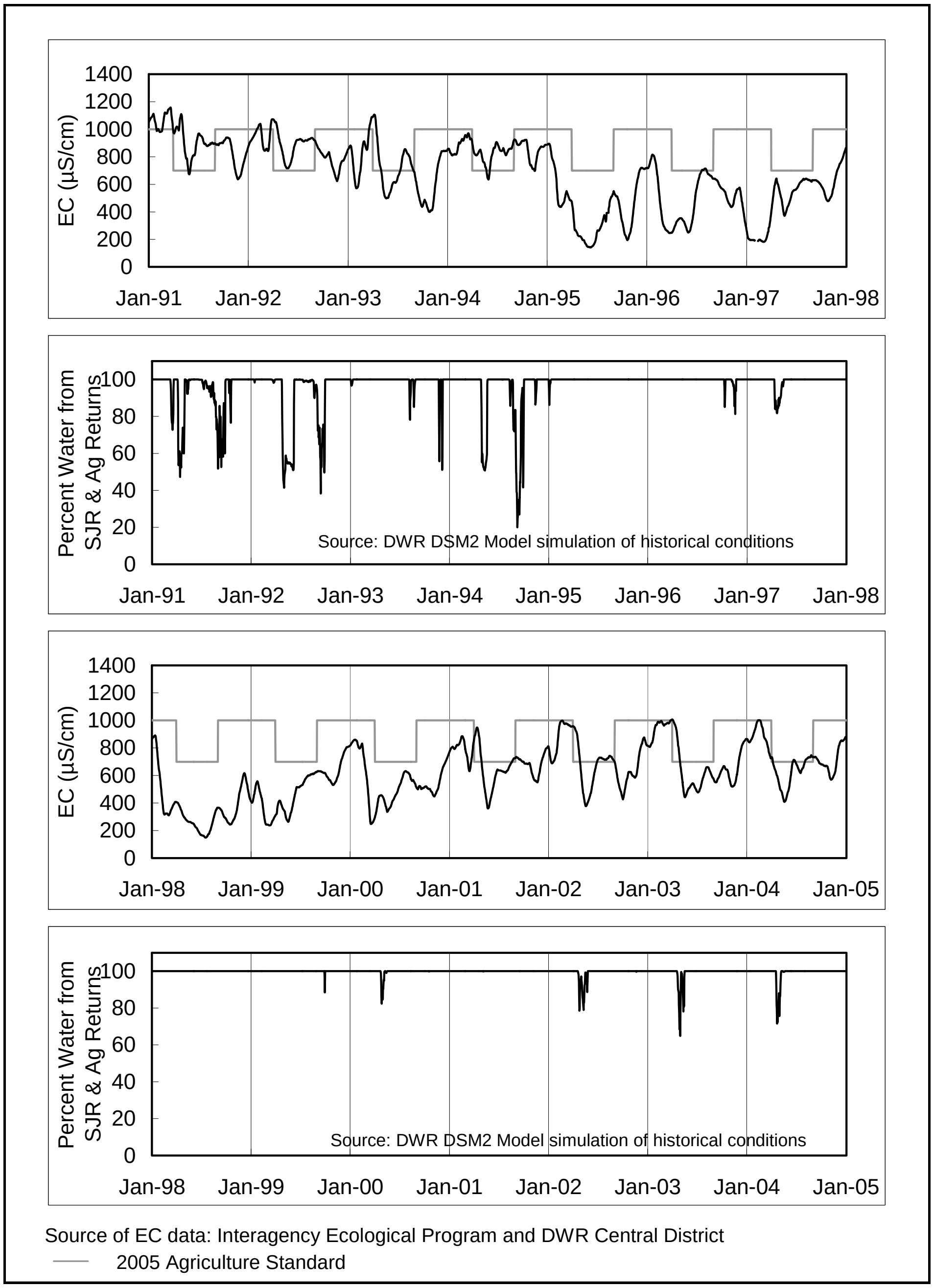


Figure 4. Middle River at Union Point 30-Day Running Average EC and Percent Water from San Joaquin River and Agriculture Returns.

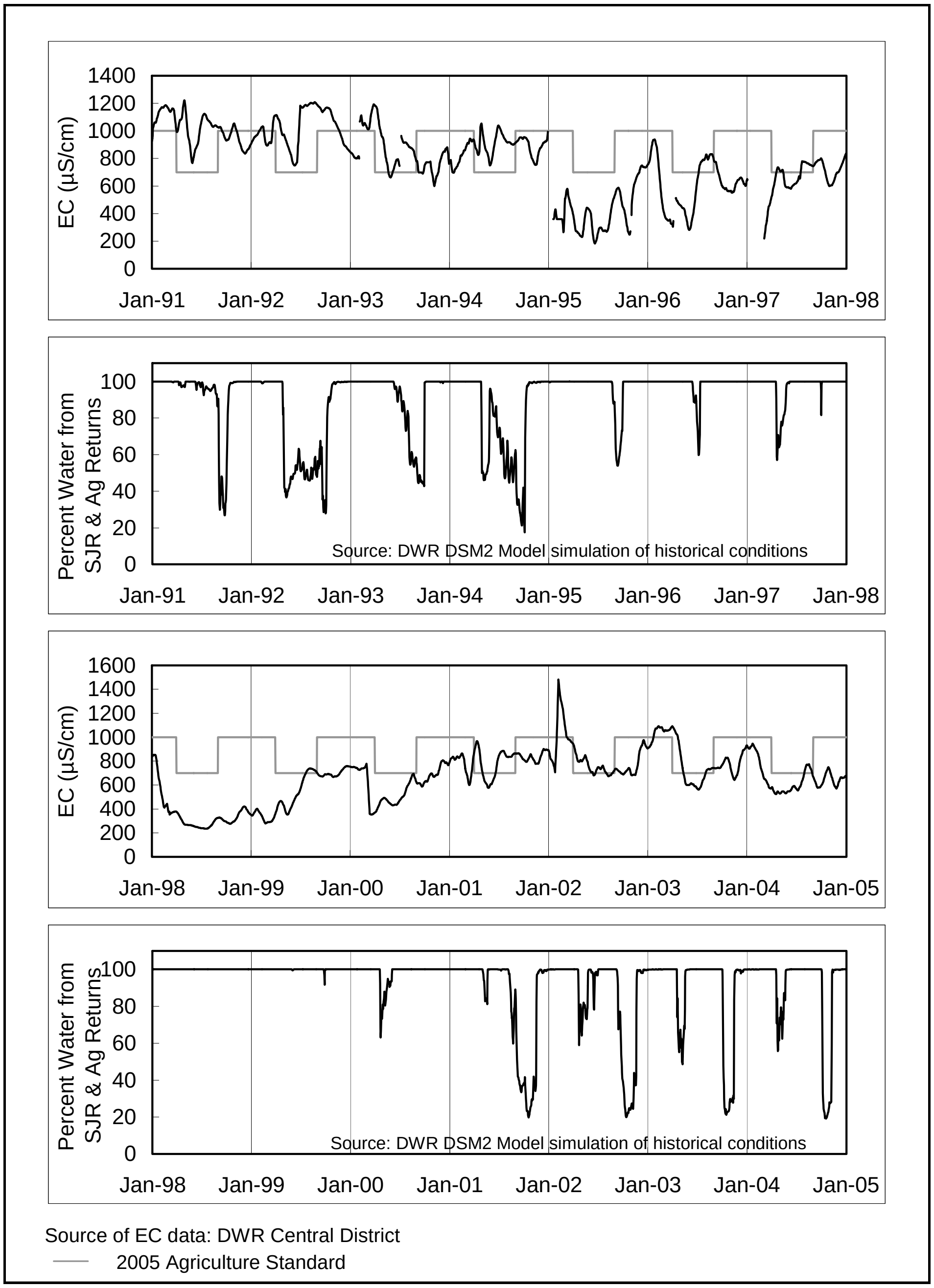


Figure 5. Old River at Tracy Road Bridge 30-Day Running Average EC and Percent Water from San Joaquin River and Agriculture Returns.

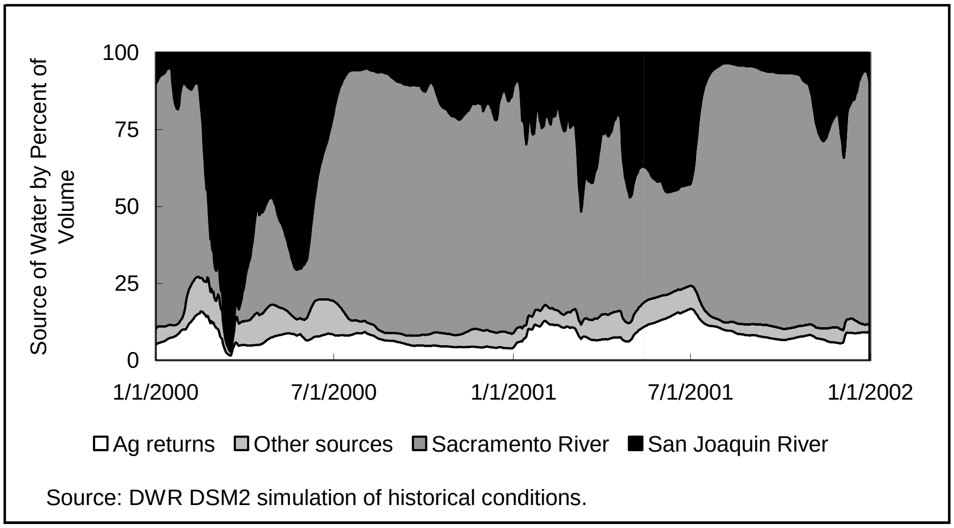


Figure 6. Volumetric Fingerprint at Clifton Court Forebay for Historical Conditions, 2000 - 2001.

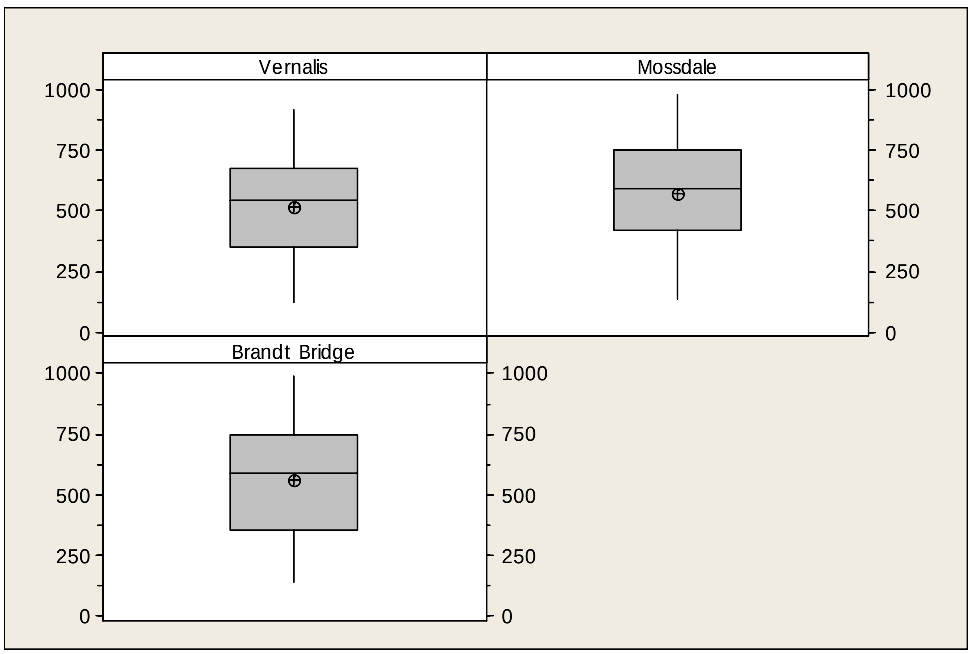


Figure 7: Boxplots of Monthly EC at Vernalis, Mossdale, Brandt Bridge

EC Locations	Total Non Missising Data Points	Mean (µS/cm)	Standard Deviation (µS/cm)	Range (µS/cm)	
				Low	High
Vernalis	108	518.4	205.6	121.0	916.8
Mossdale	86	570.3	221.5	132.9	982.0
Brandt Bridge	103	565.7	224.8	144.5	990.8

Table 1: Descriptive Statistics of Monthly EC at Vernalis, Mossdale and Brandt Bridge

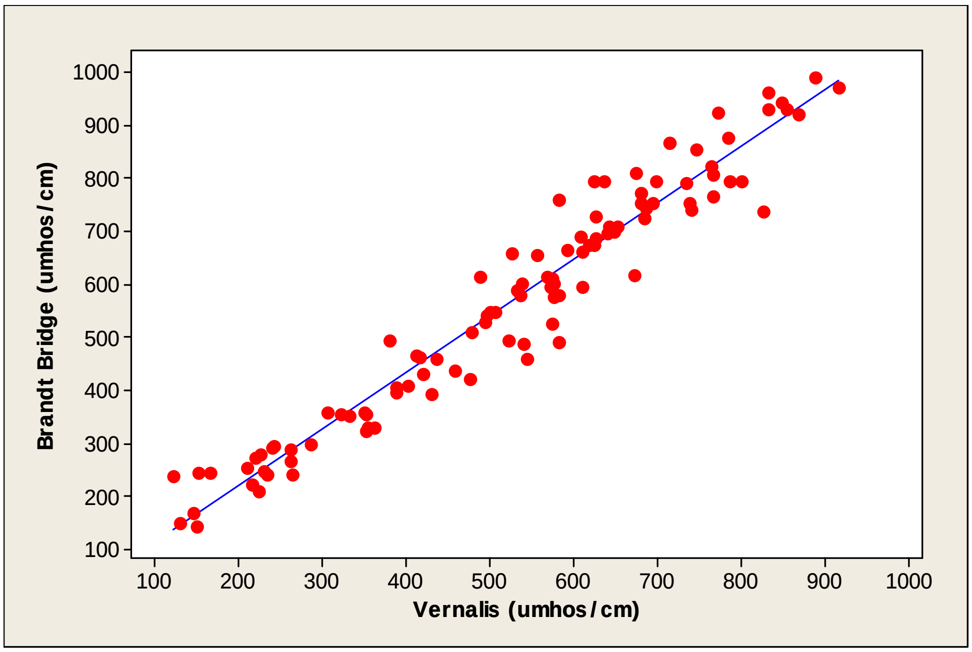


Figure 8: Monthly EC at Brandt Bridge vs. Vernalis

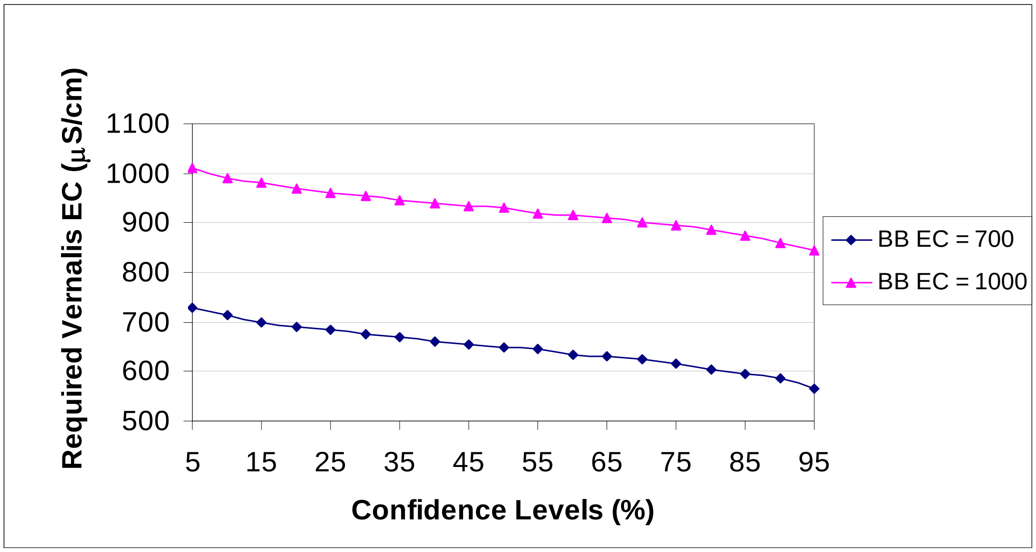


Figure 9: Required Vernalis EC to Ensure Target Brandt Bridge EC at Different Confidences Levels

Confidence levels	**Required Vernalis EC to Ensure**	
	Brandt Bridge EC = 700 µS/cm	**Brandt Bridge EC = 1000 µS/cm**
95	565	845
90	585	860
85	595	875
80	605	885
75	615	895
70	625	900
65	630	910
60	635	915
55	645	920
50	650	930
45	655	935
40	660	940
35	670	945

30	675	955
25	685	960
20	690	970
15	700	980
10	715	990
5	730	1010

Table 2: Required Monthly EC at Vernalis to Ensure Brandt Bridge EC Standards

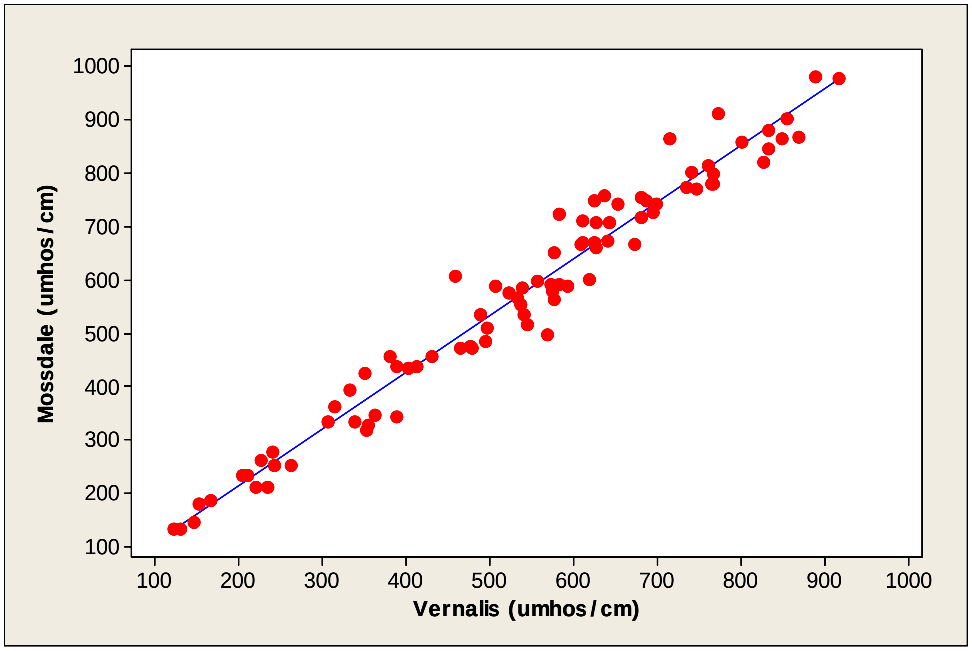


Figure 10: Monthly EC at Mossdale vs. Vernalis

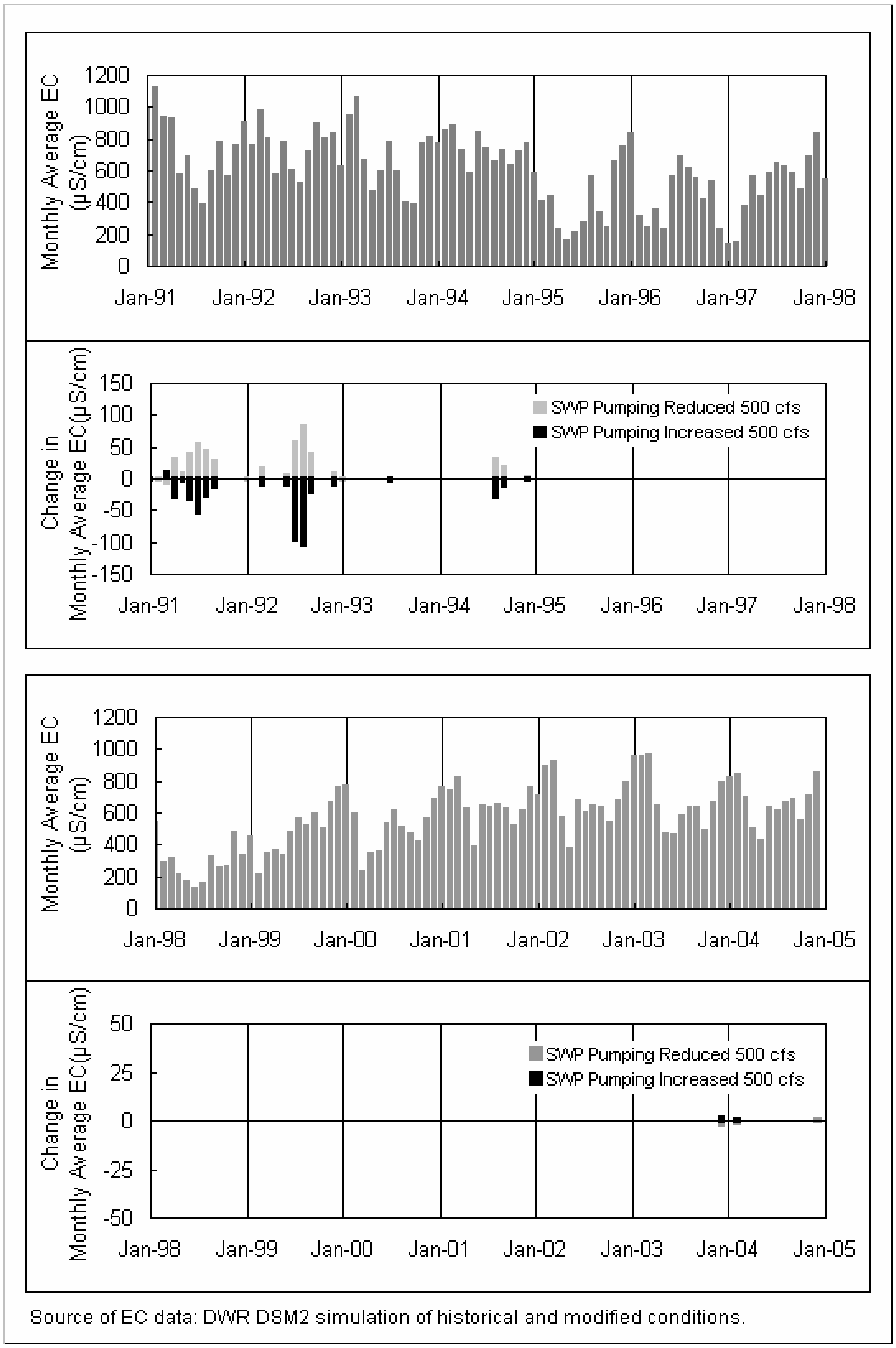


Figure 11. San Joaquin River at Brandt Bridge Simulated Historical EC and Change in EC when SWP Pumping Increased/Decreased 500 cfs, 1991 - 2004.

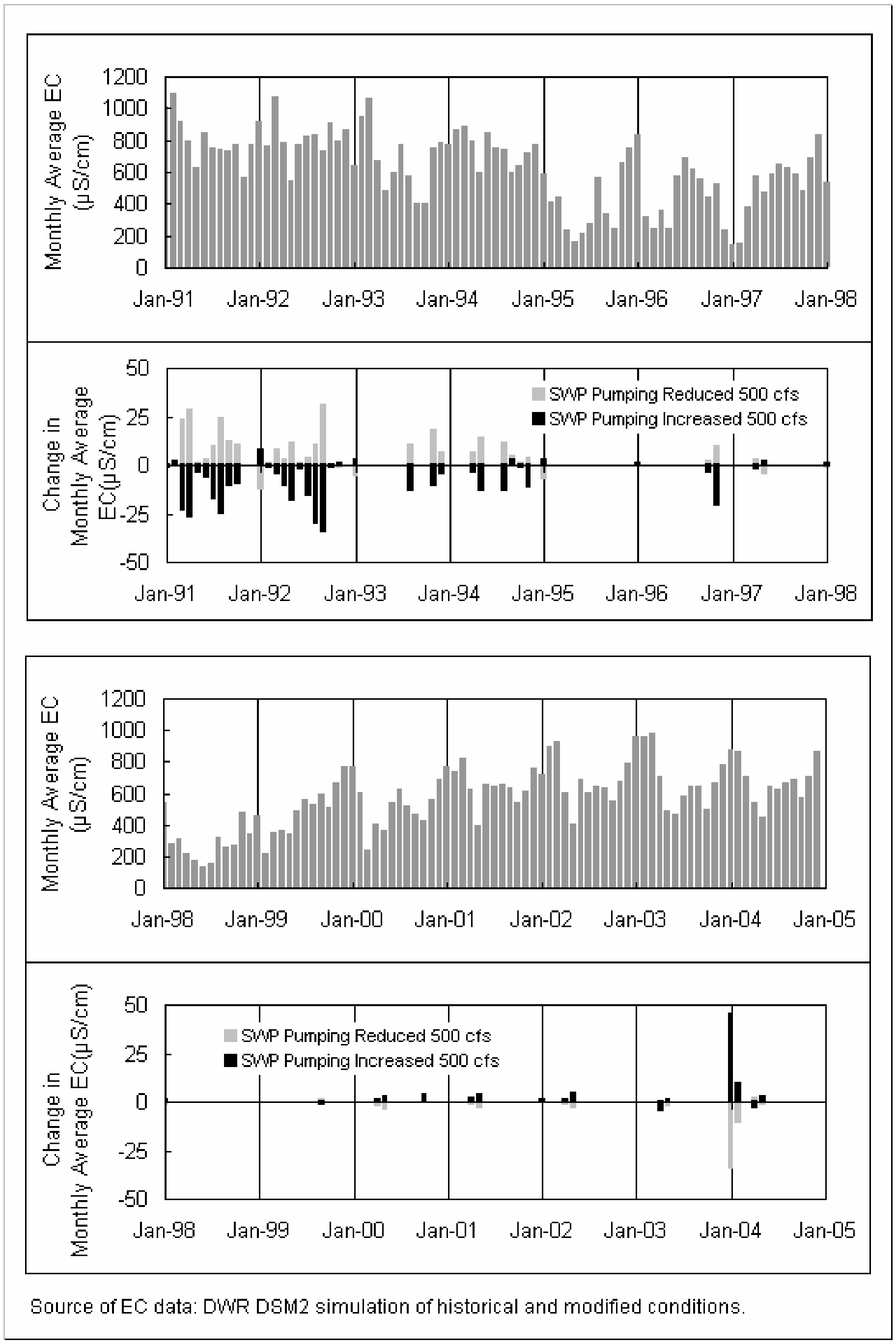


Figure 12. Middle River at Union Point Simulated Historical EC and Change in EC when SWP Pumping Increased/Decreased 500 cfs, 1991 - 2004.

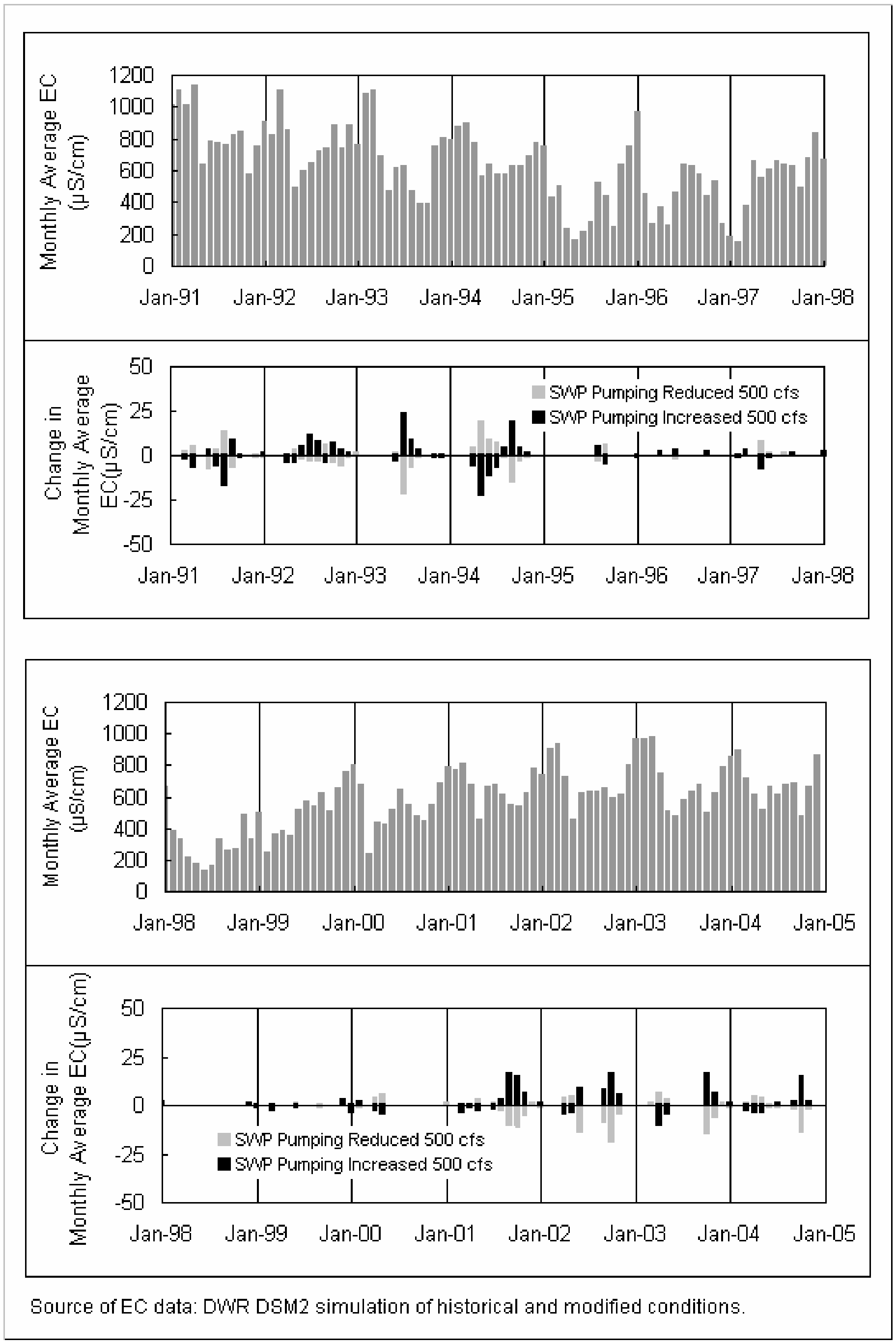
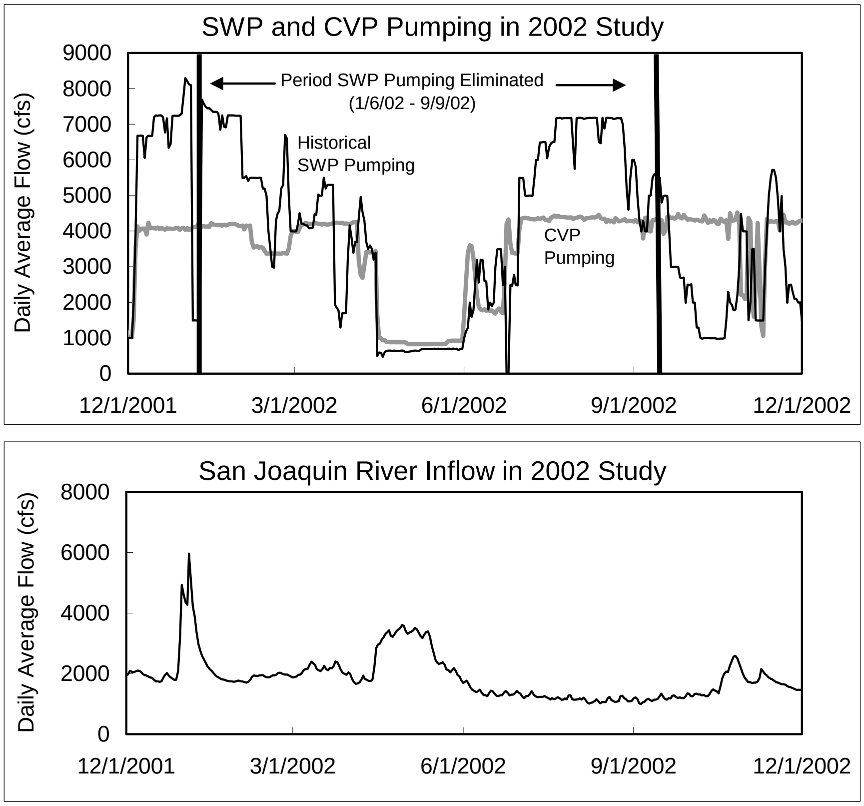


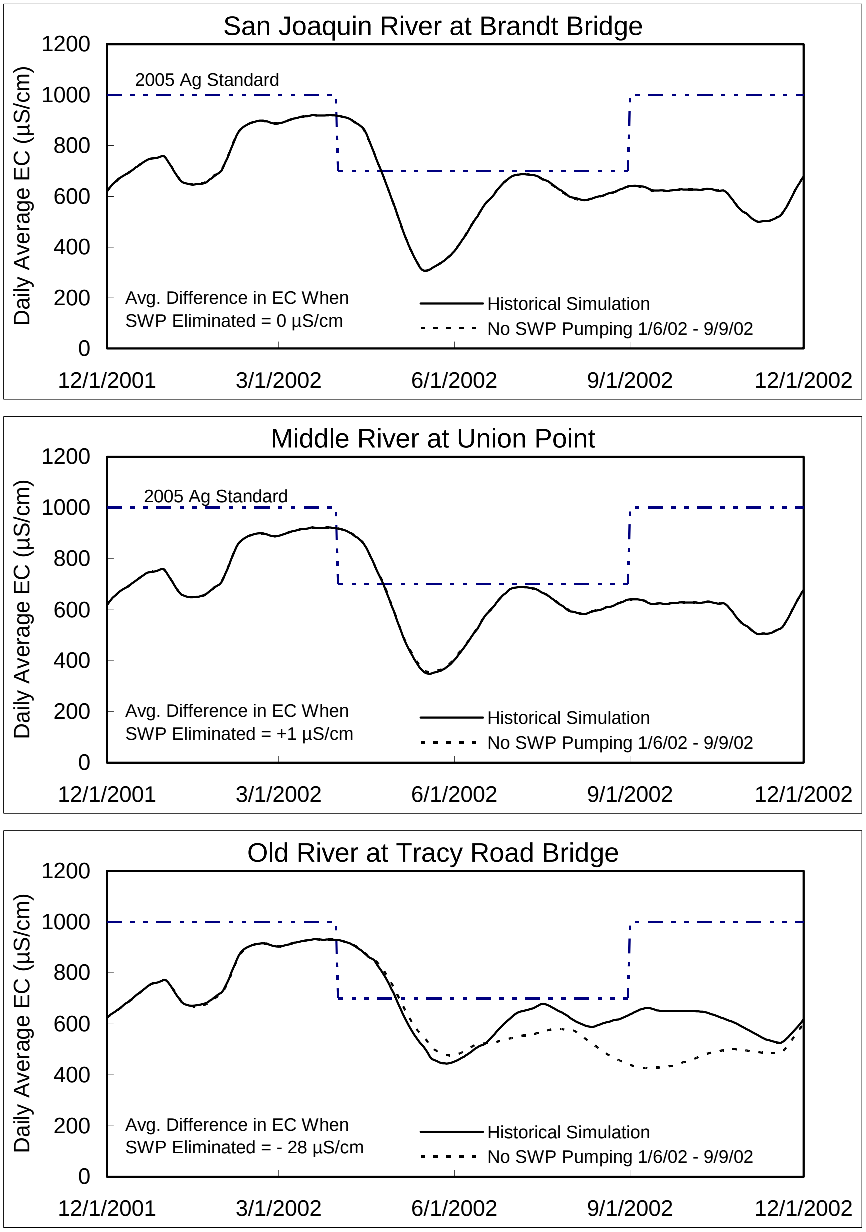
Figure 13. Old River at Tracy Road Bridge Simulated Historical EC and Change in EC when SWP Pumping Increased/Decreased 500 cfs, 1991 – 2004.

Deleted: -



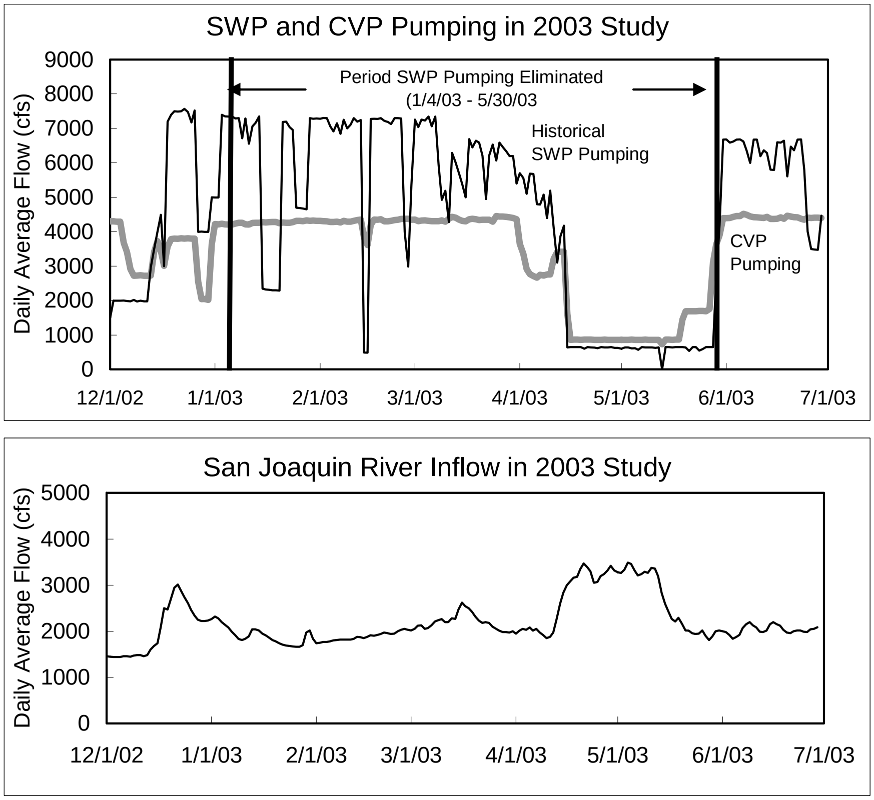
Source of Data: DAYFLOW.

Figure 14. Historical SWP and CVP Pumping and San Joaquin River Inflow in 2002 for Study of Effects on EC in South Delta of Eliminating SWP Pumping.



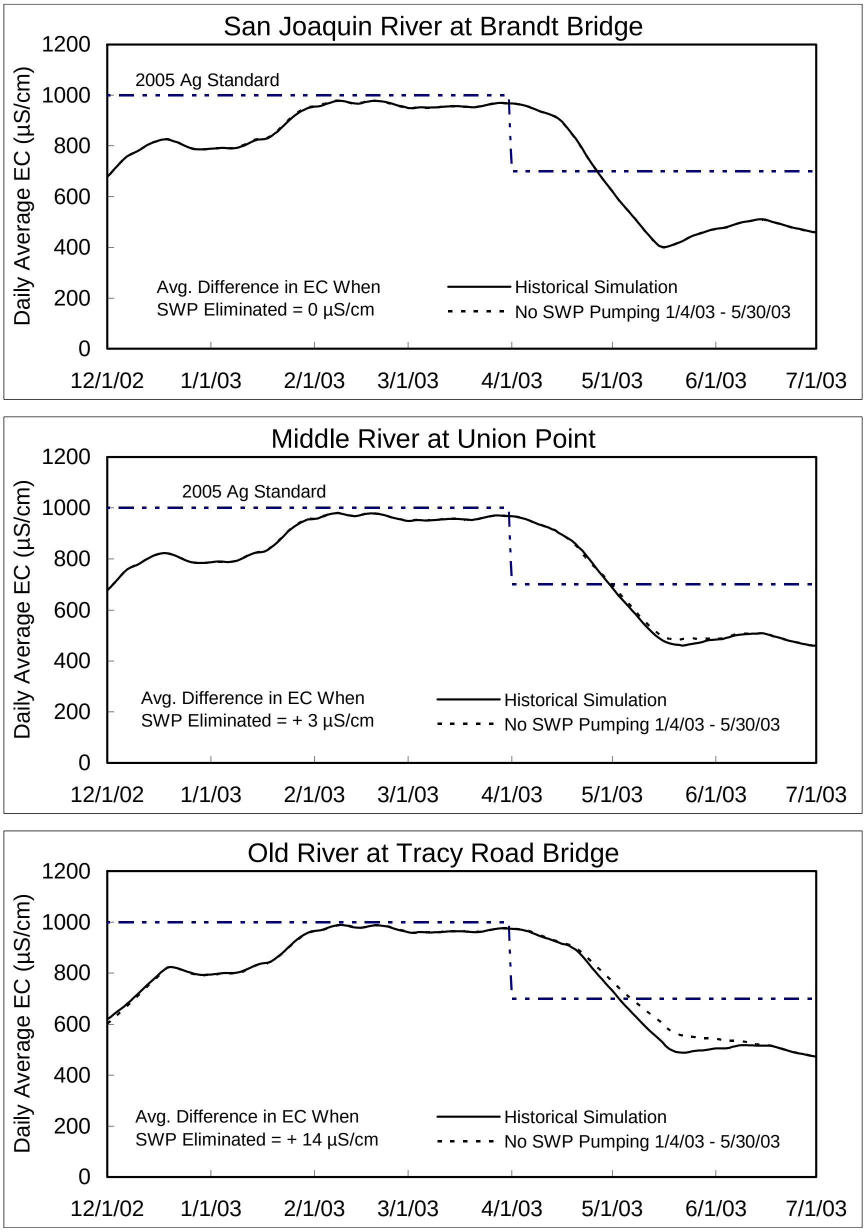
Source of Data: DWR DSM2 simulation of historical and modified conditions.

Figure 15. Effect of Eliminating SWP Pumping for Extended Period on EC at Brandt Bridge, Middle River at Union Point, and Old River at Tracy Road Bridge, 2002.



Source of Data: DAYFLOW.

Figure 16. Historical SWP and CVP Pumping and San Joaquin River Inflow in 2002 for Study of Effects on EC in South Delta of Eliminating SWP Pumping.

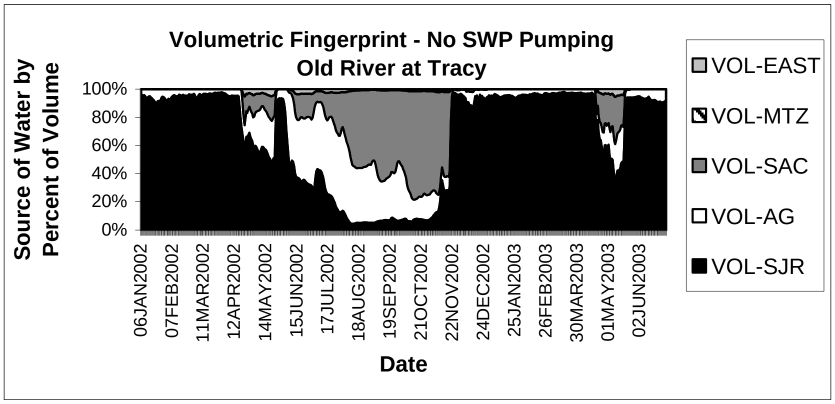


Source of Data: DWR DSM2 simulation of historical and modified conditions.

Figure 17. Effect of Eliminating SWP Pumping for Extended Period on EC at Brandt Bridge, Middle River at Union Point, and Old River at Tracy Road Bridge, 2003.

	Old River Near Tracy	Old River at Head Spring	Old River at Head Fall	Middle River	Grant Line Canal
Installation and Removal Complete - 2002	April 18 – November 29	April 18- June 7	October 4- November 21	April 15 – November 23	June 12 – November 25
Installation and Removal Complete - 2003	April 22 – November 25	April 21- June 3	September 18 – November 13	April 23- November 10	April 23 (partial), June 17 completed – November 25

Table 3 – Temporary Barrier Installation Dates



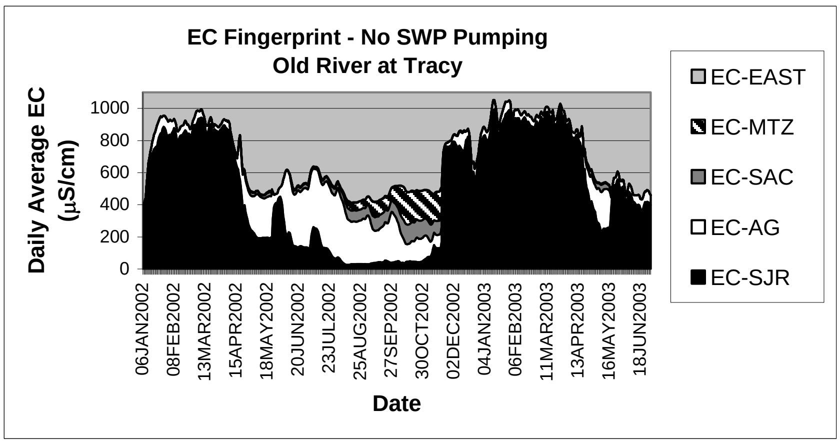
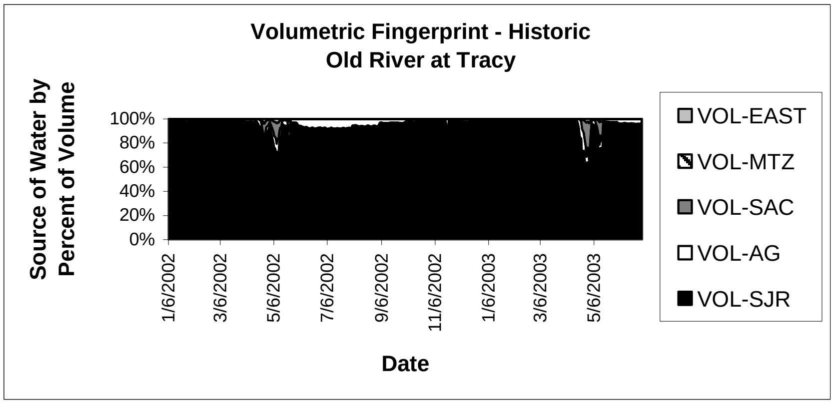


Figure 18: Volumetric and EC Fingerprint at Old River at Tracy for No SWP Pumping Simulation, Jan 2002 – July 2003



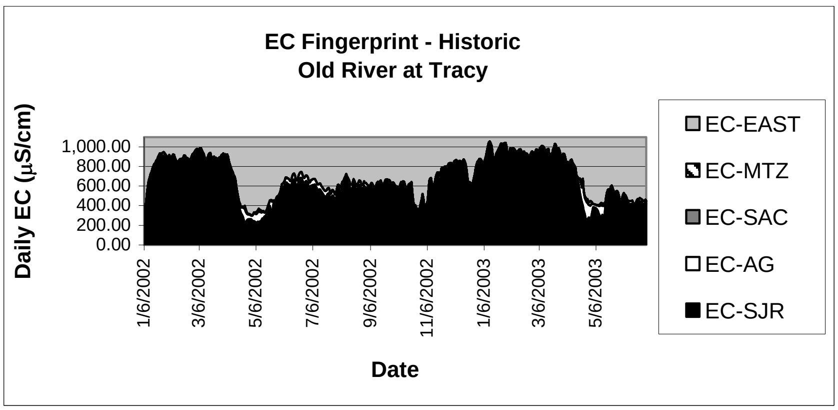


Figure 19: Volumetric and EC Fingerprint at Old River at Tracy for Historic Simulation, Jan 2002 – July 2003

References

Anderson, J. (2002). “Chapter 14: DSM2 Fingerprinting Methodolgy.” *Methodology for Flow and Salinity Estimates in the Sacramento-San Joaquin Delta and Suisun Marsh. 23rd Annual Progress Report to the State Water Resources Control Board.* California Department of Water Resources, Office of State Water Project Planning. Sacramento, CA.

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

Appendix A – Delta Simulation Model 2 (DSM2) Description

The Delta Simulation Model 2 (DSM2) is a one-dimensional mathematical model for dynamic simulation of one-dimensional hydrodynamics, water quality and particle tracking in a network of riverine or estuarine channels. DSM2 can calculate stages, flows, velocities, mass transport processes for conservative and non-conservative constituents including salts, water temperature, dissolved oxygen, and trihalomethane formation potential, and transport of individual particles.

DSM2 consists of three modules: HYDRO, QUAL and PTM. HYDRO simulates one-dimensional hydrodynamics including flows, velocities, depth and water surface elevations. HYDRO provides the flow input for QUAL and PTM. QUAL simulates one dimensional fate and transport of conservative and non-conservative water quality constituents give a flow field simulated by HYDRO. PTM simulations a quasi 3-D transport of neutrally buoyant particles based on the flow field simulated by HYDRO.

The latest full calibration/validation was completed in 2000 by the DSM2 Project Work Team as part of the Interagency Ecological Program (IEP). Information about this calibration and validation can be found at http://iep/dsm2pwt/dsm2pwt.html

The model is publicly available and can be downloaded from
http://baydeltaoffice.water.ca.gov/modeling/deltamodeling/models/dsm2/dsm2.cfm

The model is currently being utilized by various agencies and companies. Those that are running or are using results from DSM2 include:

- California Department of Water Resources (DWR)
- United States Bureau of Reclamation (USBR)
- United States Corps of Engineers (USCOE)
- United States Geological Survey (USGS)
- Metropolitan Water District (MWD)
- Contra Costa Water District (CCWD)
- CH2M HILL
- Jones & Stokes
- Montgomery Watson Harza
- HydroQual
- Surface Water Resources, Inc

A selection of recent validation plots for electrical conductivity are shown below.

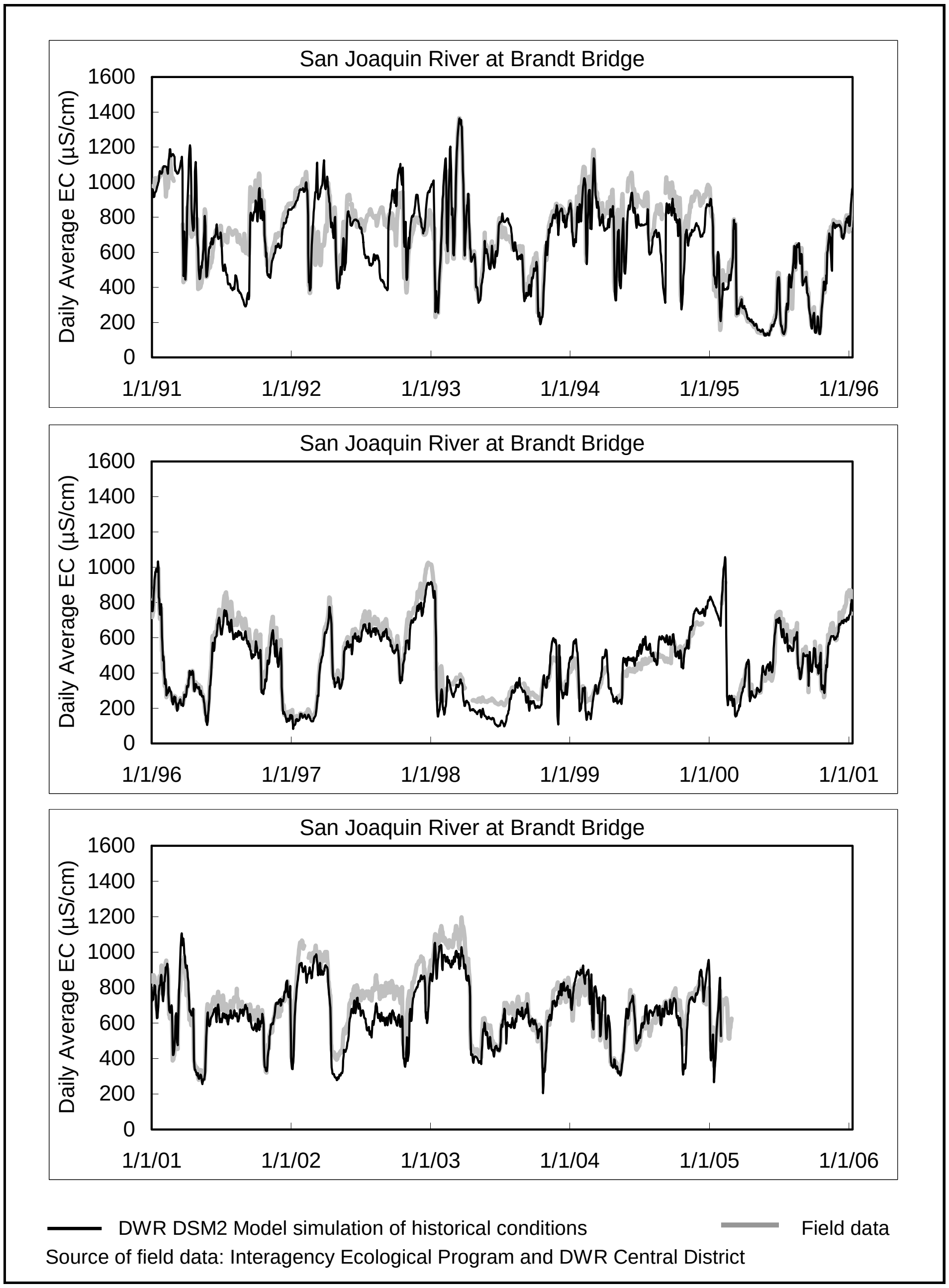


Figure A-1. Validation of DSM2 for Simulation of EC at San Joaquin River at Brandt Bridge, 1991 - 2004.

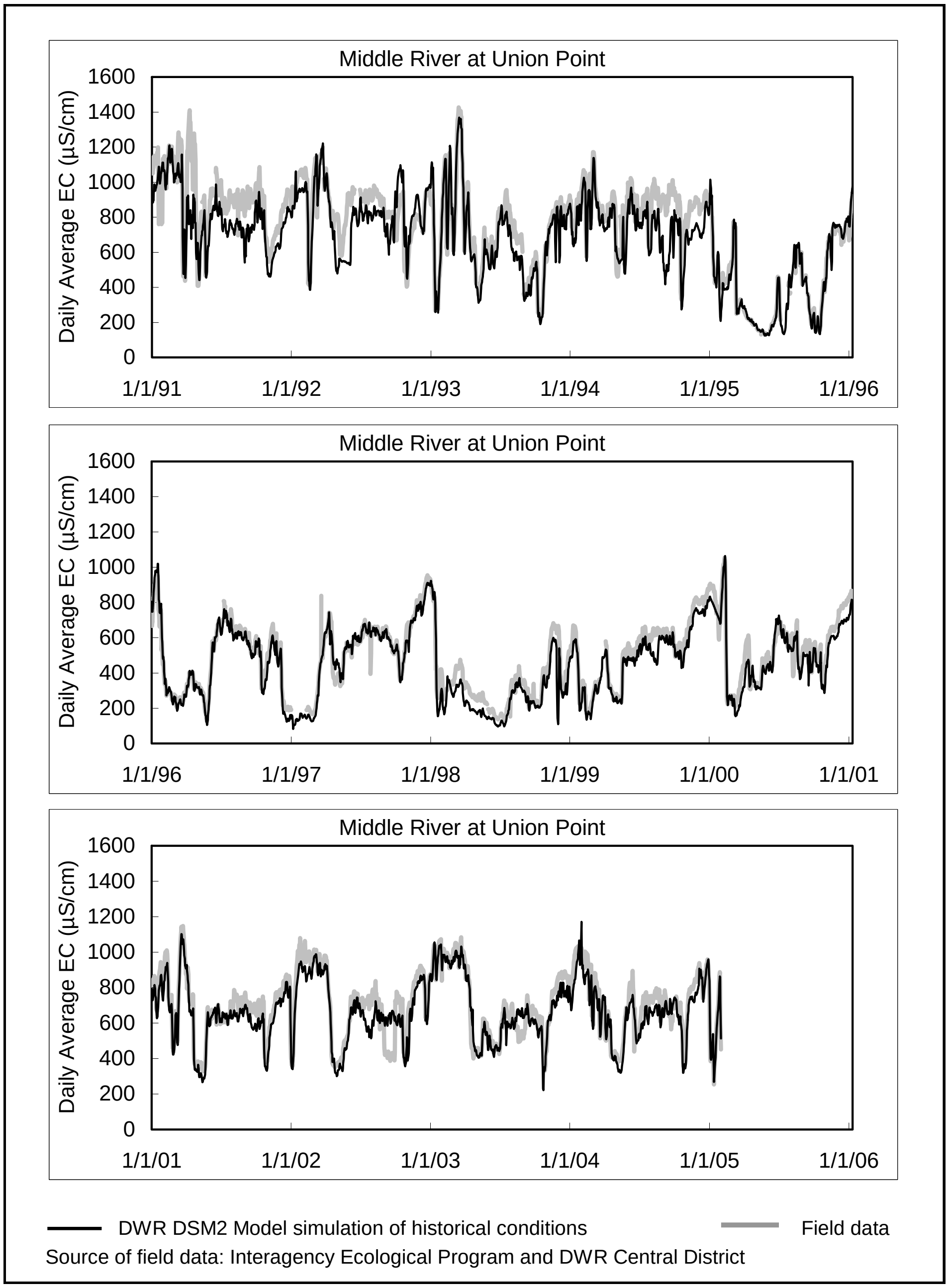


Figure A-2. Validation of DSM2 for Simulation of EC at Middle River at Union Point, 1991 - 2004.

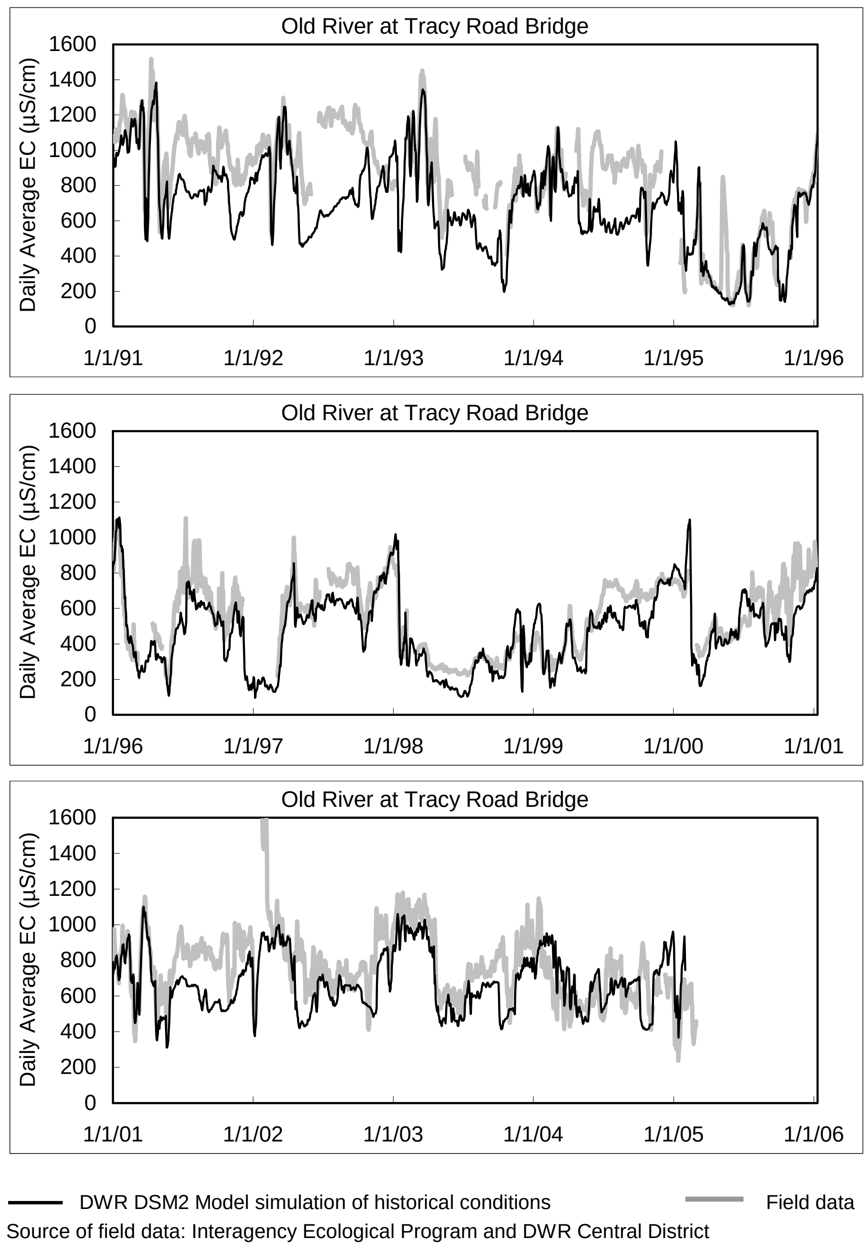


Figure A-3. Validation of DSM2 for Simulation of EC at Old River at Tracy Road Bridge, 1991 – 2004.