Review of 2003 SJR DWSC Flow and Dissolved Oxygen Data

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July 18, 2003

Several weeks ago I provided the SJR DO TMDL email lists with a draft write-up on the relationship between flow management in the SJR DWSC watershed and DO depletion below the water quality objective in the DWSC. That write-up was finalized and submitted to the USBR as comments on the "OCAP Biological Assessment – Preliminary Working Draft." The final version, "Impact of San Joaquin River Deep Water Ship Channel Watershed and South Delta Flow Manipulations on the Low-DO Problem in the Deep Water Ship Channel," is similar to the original draft except for some additions and further editing. It will be posted in the near future on both the SJR DO TMDL website, www.sjrtmdl.org, and my website, www.gfredlee.com. I can send a copy to anyone interested.

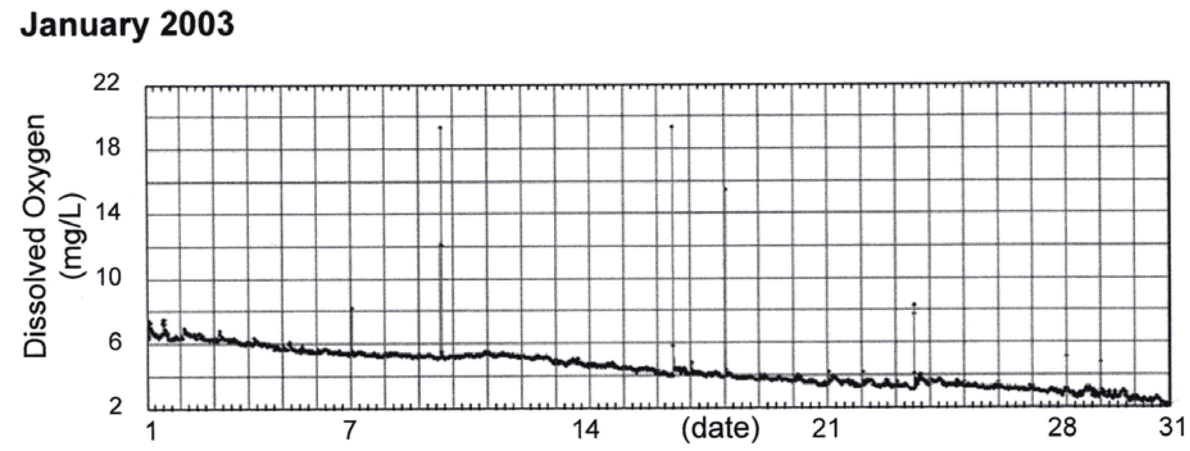
As part of finalizing these comments, I reviewed the 2003 SJR DWSC flow information that I obtained from Cathy Ruhl of the USGS, as well as the DWR Rough and Ready Island (RRI) DO data. You may recall that, in the Synthesis Report (Lee and Jones-Lee, 2003), I presented the January and February data for these parameters for 2003. This is an update of the information presented in the Synthesis Report.

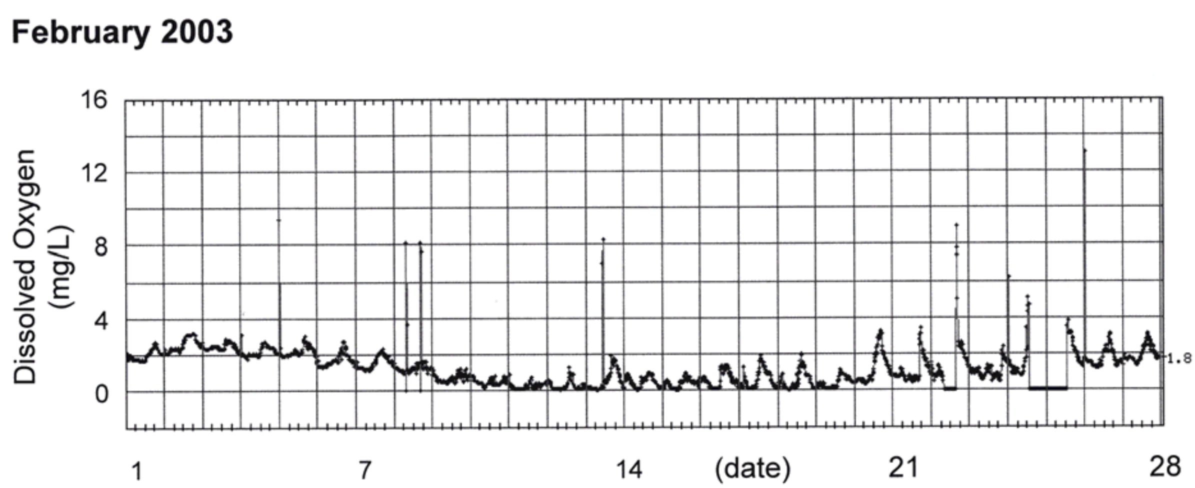
2003 Dissolved Oxygen at DWR RRI Monitoring Station

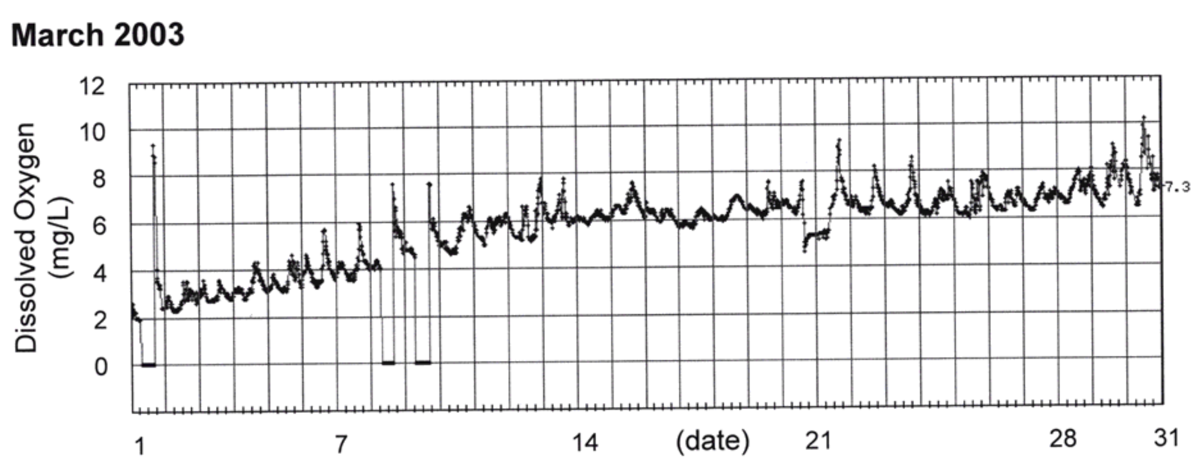
Figure 1 presents the DWR RRI DO monitoring data for January through mid-July 2003. As in the Synthesis Report, these data are preliminary, and still need to be reviewed by DWR. These data, therefore, need to be used cautiously, considering the calibration that occurs each week. The short-term spikes and dips that occur in these data should be ignored. The data are useful in their current form to indicate the magnitude of DO concentrations at the RRI monitoring station. Recall that this monitoring station measures somewhat of an integrated upper third of the water column. During the afternoon the surface waters will be somewhat higher, and during the rest of the day, the bottom waters can be one or more milligrams per liter lower in DO.

Examination of Figure 1 shows that, beginning last January the DO at this location was above the water quality objective (WQO) of 5 mg/L. There was a steady decline through January, so that by the end of the month, the DO was about 2 mg/L. In February after the first week the DO generally was less than 2 mg/L and often at or near zero in the early morning. This situation persisted for several weeks, and dead fish were observed in the DWSC. There could readily be fish kills occurring at other times (especially of larval fish) that are not observed, when the DOs are less than about 3 mg/L. This concentration is known to be lethal to many types of fish.

Figure 1
SJR DWSC RRI DO 2003







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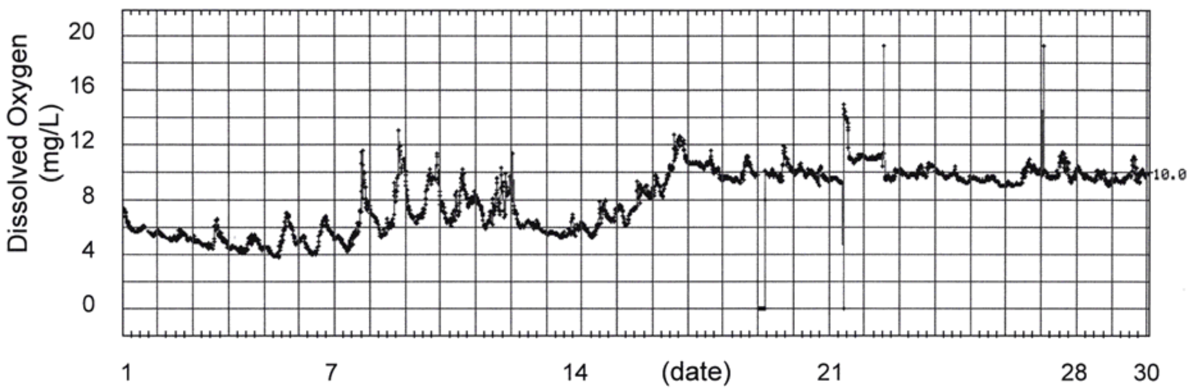

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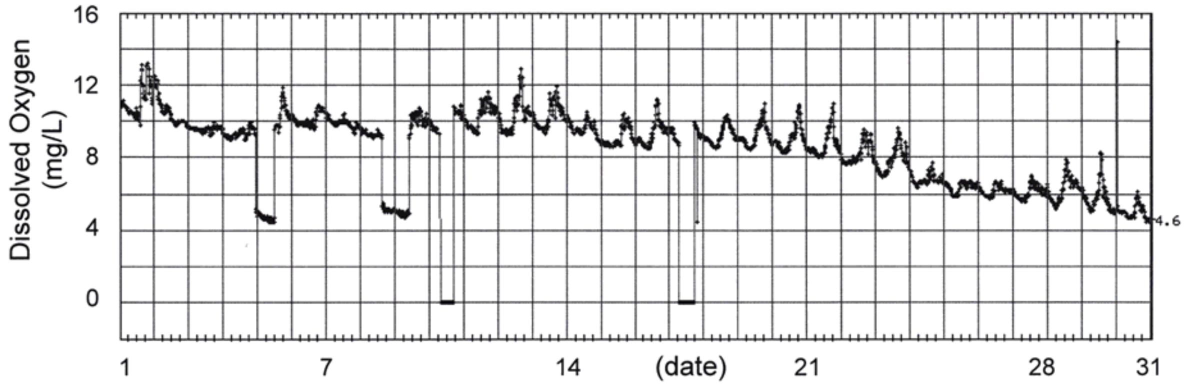

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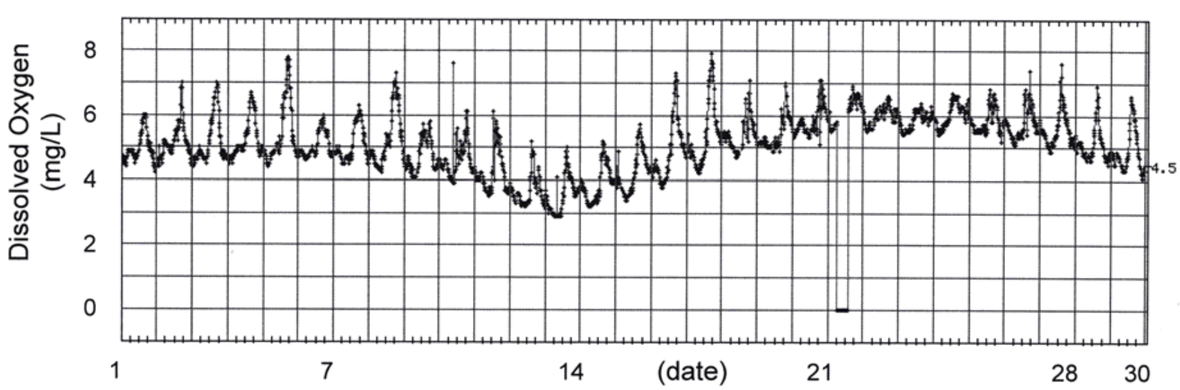

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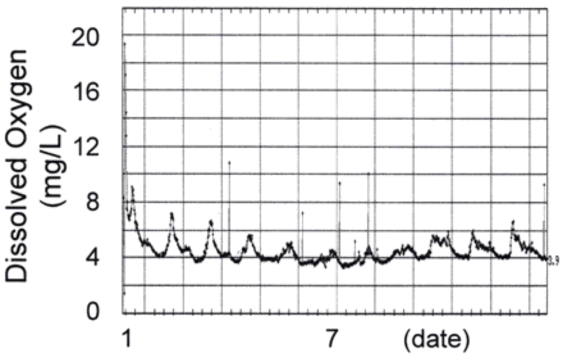


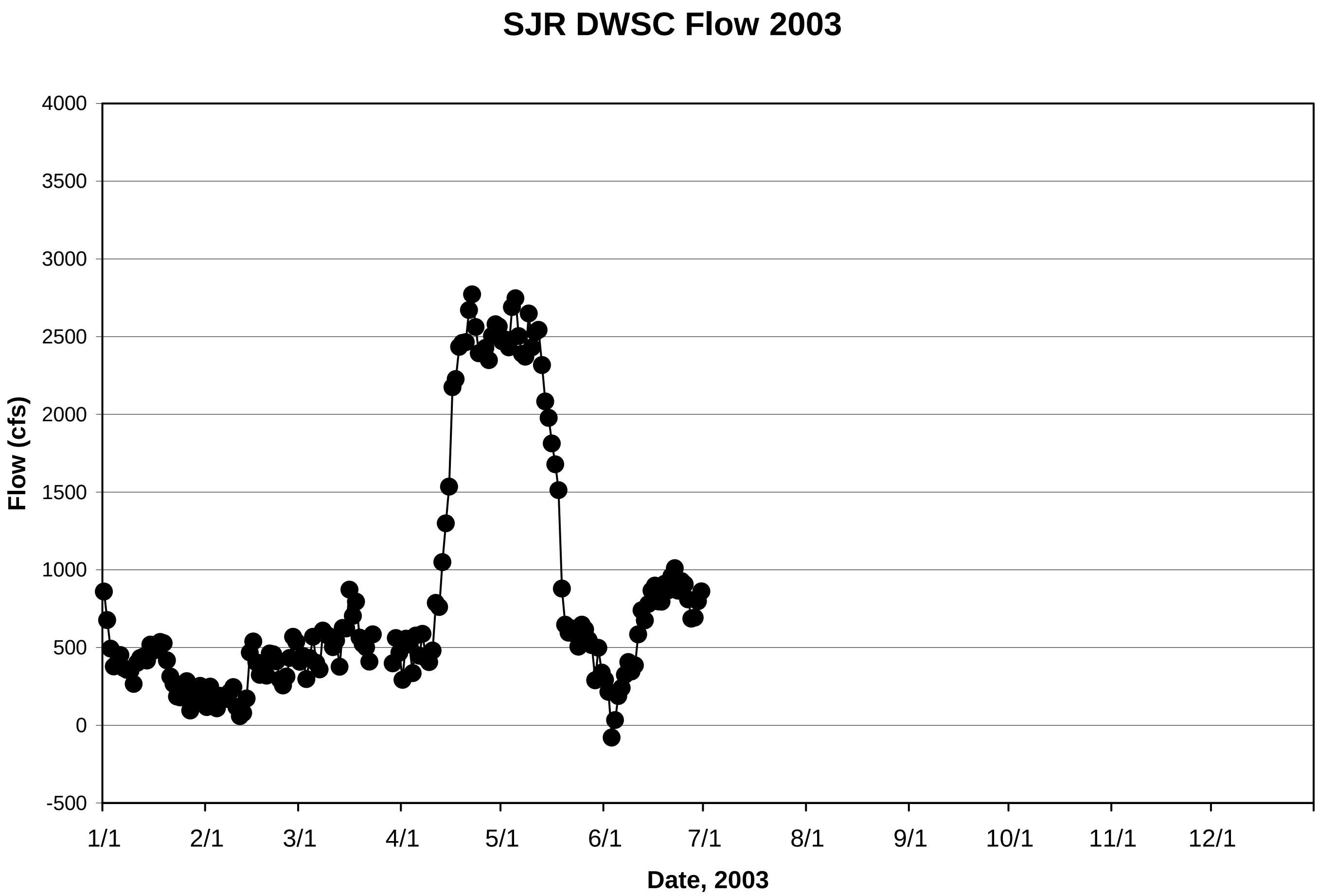
Beginning in March, the DO steadily increased, so that by mid-March the violations of the WQO were no longer occurring. In the first week of April there were several days when the DO in the early morning was 4 mg/L, and by late afternoon was above the 5 mg/L WQO. For the remainder of April all values were above the WQO. For the first three weeks of May all values were above the WQO; however, by late May, the DO was again below 5 mg/L in the early morning. That pattern persisted through the first two weeks of June, where in mid-June there were days when the DO was as low as 3 mg/L. For the rest of June the DO remained in the range of about 4 to 5 mg/L, with afternoon peaks on some days over 7 mg/L. In July the DO was between 4 and 5 mg/L. Therefore, thus far during 2003 there have been extensive periods when the DO has been less than the 5 mg/L WQO. This is of particular significance, since it further demonstrates that the DO depletion problem in the DWSC is not just a summer/fall problem, but is, based on the last two years, much more of a year-round problem than was previously thought.

2003 Flow of the SJR through the DWSC

Figure 2 presents the SJR DWSC flow for the period January through June 2003. Examination of this figure shows that in early January, when the DO in the DWSC was above the WQO, the flow of the SJR through the DWSC was above 500 cfs. From mid-January through about mid-February the SJR DWSC flows were less than 200 cfs, and there was a period in mid-February when DOs were at or near zero when the flow of the SJR through the DWSC was essentially zero. There was a significant increase in SJR DWSC flow in mid-February, which was accompanied by an increase in DO at the DWR RRI station. The March flows of the SJR through the DWSC were around 500 cfs. As discussed above, generally these flows were associated with no violations of the DO WQO.

In early April through about the first week of May, the VAMP flows occurred, which are designed to help the egress of Chinook salmon smolt through the DWSC. During this time the SJR DWSC flows were on the order of 2500 cfs. As shown in Figure 1 there were no violations of the DO WQO during the VAMP flows. However, with the shut-off of the VAMP flows in mid-May, the DO in the SJR DWSC began to rapidly decrease, reaching one day in early June when the net SJR DWSC flow was negative – i.e., upstream. In late June the flows were back on the order of 800 to 1000 cfs. Generally there were few violations of the DO WQO during this period. These data, coupled with the 2002 data, which were analyzed in a similar way and presented in the Synthesis Report, clearly demonstrate that flow of the SJR through the DWSC less than about 500 cfs can (and generally does) lead to DO concentrations below the water

Figure 2



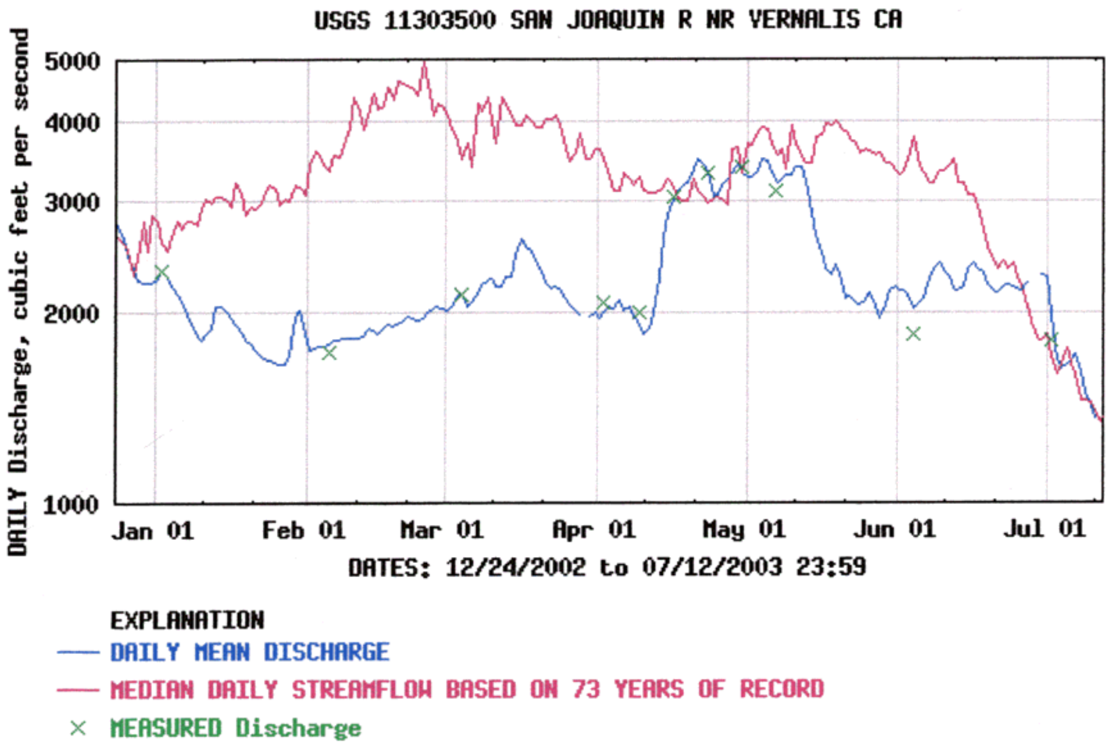
quality objective. It is important to point out that this situation of DO WQO violations associated with low flow was already established for summer-fall conditions. The 2003 data show that this situation can apply to winter-spring conditions as well.

2003 SJR at Vernalis Flows

Figure 3 presents the USGS data for the SJR flow at Vernalis during the period January through July 2003. Examination of these data shows that, throughout this period, there was a flow of at least 1500 cfs in the SJR at Vernalis. During the VAMP period the flows were from 3000 to about 3500 cfs. It, therefore, can be concluded, as for 2002, that the reason for the low flow in the SJR in the DWSC during January through July 2003 was the diversion of water that was in the SJR at Vernalis, into Old River, apparently associated with the State and Federal Projects' pumping of South Delta water. It is also now clear from the 1999 to present data that, if the SJR at Vernalis flow had been allowed to largely pass through the DWSC before export from the Delta, the low-DO problems and the fish kill that occurred in February 2003 would not have occurred.

Another aspect of the Vernalis flow that is different in 2003 from the historical record (see Figure 3), is that, while ordinarily from mid-January through mid-June the SJR at Vernalis

Figure 3



From USGS, July 2003

flow is about 3000 cfs, in 2003 the releases of water from upstream reservoirs during 2003 were considerably less than had occurred in the historical record.

Sources of Oxygen Demand

Some insight into the sources of oxygen demand that, under low flow conditions, lead to DO WQO violations in the DWSC can be gained through examining Table 1, which presents the city of Stockton's wastewater treatment plant effluent CBOD, ammonia, TKN, nitrate and nitrite data. Thus far in 2003, the City's ammonia discharges have been above 24 mg/L N. While, as discussed in the Synthesis Report, ordinarily during the summer and fall, the oxygen demand loads to the DWSC are composed primarily of city of Stockton's wastewater effluent ammonia load plus the algae/BOD load from SJR upstream sources, during February 2003 measurements by G. Litton (pers. comm., 2003) showed that the planktonic algal chlorophyll concentration at Mossdale was low, indicating that there was little upstream algal BOD load being added to the DWSC. Therefore, the extremely low DO during February was apparently due to the City's wastewater effluent ammonia load. At this time, data on the planktonic algal chlorophyll in the SJR at Mossdale for late spring and summer is not available. However, as shown in Table 1, the City's wastewater effluent ammonia load, at least through May 2003, has remained high, while in 2002 and in many other years, the ammonia load during late spring and early summer was about 2 to 5 mg/L. This same type of situation occurred to some extent in 2001, when there were elevated ammonia concentrations in the wastewater effluent in June and July. While it has been said that the high ammonia discharge problem that the City has was a late summer-fall problem,

Table 1
City of Stockton's Domestic Wastewater Treatment Plant
Effluent Characteristics

Month-Yr	Monthly Average					
	Flow (mgd)	CBOD (mg/l)	Ammonia (mg/l)	TKN (mg/l)	Nitrate (mg/l)	Nitrite (mg/l)
Jan-01	35.36	7.3	13			
Feb-01						
Mar-01						
Apr-01	28.11	3.6	4.3			
May-01	29.01	2.9	7.9			
Jun-01	26.86	3.7	7.2			
Jul-01	26.9	2.9	10.8			
Aug-01	33.59	5	12.1			
Sep-01	29.7	4	9.4			
Oct-01	28.66	4.5	19.1			
Nov-01	30.1	6	16.1			
Dec-01	34.08	3.4	11.5			
Jan-02						
Feb-02	25.21	8.4	22.0			
Mar-02	28.07	8.4	22.7			
Apr-02	27.86	5.0	4.3			
May-02	37.34	3.5	2.0	4.3	7.9	0.040
Jun-02	33.00	3.9	2.6	5.0	5.2	0.070
Jul-02	38.49	4.3	2.3	5.0	1.1	0.056
Aug-02	34.48	4.0	10.8	13.9	<0.2	0.060
Sep-02	38.01	4.1	23.9	26.4	<0.2	0.120
Oct-02	33.70	4.0	27.1	30.2	<0.2	0.040
Nov-02	38.08	4.7	27.9	31.6	<0.2	0.040
Dec-02	38.67	3.7	26.6	30.8	0.3	0.060
Jan-03	33.76	4.3	24.9	29.5	0.4	0.090
Feb-03	28.11	7.2	26.3	31.7	0.5	0.110
Mar-03	25.27	5.1	25.9	31.5	<0.2	0.170
Apr-03	27.70	3.4	24.0	28.1	0.5	0.300
May-03	28.20	2.3	26.6	30.0	0.3	0.200

Based on city of Stockton's reports to the CVRWQCB.

it appears now that it has been essentially a year-round problem. This makes the City's ammonia load of oxygen demand of even greater significance than originally thought for winter, late spring after VAMP, and early summer.

While the Regional Board staff's recently released TMDL report has assigned a 30 percent allocation to the city of Stockton's ammonia load as a source of oxygen demand, as discussed in the Synthesis Report, the City's ammonia load contribution to the oxygen demand load can vary from about 10 percent during periods when there is high SJR flow through the DWSC and when this flow contains a high algal BOD and the City's wastewater effluent ammonia is 2 to 3 mg/L N, to 90 percent of the total oxygen demand load under low SJR DWSC flow conditions and when the City's wastewater effluent ammonia is greater than about 25 mg/L N. From my perspective, there is need to adjust the City's allowable wastewater effluent ammonia discharge, to take into consideration the SJR DWSC flow.

There is an aspect of this situation discussed in the Synthesis Report that still needs to be resolved, with respect to the relationship between algae and oxygen demand loads and the impact of these loads on DO depletion within the DWSC. The key issue is the rate of oxygen demand exertion of the load for the algal BOD and the ammonia. This is an area that needs further attention.

Summary

During the winter-spring and early summer 2003, the SJR DWSC experienced several periods when DO concentrations were in violation of the WQO. There was one period in mid-February 2003 when the DO concentrations in the DWSC at the RRI station were at or near zero each day. This was accompanied by a visible fish kill. The low-DO conditions that occurred in January through July 2003 were accompanied by low SJR DWSC flows of a few hundred cfs or less. The data collected since 1995 by DWR in the Hayes cruises (as discussed in the Issues Report, Lee and Jones-Lee, 2000), as well as the CALFED-supported studies since 1999 (summarized in the Synthesis Report) have demonstrated that, with SJR DWSC flows of 1500 cfs or more, the current oxygen demand load to the DWSC rarely causes DO depletion below the WQO within the DWSC. There is, however, a potential for low-DO conditions to occur under certain conditions in the Central Delta associated with the export of high oxygen demand water from the DWSC through Turner Cut and Columbia Cut.

The oxygen demand source responsible for the DO depletion under low SJR DWSC flow conditions is ordinarily, during the winter and spring, elevated ammonia in the city of Stockton's wastewater discharges. During the summer, algae that develop in the SJR watershed upstream of Mossdale can contribute a high algal BOD load to the DWSC that, combined with the City's wastewater ammonia load, contributes to low DO in the DWSC.

From my perspective, there is need to work to achieve having the SJR at Vernalis flow essentially completely pass through the DWSC – i.e., minimize the diversions of the SJR at Vernalis flow into Old River. There is also need for the city of Stockton to develop control of its wastewater effluent ammonia through nitrification of the effluent. This approach is widely practiced at domestic wastewater treatment plants across the country and needs to be implemented by Stockton. There is also need to determine whether it is economically feasible to control SJR upstream algal loads through the control of nutrients that start the growth of the "seed" algae that develop in the Mud and Salt Slough watersheds to high algal BOD loads where these sloughs discharge to the SJR.

References

Lee, G. F. and Jones-Lee, A., "Issues in Developing the San Joaquin River Deep Water Ship Channel DO TMDL," Report to Central Valley Regional Water Quality Board, Sacramento, CA, August (2000).

Lee, G. F. and Jones-Lee, A., "Synthesis and Discussion of Findings on the Causes and Factors Influencing Low DO in the San Joaquin River Deep Water Ship Channel Near Stockton, CA: Including 2002 Data," Report Submitted to SJR DO TMDL Steering Committee and CALFED Bay-Delta Program, G. Fred Lee & Associates, El Macero, CA, March (2003). http://www.gfredlee.com/SynthesisRpt3-21-03.pdf