Suggested Approach for Defining Non-Aeration Alternatives for Managing the Low-DO Problem in the SJR DWSC

G. Fred Lee, PhD, DEE
Ph: (530)753-9630 Fx: (530)753-9956 Em: gfredlee@aol.com
December 8, 2003

As part of developing the activities that are to take place during the Phase I TMDL to solve the low-DO problem in the SJR DWSC, there is need to develop an evaluation of the promising alternative approaches for solving this problem. Table 1 presents a listing of the approaches that have been found to have potential merit as alternatives for solving the low-DO problem. The Table 1 listing is based on my over 40 years of work on similar problems in various areas of the US and other areas of the world and the past four years' work on the SJR DO TMDL project. Information on many of the alternative approaches listed in Table 1 for management of the low-DO problem was provided in the peer review draft and the draft and final March 2003 Synthesis Report (see attached sections of the Synthesis Report).

Table 1 incorporates information provided by several individuals who provided comments on the drafts of the Synthesis Report in which many of these alternative approaches were discussed. Chris Foe provided significant information on the alternative approaches for controlling the SJR DWSC low-DO problem. Alex Hildebrand and John Herrick provided valuable information on South Delta Issues. Joe McGahan and David Cory provided information on the Grasslands area. Bill Jennings of the DeltaKeeper provided information and support for the summer 2003 field studies in connection with this effort in formulating alternative approaches for solving the low-DO problem.

Table 1 lists topic areas that have evolved out of the studies that Lee and Jones-Lee have conducted since the completion of the Synthesis Report in March 2003. Also listed in Table 1 are a number of the areas that need initial or further study that are pertinent to gaining a better understanding of the low-DO problem and its management. Focused studies in each of these areas need to be conducted as part of the Phase I TMDL.

It is recommended that, as part of CBDA Task Order 1 Work Assignment No. 7 to Jones & Stokes, a discussion of these approaches, including their potential merits, information gaps and potential implementation problems, be developed that can be reviewed at workshop(s). Based on these discussions, CBDA could then develop an approach for funding the necessary highly-focused studies to evaluate the potential for the non-aeration approaches as part of managing the SJR DWSC low-DO problem. It will be important that those who are developing the discussion of these issues be highly knowledgeable and experienced in the topic and present/discuss the factors that need to be considered in selecting a particular alternative.

Table 1
Alternative Approaches for Solving the
Low-DO Problem in the SJR DWSC[1]
Compiled from Lee and Jones-Lee (2003) SJR DWSC DO Synthesis Report
And Information Developed Since the Completion of this Report

- Supplemental Aeration of the DWSC
  Being evaluated by Jones and Stokes
  There may be need for supplemental studies to fully evaluate the feasibility and impacts of aeration of the DWSC. There is need to review the details of the proposed aeration studies to determine their adequacy in addressing the issues that will need to be addressed to use aeration of the DWSC to help control the low-DO problem in the DWSC.

- Supplemental Flow of the SJR through the DWSC
  The studies by Lee and Jones-Lee completed with support by CALFED Directed Action Project and subsequent studies by Lee and Jones-Lee have shown that if SJR DWSC flows are above about 1,500 cfs, the frequency and magnitude of DO WQO violations can be greatly reduced. From the NAPA discussions, it now appears that supplemental SJR flow through the DWSC is possible. However, there are a number of issues that need to be evaluated and resolved. Of particular concern is the potential for impacts of altered flows in the South Delta and the lower SJR just upstream of the DWSC on fisheries.

  The highest priority in evaluating the non-aeration alternative approaches should be given to evaluating the feasibility of achieving supplemental flow of the SJR through the DWSC. A key component of these evaluations is the initiation of evaluations of the potential biological (fisheries) impacts of altered flows in the SJR, DWSC, South Delta and Central Delta.

  Supplemental SJR DWSC flow can be accomplished by:

  Operation of the Head of Old River barrier to reduce SJR Vernalis flow down Old River to the South Delta, including South Delta barrier reverse-flow pumping.

  As part of the NAPA discussions, MWD of Southern CA staff have indicated that there may be funding available to support this approach.

  Recirculation of South Delta water through the upper SJR

  It appears that there are significant timing problems as to when these flows would be available. Also, this approach may not receive approval for several biological and other reasons.

Purchase of Water to Increase Flow of Eastside Rivers (Tuolumne, Stanislaus, and Merced Rivers) into the SJR/DWSC during the summer and fall.

Evaluation of this issue will provide information on the costs of upstream diversions of water that are adverse to the DO in the DWSC.

- City of Stockton Wastewater Ammonia Control to 2 mg/L N and Below

    It is still unclear whether the city of Stockton will accept the current NPDES permit ammonia limitations. There is need to determine if a 2 mg/L ammonia monthly average in Stockton wastewaters is adequate to control part of the SJR DWSC low-DO problem.

- Nutrient/Algae Control in the Mud and Salt Slough and SJR Upstream of Lander Avenue Watersheds

    Focus on "Seed" Algae Control through Nutrient/Phosphorus Control from Agricultural Sources in the Upper Parts of the Watersheds

    This issue is entangled with the politics of the CVRWQCB agricultural waiver issues. It may not be possible to develop the needed information since, based on recent experience, the agricultural interests in the SJR DWSC watershed may not cooperate in the needed studies.

- Evaluation of the potential benefits of allowing as much of the algae as possible that is present in the SJR just upstream of the DWSC to enter the Central Delta as a source of available organic carbon for the Central Delta aquatic food web

    It is doubtful that effective nutrient control can be implemented in the headwaters of Salt and Mud Sloughs that will be effective in controlling the low-DO problem in the DWSC. Allowing the algae in the SJR upstream of the DWSC to enter the Central Delta via Turner Cut and Columbia Cut could eliminate the need to try to control SJR upstream algae and help the Delta aquatic food web.

- Stop Maintenance Dredging of the DWSC

    This evaluation will demonstrate the economic significance of the DWSC and the Port of Stockton to those who benefit from the existence of the DWSC and thereby provide incentives to help fund the control of the low-DO problem

- Burns Cutoff Diversion of SJR on the west side of RRI

    This approach should receive preliminary engineering evaluation. If it looks promising, more detailed evaluations should be conducted.

Areas that Need Further Investigation[1]
Compiled from Lee and Jones-Lee (2003) SJR DWSC DO Synthesis Report

- Oxygen Demand Dynamics in the SJR DWSC Watershed and DWSC

  This issue may be investigated to some extent in the SJR upstream studies, although there are significant deficiencies in these proposed studies in providing this information. There is need to examine the details of the scope of work for each of the component projects for the upstream studies to determine the magnitude of the deficiencies in these studies in providing the needed information.

- Nitrification Rates in DWSC, including on Suspended Solid Particles near DWSC Sediments

  See the Synthesis Report.

- DO "Crashes" in the DWSC

  See the attached discussion.

- Causes and Sources of Oxygen Demand that Lead to DO Depletions below the WQO during the Winter

  See below and the Synthesis Report.

- DO Depletions and other Potential Water Quality Problems within the Central Delta and South Delta and to Downstream of the Delta Water Users associated with Diversion of the SJR DWSC Water into the Central Delta via Turner Cut and Columbia Cut

  This is a key part of any supplemental flow through the DWSC.

- Impact of Urban Stormwater Runoff Oxygen Demand Load on DO Depletion, with Particular Emphasis on City of Stockton and other nearby Communities' First Major Storm of the Season Impacts on DO in the DWSC.

- DO Water Quality Objectives

  Impact of DO concentrations on DWSC Chinook salmon migration and aquatic life habitat. This effort could lead to revision of the September through November WQO from 6 mg/L to 5 mg/L.

  Also there is need to evaluate the appropriateness of allowing averaging of the DO over the depth of the DWSC and over the day. *There is considerable doubt about the technical validity of the 6 mg/L DO WQO as a barrier to fall run Chinook salmon migration through the DWSC. Further, since the US EPA and a number of states allow DO depletion near the sediment and over the day, this approach should be evaluated for the Central Valley waterbodies.*

- Oxygen Demand Sources and Dynamics between Mossdale and Channel Point, including French Camp Slough as a Source of Oxygen Demand
  This may be adequately investigated in the upstream study project. There is need to see the details of the scope of work for this project to determine if it will adequately address this issue.

CVRWQCB	Central Valley Regional Water Quality Control Board
DWSC	Deep Water Ship Channel
RRI	Rough and Ready Island
SJR	San Joaquin River
WQO	Water Quality Objective

[1]Further information on each item is provided in

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

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). Available from gfredlee@aol.com upon request. http://www.gfredlee.com/psjriv2.htm

---

Excerpts from Lee and Jones-Lee (2003) Synthesis Report

Implications of Technical Studies for Managing the Low-DO Problem

The studies of the past four years and since then, plus other data, have provided information that can be used to formulate a management plan to control the DO problem in the DWSC. A summary of these results is presented herein.

Port of Stockton. Since the DO depletion problems that occur in the first seven miles of the DWSC below the Port of Stockton would not occur if the DWSC had not been dredged, it seems appropriate that the future budget for the maintenance dredging of the DWSC performed by the Corps of Engineers under its Congressional mandate, should be expanded for this reach of the DWSC to include funds to control the low-DO problem created by the continued existence/maintenance of the DWSC. Justification for this approach stems from the fact that, without continued maintenance of the 35-foot deep DWSC, the DWSC would soon shoal and thereby become better able to assimilate the oxygen demand loads that are delivered to it from the SJR upstream of the Port. The SJR upstream of the Port is 8 to 10 feet deep. It has the same oxygen demand loads as the DWSC, but does not experience DO depletions below the water quality objective.

Supplemental Aeration. Preliminary studies have shown that it appears to be technically and economically feasible to provide supplemental aeration of the DWSC to control DO depletions below the WQO. The box model calculations, Strawman analysis and the Brown evaluation of aeration for the DWSC show that, based on the past three years' data, on the average about 2,300 lb/day of oxygen needs to be added to the DWSC to eliminate violations of the DO WQO. Considering the worst-case conditions for DO depletion below the WQO found in the box model calculations for data collected over the past three years, on the order of about 6,000 lb/day of DO would be needed to keep the DWSC from violating a WQO. Other approaches for estimating the needed aeration have shown that, typically, a few thousand to ten thousand lb/day of oxygen is needed to eliminate WQO violations. It has been estimated that the amount of needed aeration can be obtained for a construction cost of less than $2.5 million, with annual operating expenses of less than $500,000. An engineering evaluation leading to pilot studies of DWSC aeration is needed to develop an aeration system that can control DO concentrations in the DWSC above the WQO.

It is likely that a combination of supplemental aeration, upstream oxygen demand load control and increased flow of the SJR through the DWSC will be used to control the low-DO problem in the DWSC. It should be noted, however, that increased flow through the DWSC would require increased amounts of aeration with the result that there is need to optimize increased flow versus aeration to control the DO depletion problem in the most cost-effective manner.

Nutrient/Algae Control in the Mud and Salt Slough and SJR Upstream of Lander Avenue Watersheds. It was found during the summer/fall 2000 and 2001 studies that the Mud and Salt Slough and SJR upstream of Lander Avenue watersheds are the primary sources of algae/oxygen demand that lead to the DO problem in the DWSC. There is little understanding at this time of algal growth dynamics and nutrient sources that lead to high algal populations in discharges to the SJR from these areas. There is need to conduct studies within these watersheds to understand the specific sources of nutrients that lead to elevated concentrations of algae in the discharges (from Mud and Salt Sloughs and the SJR above Lander Avenue) to the SJR that ultimately lead to low-DO problems in the DWSC. Through such an understanding, it may be possible to effect some control of the high algal concentrations/loads that are discharged to the SJR from these watersheds during the summer/fall months that cause high oxygen demand in the DWSC.

It will be important to evaluate the relationship between decreased algae/BOD from the Mud and Salt Slough and SJR at Lander Avenue watersheds and decreased algae/BOD concentration/load at Mossdale. Guidance is provided in this Synthesis Report on the studies that should be done in the Mud and Salt Slough watersheds to determine if it is economically feasible to control oxygen demand loads from these watersheds that impact DO depletion in the DWSC. The recommended approach involves the use of alum addition to bind the available phosphorus, thereby limiting algal growth in the headwaters of the Mud and Salt Slough watersheds.

City of Stockton Wastewaters. The city of Stockton wastewater discharges of elevated ammonia at times can be a significant contributor to the low-DO problem in the DWSC. The city of Stockton's wastewater oxygen demand load, which is principally in the form of ammonia, can represent up to about 90 percent of the total BOD load to the DWSC. The CVRWQCB has recently adopted a revised NPDES wastewater discharge permit for the city of Stockton that limits the monthly average ammonia concentration in the effluent to 2 mg/L for aquatic life toxicity reasons. The city of Stockton's appeal of this permit to the State Water Resources Control Board (SWRCB) was not supported by the Board. At this time, it appears that the city of Stockton may appeal the Board's decision to the courts. If the permit is upheld, then the oxygen demand load would be reduced by up to about 20,000 lb/day BOD_u.

While there can be little doubt that, when the city of Stockton is discharging 25 to 30 mg/L ammonia nitrogen in its effluent to the SJR, and the SJR DWSC flows are a few hundred cfs or less, the City's wastewater ammonia oxygen demand loads are the principal source of oxygen demand for the DWSC, there are questions about the significance of the City's wastewater oxygen demand loads as a cause of DO depletion in the DWSC when the concentrations of ammonia in the effluent are a few milligrams per liter, especially when the SJR DWSC flows are above about 800 cfs. An issue that needs to be resolved is whether the City's ammonia discharges are subject to "enhanced" nitrification rates, which would lead to a greater proportion of the ammonia being oxidized in the critical reach of the DWSC before it is diverted/diluted into the Central Delta at Turner Cut and Columbia Cut. This is an area that needs further study.

Additional Areas that Need Attention
In addition to those mentioned above, there are several areas that have evolved from the past three and a half years' studies that need attention through further studies. These are briefly summarized below.

DO "Crashes" in the DWSC. At times there will be short-term DO depletions in the DWSC to relatively low levels -- i.e., <3 mg/L. These DO "crashes" are particularly significant since they may ultimately become the controlling DO depletions that must be managed. At this time, the causes of the DO crashes are not understood, but may be related to pulses of higher-than-normal algal concentrations in the SJR that enter the DWSC, or pulses of increased inorganic turbidity that decrease light penetration in the DWSC and thereby reduce the oxygen produced by algal photosynthesis in the surface waters of the DWSC. They may also be due to pulses of colored waters released from upstream wetlands areas that decrease algal photosynthesis in the DWSC. There is need for intensive field studies involving more frequent monitoring of sources and DO depletion than has been conducted in the past three years. Such studies should be designed to understand and thereby control the DO crash episodes that occur occasionally in the DWSC.

DO Depletions during the Winter. During the winters of 2001-2002 and 2002-2003 significant DO depletions below the WQO have been found in the DWSC off of Rough and Ready Island. There is need to understand the oxygen demand loads and other factors that lead to these low-DO conditions.

DO Depletions within the South and Central Delta. There are DO depletions below the water quality objective in some of the South Delta channels. The role of algal related oxygen demand added to these channels from the SJR via Old River has not been determined. It could be part of the low-DO problems that are now occurring in the South Delta channels. This is an area that needs investigation.

At times, especially under high SJR DWSC flow, large amounts of oxygen demand and oxygen deficit are exported into the Central Delta at Turner Cut and Columbia Cut by the cross-DWSC flow of the Sacramento River on its way to the South Delta to be exported to Central and Southern California by the State and Federal Projects. At this time, no studies have been conducted to determine if low-DO problems are occurring in Turner Cut, Columbia Cut and/or Middle River due to the oxygen demand loads from the DWSC. These studies are needed as part of any implementation program that would alter flows through the DWSC. Particular attention should be given to the Turner Cut situation since the SJR flows that enter Turner Cut during ebb tide are not diluted to a significant extent by Sacramento River water.

Impact of Urban Stormwater Runoff Oxygen Demand Load on DO Depletion. City of Stockton stormwater runoff has been found to contain about 14 mg/L BOD_5. It is estimated that a 0.5-in storm in Stockton will result in a BOD load to the DWSC equal to the upstream BOD load from the SJR DWSC watershed including the City's wastewater treatment plant load. In November 2002 several inches of rainfall occurred in the

Stockton area. Prior to the rainfall the DO in the DWSC was above the water quality objective. Within a few days the DO in the DWSC was below the WQO for several weeks. At the same time the DO concentrations decreased to low levels in the creeks and sloughs that drain Stockton rainfall runoff to the DWSC. There were major fish kills in these waterbodies apparently because of low DO. It appears that potentially significant DO depletion could occur in the DWSC associated with rainfall-runoff-associated BOD derived from urban areas. This is an area that needs further evaluation through examination of the DO concentrations as measured by the DWR Rough and Ready Island monitoring station and the occurrence of fall-winter rainfall runoff events.

DO Water Quality Objectives

As discussed by Lee and Jones-Lee (2000a), there has been considerable discussion about the appropriate dissolved oxygen water quality objective for the Deep Water Ship Channel (DWSC) that will protect the beneficial uses of the DWSC, upstream waters and the Delta without unnecessary expenditures for DO depletion control. The current Central Valley Regional Water Quality Control Board Basin Plan objective (CVRWQCB, 1994) for dissolved oxygen is that the concentration of DO at any location in the Deep Water Ship Channel between Channel Point and Disappointment Slough shall not be less than 6 mg/L between September 1 and November 30, and 5 mg/L between December 1 and August 31. Gowdy and Foe (2002) have recently reviewed the origin of these objectives. The 5 mg/L WQO is similar to, but not the same as, the US EPA's national water quality criterion for DO (US EPA, 1986, 1987). The current US EPA national water quality criterion for DO allows for averaging and for low DO concentrations to occur near the sediment water interface. The 6 mg/L WQO was adopted to protect the fall run of Chinook salmon migration through the DWSC to their upstream home waters. The DO TMDL target for the DWSC is an extremely important value that could influence large expenditures for oxygen demand constituent control in the watershed, aeration of the DWSC and/or enhanced flow of the SJR through the DWSC.

South Delta Barrier Reverse-Flow Pumping. At this time, the barriers in the South Delta are manually operated. CALFED has committed to the installation of automatic tidal barriers, which are reported to better manage flows in the South Delta channels, to eliminate the low water levels that occur now, associated with export pumping of South Delta water to Central and Southern California. As discussed above, it has been proposed that the operation of the barriers can be conducted in such a way as to increase the flow of the SJR through the DWSC. Hildebrand (pers. comm., 2002) proposed that barrier operations, coupled with low-head, reverse-flow pumping over the barriers, can be conducted in such a way as to export water from the South Delta into the SJR via Old River. This, in turn, would shorten the hydraulic residence time of oxygen-demanding materials added to the DWSC, potentially resulting in less DO depletion in the DWSC. It has been found by Rajbhandari, *et al.* (2002) that low-head, reverse-flow pumping is technically feasible in providing South Delta water to the SJR DWSC. There are, as discussed above, a number of issues that need to be addressed in connection with developing this proposed approach to helping solve the low-DO problem in the DWSC.

The Strawman results from Foe, *et al.* (2002), as well as the observations made from the Hayes cruise data on the impact of flow on the low DO in the DWSC over the past 15 years, and the box model calculations presented herein, have raised questions about the ability of supplemental flow to the DWSC to control the low-DO problems. There is no issue that SJR flows greater than about 2,000 cfs through the DWSC will control the low-DO problem in the first seven miles below the Port of Stockton in the DWSC by exporting the oxygen demand loads into the Central Delta before they can be exerted in the DWSC. At this time there is not a readily discernable relationship between SJR flow through the DWSC between about 500 and 1,500 cfs and DO depletion in the DWSC. While the Chen and Tsai (2002) modeling presents a generalized relationship between SJR DWSC flow and DO depletion in the DWSC, the DWSC monitoring data, such as those presented herein based on the city of Stockton's monitoring as well as those developed in the Hayes cruises, raise questions about the reliability of the Chen model results. This is an issue that has not been resolved at this time.

The Rajbhandari, *et al.* (2002) modeling predicted that reverse-flow, low-head pumping over the permanent South Delta barriers would improve water quality in the South Delta as a result of introducing Sacramento River water into the South Delta. It is desirable that the supplemental flow into the SJR should be of a low oxygen demand content and thereby dilute the oxygen demand in the SJR waters that enter the DWSC. While this appears to be feasible, there are other South Delta water quality issues that are not well understood. There are a number of South Delta water quality issues that need to be addressed before the barrier reverse-flow pumping approach can be adequately evaluated. There is need for further studies on the hydraulics of the South Delta, with particular reference to how the permanent barriers would impact the water quality that is occurring in the South Delta and the quality of water that would be exported from the South Delta to the SJR via Old River.

At this time there is limited understanding of the specific sources of nutrients in the Mud and Salt Slough and SJR upstream of Lander Avenue watersheds that develop into algae that grow to a sufficient extent, within the Mud and Salt Slough watersheds as well as the SJR upstream of Lander Avenue watershed, to lead to high algal concentrations/loads in the SJR upstream of where the Merced River enters the SJR. It is the growth of algae, based primarily on the nutrients derived from these watersheds, that ultimately becomes the high algal-caused oxygen demand loads that have been found in the SJR at Mossdale. The initial focus of the Mud and Salt Slough and SJR upstream of Lander Avenue watersheds' oxygen demand load control program should be on gaining an understanding of algal growth dynamics and nutrient sources in these watersheds, focusing on the headwater areas of the watersheds. This understanding can then potentially be used to control the algal populations that are present in the SJR upstream of where the Merced River enters the SJR.

Eastside Rivers. An increase in flow of eastside rivers (Tuolumne, Stanislaus, and Merced Rivers) into the SJR can be a major factor in reducing the oxygen demand derived from the Mud and Salt Slough and SJR upstream of Lander Avenue watersheds that leads to low-DO problems in the DWSC. This is a result of diluting the elevated SJR algal concentrations that are present upstream of where the eastside rivers enter the SJR. Further, additional eastside river flow would decrease the travel time of the oxygen demand loads through the DWSC. This conclusion is particularly important since, as discussed by Lee and Jones-Lee (2000a), the San Joaquin River watershed is predicted to double in population over the next 20 years. Such doubling can only occur if additional water supplies are developed to serve this population. It appears now that there would likely be opposition to the use of any eastside river water to serve as a domestic supply for any new populations or any additional growth in the Central Valley or in the San Joaquin River watershed because of the potential adverse impacts on the flow of the eastside rivers to the SJR.

Issues that Need to be Resolved

There are a number of key issues that evolve from the conceptual models for the sources and impacts of oxygen demand on the DO resources of the SJR DWSC that need to be resolved. With respect to the constituents responsible for the DO depletion in the DWSC, the key issue is identifying the constituents primarily responsible for DO depletion below water quality objectives in the DWSC. Of equal importance is the origin of these constituents, their respective loads and how reducing these loads will improve water quality in the DWSC.

Oxygen Demand Dynamics in the SJR DWSC Watershed. A major issue that needs to be addressed in formulating a technically valid, cost-effective DO depletion control program for the DWSC is an understanding of the dynamics of oxygen demand development and changes in the oxygen demand that occur in the SJR during transport to the DWSC. As discussed herein, this understanding of the dynamics of oxygen demand development, transport and fate upstream of the DWSC must be addressed for the various seasons (monthly), especially during the late spring, summer and fall. In addition, since the studies of the past three years were conducted during wet-year periods, they may not be fully applicable during dry years. There is need to consider how the wet-year versus dry-year conditions within the SJR watershed influence oxygen demand dynamics within the DWSC watershed.

An issue that will need to be considered in developing nutrient control programs within the SJR watershed is the potential adverse impact of such programs on the fisheries resources of the Delta. Lee and Jones (1991) have shown that there is a direct relationship between fish production in waterbodies and their nutrient loads. Since there is an interest in improving the fisheries of the Delta, controlling nutrient inputs to the Delta from its tributaries could prove to be detrimental to Delta fisheries. This issue will need to be evaluated as part of any nutrient management program within the Delta and its tributaries.

City of Stockton Wastewater Discharges. The wastewater discharges from the city of Stockton are, at times, potentially significant sources of oxygen demand for the DWSC. In addition to the residual BOD present after treatment, the wastewaters, at times, can contain high concentrations of algae that develop in the City's treatment ponds. While at times the City filters its effluent to remove many of the algae, at other times discharges of algae occur. This adds to the algal load within the DWSC which could be significant during low SJR DWSC flow. Another factor to consider with the City's wastewater discharges is that they are not constant, but are often shut off over the weekends, and then are allowed to occur again on Monday. This discharge pattern could be influencing the oxygen depletion within the upper parts of the DWSC, especially near Channel Point. The impacts of this discharge pattern on DO depletion in the DWSC need to be evaluated.

The CVRWQCB has adopted a revised NPDES wastewater discharge permit for city of Stockton which will limit the amount of ammonia discharged to the SJR because of the potential for these discharges to cause toxicity to aquatic life. There is need to evaluate the degree of control that the City must exercise to control ammonia-caused significant oxygen demand that influences DO depletion in the DWSC.

Oxygen Demand Dynamics between Mossdale and Channel Point. Foe, *et al.* (2002), as part of the Strawman analysis, have addressed the issue of whether there are unusual or unexpected changes in oxygen demand that occur between the SJR at Mossdale and the DWSC at Channel Point. Confusing information has been presented on this issue, where claims of large amounts of oxygen demand disappearance occurred in this reach of the San Joaquin River. There are questions, however, about the reliability of that assessment, based on the ability to reliably conduct a mass balance in the tidal part of the DWSC at Channel Point. Measurements at Channel Point reflect dependence on tidal stage and direction, inputs from the SJR DWSC downstream of this location, inputs from the upstream SJR and inputs from the Port of Stockton's Turning Basin. The Turning Basin has significantly different surface and bottom water characteristics than the main body of the DWSC near Rough and Ready Island. Channel Point is an extremely difficult area to properly monitor and understand factors influencing algae and oxygen demand concentrations in samples taken from this location. In order to properly characterize the concentrations of constituents at Channel Point, an extensive sampling and flow measurement program far beyond those that have been conducted thus far is needed to be able to reliably claim that there are unexpected or unusual concentrations of oxygen demand constituents in samples taken from Channel Point.

Foe, *et al.* (2002) have shown that the changes that occur in oxygen demand between Vernalis and Mossdale are in accord with what would be expected, where there is increased algal growth in the SJR between these two locations. Quinn and Tulloch (2002) have pointed out that there is a major agricultural diversion (Banta Carbona) of SJR water between Vernalis and Mossdale. According to Quinn (pers. comm., 2002) during July 2001, the Banta Carbona diversion represented about 200 cfs. This water district, therefore, has the potential to divert a substantial part of the oxygen demand load present in the SJR at Vernalis and thereby reduce the total load that is present at Mossdale.

As shown in Figure 7, at 1,000 cfs of SJR flow through the DWSC there is about a 1.5-day travel time between Mossdale and Channel Point, while at 600 cfs the travel time between these two points is about 2.5 days. During a one- to two-day travel time between Mossdale and Channel Point, significant changes in the oxygen demand, algae, etc., would not be expected. However, under SJR DWSC flows of a few hundred cfs, such as frequently occurred in 2002, much longer travel times exist between Mossdale and Channel Point, during which major changes in the algal population and oxygen demand load constituents can occur. This is an area that needs intensive study.

Overall, it does not appear that under SJR DWSC flows above about 600 cfs there is any unusual behavior of oxygen demand loads present at Vernalis that cause the concentrations at Mossdale, or for that matter at Channel Point, to be significantly different from what is expected. This may not be the case, however, under extreme low flows of less than 500 cfs.

Impact of DO Concentrations on DWSC Chinook Salmon Migration And Aquatic Life Habitat

An issue that needs to be resolved is the appropriate dissolved oxygen concentration that will prevent inhibition of the fall run of Chinook salmon migration through the DWSC to their home waters. There is need to conduct studies over a several-year period to determine whether the 6 mg/L DO water quality objective adopted by the State Water Resources Control Board is technically justified. The Department of Fish and Game studies, conducted in 1970, concluded that the DO in the DWSC should be above 5 mg/L to avoid inhibition of Chinook salmon migration through the DWSC due to low-DO. These studies need to be updated.

Another area that needs attention during the Phase I TMDL is the need to establish the 5 mg/L minimum DO water quality objective as being applicable to all locations and times within the DWSC. The US EPA and a number of states allow averaging of the diel (day/night) DO. Further, they allow lower DO in the near-bottom waters of some waterbodies. An issue that needs to be resolved is whether following this approach would be significantly detrimental to the aquatic life resources of the DWSC and, for that matter, the South Delta.

A review of the appropriate DO water quality objective for the DWSC should be conducted which may conclude that there is need for studies to examine how DO values less than 6 mg/L, between September 1 and November 30, impact Chinook salmon migration through the DWSC. Also, the water quality and the aquatic life resource impacts of an average diel DO and a lower DO in the near-bottom waters of the DWSC should be evaluated.

Alternative Approaches for Solving the DWSC Low-DO Problem

From the Synthesis Report

Presented below are several alternative approaches that have been suggested that should be considered and, if found appropriate, evaluated to help solve the low-DO problem in the DWSC. Information on several of these approaches will be needed as part of the CEQA alternatives evaluation that will be associated with the final TMDL for solving the low-DO problem in the DWSC.

Impact of Continued Operation of the Port of Stockton on the DO Problem in the DWSC

The previous studies have determined that, without the existence of the Port of Stockton and its associated Deep Water Ship Channel, there would be few, if any, DO depletion problems below the water quality objective in the DWSC. This situation causes the Port of Stockton and those who benefit from the Port to be one of the, if not the, primary responsible party for the DO problem in the DWSC. Since the continued existence of the Port is of economic value to a variety of entities within the Central Valley, especially in the San Joaquin River watershed, it is appropriate to examine the economic and other consequences of terminating the existence of the Port of Stockton as a deep water ship port and thereby allow the DWSC to fill in. In time, the DWSC would become shallower and ultimately, shoal in sufficiently so that the DO depletion problems in the DWSC would be greatly reduced. It is suggested that an economic study be conducted of the value of the Port to stakeholders in the region and its cost in terms of controlling the low-DO problem in the DWSC.

Altered Flow of the SJR past Rough and Ready Island

It has been suggested by representatives of the Port of Stockton that Burns Cutoff, which connects to the SJR just upstream of Channel Point and flows on the westside of Rough and Ready Island, could be used as a channel that would carry SJR water around Rough and Ready Island and thereby discharge the oxygen demand loads in the SJR that enter the DWSC several miles downstream of Channel Point. The waters in Burns Cutoff could be aerated and thereby reduce the oxygen demand load that now enters the DWSC at Channel Point. The aeration of Burns Cutoff could be done in such a way as to eliminate the interference with ship traffic. It has been suggested that there may be need for a lock on the SJR at Channel Point to allow small boat traffic to pass from the DWSC into the SJR and to divert SJR water into Burns Cutoff. It is suggested that an engineering study of the potential use of Burns Cutoff as an alternative low flow summer channel for routing and aerating the SJR water and its associated oxygen demand load into the DWSC downstream of Rough and Ready Island be conducted.

References

See the Synthesis Report for references cited herein.