Comments on

AMENDMENTS TO THE WATER QUALITY CONTROL PLAN FOR THE SACRAMENTO RIVER AND SAN JOAQUIN RIVER BASINS FOR THE CONTROL PROGRAM FOR FACTORS CONTRIBUTING TO THE DISSOLVED OXYGEN IMPAIRMENT IN THE STOCKTON DEEP WATER SHIP CHANNEL

DRAFT FINAL STAFF REPORT December 13, 2004

submitted by

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Presented herein are our comments on the Central Valley Regional Water Quality Control Board (CVRWQCB) staff's proposed Basin Plan Amendment to control dissolved oxygen (DO) water quality objective (WQO) violations in the San Joaquin River (SJR) Deep Water Ship Channel (DWSC). These comments are based on our involvement in investigating and reporting on the low DO problem in the San Joaquin River Deep Water Ship Channel since the spring of 1999. Prior to that time over the past 40 years, I (Dr. G. Fred Lee) have been involved in investigating and developing management approaches for similar kinds of problems in various water bodies located throughout the US and several other countries. Our previous work on behalf of CALFED, the CVRWQCB and the SJR DO TMDL Steering Committee has been reported in several reports which include the Lee and Jones-Lee (2000) "Issues Report" and the Lee and Jones-Lee(2003a), "Synthesis Report" and in several supplements to the synthesis report (Lee 2004a, Lee and Jones-Lee 2003b, 2004a,b,c,d, 2005). These reports and others have been made available to the SJR TMDL Steering Committee email list, and the CVRWQCB and are available from our web site, www.gfredlee.com.

In the fall of 2004, we presented a summary review of the nature of the low DO problem in the DWSC and our recommended approach for solving this problem at the Society for Environmental Toxicology and Chemistry (SETAC) World Congress that was held in Portland, Oregon in November 2004 (Lee and Jones-Lee 2004e). The PowerPoint slides from this presentation are included in Appendix A of this report. These slides provide an outline of many of the issues that the CVRWQCB/SWRCB will need to consider and adequately address in developing a technically valid TMDL for solving the low DO problem in the DWSC.

Overall, we find that the CVRWQCB staff, Gowdy and Grober, have done a good job in presenting the issues that need to be addressed to solve the low-DO problem in the DWSC. There are however, several issues that we find need additional attention in the formulation and implementation of this proposed Basin Plan Amendment. Many of these issues were discussed in the comments on the initial draft Basin Plan Amendments submitted by Lee (2003a). The issues of continued concern are discussed below. Also presented below, are several pertinent references to the updated information on SJR DWSC low DO problem and its management that are not included in the draft Basin Plan Amendment.

Need for Comprehensive TMDL Programs

One of the major problems with the current CVRWQCB efforts to develop control programs for WQO violations is that they are not conducted in a comprehensive coordinated manner to address well known existing water quality problems in the SJR watershed. At this time, there is no overall evaluation approach that leads to a coordination of the management approaches that will need to be implemented to solve the variety of water quality problems that exist in the SJR watershed and South Delta. Many of these water quality problems are interrelated. Under the current approach, large amounts of funds could be spent developing a control program to meet a particular TMDL requirement that subsequently under a more comprehensive review will need to be changed or modified to consider the broader picture for controlling multiple water quality objective violations that are occurring in the SJR DWSC watershed. Examples of this type of situation are discussed below.

There is immediate need for the state Water Resources Control Board (SWRCB) and the CVRWQCB to develop a much more comprehensive water quality management program in the San Joaquin River watershed that properly considers all of the various water quality issues that are known to exist and will have to be addressed to manage them. These various issues have been outlined in the PowerPoint slides presented in Appendix A; some of them discussed herein.

Page 1 of the Executive Summary states,

Waste Load and Load Allocations

> *"Thirty percent of the ENOD apportioned to sources of oxygen demanding substances is allocated as a waste load allocation to the City of Stockton Regional Wastewater Control Facility (RWCF). Sixty percent of the ENOD apportioned to sources of oxygen demanding substances is allocated as a load allocation to non-point sources of algae and its precursors upstream of the DWSC. Ten percent of the ENOD apportioned to sources of oxygen demanding substances is allocated as a reserve for unknown sources and impacts, and known or new sources that have insignificant impact, including waste load allocations for point sources set at their corresponding effluent limitations applicable on 28 January 2005."*

In previous comments on the staff's draft Basin Plan Amendment (Lee 2003a) for the low DO TMDL, we have indicated that the one third one third one third approach is not a valid approach for controlling the low DO problem in the DWSC.

Page 41 states,

"Given the above arguments, this TMDL considers each of the three contributing factors to be 100% responsible for the impairment. Those parties collectively responsible for each contributing factor will need to coordinate with those responsible for the other factors to implement control measures that eliminate excess net oxygen demand (plus the margin of safety). This TMDL does not specify the relative responsibility among these three factors. Entities responsible for each of the three main contributing factors will need to determine among themselves the relative responsibility that will be assumed by each contributing factor."

As discussed in our reports and in previous comments to the CVRWQCB staff, the apportionment of oxygen demand loads and factors influencing this problem should focus on the

impact of the continued maintenance dredging of the DWSC to maintain navigation depth. The Corps of Engineers continued maintenance dredging of the DWSC is strongly contrary to controlling the low DO problem in the DWSC in the most cost-effective manner. As discussed in our recommended approach for solving the low DO problem (Lee 2003b, Lee and Jones-Lee 2004d) considerable effort needs to be made to get the US Congress to provide funds that can be used to control DO WQO violations associated with mitigation for continued maintenance dredging of the DWSC.

Another major responsibility for this problem is due to the manipulations of SJR DWSC flows in the SJR DWSC watershed and South Delta. Recently, the San Joaquin River Water Quality Management Group (SJRWQMG) have focused attention on managing SJR flow and salt loads in the SJR watershed to control violations of the total salt concentrations in the SJR at Vernalis as part of an effort to meet the current water quality objective for salt (TDS, EC) in the SJR at Vernalis. As discussed in our reports, the current 700µmhos/cm EC objective for the SJR at Vernalis needs to be significantly lowered so that the EC in a SJR water that enters the South Delta through the Head of Old River will enable irrigated agriculture in the South Delta to discharge tail water to South Delta channels without causing violations of the South Delta EC WQO of 700 µmhos/cm. At this time the SJRWQMG has failed to address this problem.

Developing a flow and salt load management program for the SJR watershed to meet the 700 µmhos/cm EC WQO at Vernalis may have limited applicability to the management program that will ultimately have to be developed to meet the EC objective that will need to be adopted to enable irrigated agriculture in the South Delta to continue to exist. These issues have been discussed by Lee et al. (2004a,b). While there have been some who claim that the 700 µmhos/cm EC objective for the South Delta channels is overly protective the facts are that total concentrations above this level is detrimental to irrigated agriculture. It will be important to properly consider all the excess salt problems in the lower SJR and South Delta in a comprehensive program. What ever is done with respect to managing flows and the salt loads in the SJR at Vernalis can have significant impacts on managing the low DO problem in the DWSC.

The current SJRWQMG approach to address the impact of SJR watershed flow manipulations on the low DO problem in the DWSC is to address this issue as a secondary issue to managing flows to control total salts in the SJR at Vernalis. Since as documented in our reports, the management of flow in the SJR watershed and in the South Delta are a major contributor to the low DO problem in the DWSC, there is need to focus on determining the maximum readily attainable steady flows of the SJR through the DWSC in order to minimize the funds needed for aeration and oxygen demand load control. As discussed by Lee and Jones-Lee (2003a,c, 2004a) and Lee 2004a,c), it will be important to gain control of SJR DWSC extreme flow variability that occurs now. This variability is directly responsible for some low DO events. Of particular concern are situations where there have been moderate flows of the SJR through the DWSC followed by periods of essentially no flow. This leads to loading up the DWSC with oxygen demand constituents where there is no transport flow through the first 7 miles of the DWSC to Turner Cut. Repeatedly over the past five years that there's been data collected, such situations lead to severe DO depletions below the WQO.

Oxygen Demand Load Sources

The third area that needs more directed attention then is provided for in the draft Basin Plan Amendment is the control of oxygen demanding substances that are added to the DWSC. As discussed in our reports, the principal sources of oxygen demand for the DWSC are the city of Stockton domestic wastewater ammonia discharges and the algae that develop in the SJR DWSC watershed that are added to the DWSC. With respect to the city of Stockton's ammonia discharges, a review of the data that was collected in 1999, 2000 and 2001, shows that there was only one occasion during the summer and fall when the city of Stockton ammonia discharges were more than 50% of the total oxygen demand load to the DWSC. Generally, the dominant source of oxygen demand was the algae that develop in the DWSC watershed. The exceptions to this situation occurred when the SJR flow to the DWSC was very low as a result of the state and federal export projects pumps sucking all of the SJR Vernalis water into the South Delta through the Head of Old River. Under these conditions, the city of Stockton's wastewater discharged ammonia and other oxygen demand constituents in the wastewater become the dominant source of oxygen demand for the DWSC. During the winter months, especially in February, the city of Stockton's wastewater discharge of ammonia and other oxygen-demanding constituents becomes the primary source of oxygen demand, due primarily to the diversion of SJR Vernalis water into the South Delta and the low algal content of the SJR water at Vernalis.

It has been suggested that the winter low-DO problem in the SJR DWSC will not occur in future years when the city of Stockton controls the ammonia discharges to the 2 mg/L monthly average discharge NPDES limit that the CVRWQCB as placed on the cities wastewater discharges. It is important to understand however, that this limit is based on meeting the ammonia concentrations in the lower SJR and upper DWSC that will not lead to violations of the ammonia toxicity water quality criterion established by the US EPA. This limit is based on a monthly average ammonia concentration.

With respect to the violations of the DO water quality objective, there can only be one violation of this objective by any magnitude at any location in the DWSC every three years. Violations that occur more frequently will require further control of DO concentrations in the DWSC. As indicated in Appendix A, under low flow conditions with the allowed excursions above the 2 mg/L ammonia monthly average discharge limit, there can be DO depletions below the water quality objective in the DWSC that would require further oxygen demand control.

It will be important that the SJR DWSC flows during all times of the year, including the winter be managed in such a way as to achieve maximum steady flow. There is need for further study to define the minimum flows of the SJR through the DWSC that can be allowed and avoid DO water quality objective violations. For planning purposes, the issue of flow of the SJR through the DWSC should be addressed as a separate issue, not as a secondary issue to salt TMDL flows. The flow needed to meet both of these TMDLs, will need to be addressed by the state Water Resources Control Board as part of the D 1641 water rights hearings where the required flows to optimize solving the salt TMDL and the low DO TMDL to the maximum extent possible through management of SJR and South Delta flows.

As discussed in the synthesis report and in the supplement to this report, there is need to define the ability to and associated costs for controlling the high algal loads (oxygen demand loads) that

developed in the SJR upstream of Mossdale. Of particular importance is the role of algae that develop in Mud and Salt Slough watersheds that become the major algal oxygen demand source that enter the DWSC that lead to DO violations below the WQO. As discussed in the synthesis report, and in other comments in reports on our web site, www.gfredlee.com, the upstream monitoring program developed by agricultural interests falls far short of a credible oxygen demand source study to determine whether it is economically possible to control oxygen demand that develops in the SJR DWSC watershed through the control of nutrients in the headwaters of Mud and Salt Sloughs. Both Drs. Foe and Lee independently, commented on the draft proposed monitoring program on the significant deficiencies in this program. While those responsible for developing the program claimed to the SJR DO TMDL steering committee that these issues would be addressed in finalizing the proposal, in fact they were not addressed. As discussed by Lee (2003d), this caused the upstream monitoring proposal to be technically flawed.

Lee (2003d) also pointed out in his comments to CALFED/CBDA that there are several other reasons not to fund this proposal including the fact that the salt TMDL implementation could significantly affect the oxygen demand load that reaches the DWSC in the form of upstream developed algae. Now that the SJRWQMG has begun to formulate an approach for controlling the excessive TDS/EC in the SJR at Vernalis it is clear that conducting studies now before the salt TMDL implementation approach is better defined could lead to a waste of CALFED/CBDA funding. Any alterations of salt load and or flows affect in the mud and salt Slough watersheds could readily impact the nutrients that develop into algae in the sloughs that become the primary seed for the algal load of oxygen demand to the DWSC from upstream sources.

Another issue that needs to be investigated as part of formulating the final TMDL to control the low-DO problem in the DWSC, is the potential benefits of reducing nutrient concentrations in the SJR upstream of the DWSC on the algae associated oxygen demand loads to the DWSC that cause DO WQO violations. While both nitrogen and phosphorus are present in the SJR at concentrations well above growth rate limiting concentrations, there is evidence from the literature (Lee and Jones-Lee 2002, Van Nieuwenhuyse 2004) that even under the conditions of surplus nutrients, reducing the nutrient loads/concentrations especially phosphorus can reduce the magnitude of algal biomass that develops in a waterbody. As outlined in Appendix A, the situation that developed in the Rhine River in Europe where reducing phosphorus loads/concentrations in the Rhine reduced the algae concentrations and the dissolved oxygen water quality problems. Similar situations have been observed for a number of waterbodies where reducing the phosphorus concentration in the waterbody through reducing the phosphorus loads to the waterbody resulted in reduced algal biomass and improve water quality. This same kind of situation could occur in the SJR upstream of the DWSC. Studies need to be conducted to determine whether this is feasible and the potential costs of nutrient control to eliminate DWSC DO WQOs violations. Jassby and Van Nieuwenhuyse (2004) and Dahlgren and Van Nieuwenhuyse (2004) has recently provided additional information that is pertinent to understanding and managing of the development of planktonic algae in the SJR DWSC watershed. Studies significantly different from those that were approved by CALFED/CBDA in the fall 2003 will need to be conducted however to properly examine the situation.

Page 46 states,
"The CVRWQCB staff will review sampling and analysis plans for the various studies

performed during the study phase of this TMDL to ensure their adequacy in meeting the objectives of the individual studies and the TMDL study plan overall."

Because of the way in which the upstream monitoring program was developed by the agricultural interests, a significant conflict of interest situation has developed in conducting the proposed upstream studies. The currently proposed CVRWQCB Basin Plan Amendment calls for dischargers such as upstream agricultural interests including irrigation district managers to conduct studies on the impact and control of oxygen demanding substances in the SJR watershed. Under the conditions that exist where those responsible for developing these studies have deliberately avoided the development of data that could show that a particular discharger is significantly contributing to the low-DO problem, There is need to appoint an independent science/engineering review panel who would be responsible for formulating the approach for conducting upstream studies, review of the study results as there being developed and review of the adequacy of the reports that a developed by those conducting studies. The members of this panel should not be agricultural interests or others who have a vested interest in how the DO TMDL is implemented.

The draft Basin Plan Amendment on page 3 states,
Actions Addressing Sources of Oxygen Demanding Substances and their Precursors

To address loads of oxygen demanding substances and their precursors, this proposed Basin Plan Amendment will require completion of the scientific studies needed to obtain the information for more detailed allocations and eventual implementation of alternate measures by those responsible for the various sources. This will be achieved by the CVRWQCB taking the following actions:

- *Require submission of a study plan from entities responsible for the various sources of oxygen demand by 31 July 2005. Studies must identify: i) sources of oxygen demanding substances, ii) their transformation between sources and the DWSC, and iii) their conversion to oxygen demand in the DWSC by December 2008*

Rather than allocating responsibility for controlling the low-DO problem based on a one third one third one third approach in which each of those responsible for a third are to develop study programs and report the results to the Regional Board in 2008, the Basin Plan Amendment should define the issues that need to be properly addressed and indicate that the CVRWQCB working with an advisory panel will be developing specific guidance on the studies it need to be done. In addition the overall framework for administration of the studies should be clearly delineated. The current approach as presented in the proposed Basin Plan Amendment is far too nebulous and could readily lead to little being accomplished compared to that needed to develop a final TMDL to control the low-DO problem in the DWSC.

Need to Address DO WQOs for the DWSC

One of the most significant deficiencies in the proposed Basin Plan Amendment is the failure to initiate work to develop more appropriate DO water quality objectives for the SJR DWSC. These issues are discussed in the "issues" and "synthesis" report's and in comments submitted by Lee (2004b). They are also outlined in Appendix A. The current Basin Plan requirement limiting the number of WQOs violation's to only one of any magnitude and any location every three years will place severe unnecessary constraints on oxygen demand control. Other states

with the approval of US EPA, adopt diel (night to day) averaging of the daily DO. This can be extremely important in the DWSC since at times, early morning to late afternoon changes in DO in the near surface water can be as much as 8 mg/L. Also there is need to consider that the waters within the bottom meter of the DWSC can be 1 to 2 mg/L lower in DO than the waters that mid depth. Eliminating the WQO DO violations that occur near the bottom and in the early morning will require a much more comprehensive water quality monitoring program than has been proposed by CBDA consultants. Eliminating these violations compared to averaging over the day for with depth will not be significantly detrimental to the aquatic life resources of the DWSC.

One of the most significant areas that need attention is the validity of the 6 mg/L DO WQO as being necessary to allow migration of Chinook salmon through the DWSC. As discussed in the synthesis report is considerable information that would lead to the conclusion that that an average with depth and during the day 5 mg/L would allow unimpeded Chinook salmon migration through the DWSC. As part of developing the basin plan amendment, a component of this plan should be specific delineating a study plan to develop appropriate DO WQOs for the upper DWSC. Failure to begin to address this issue at this time could result in the expenditure of large amounts of public and private funds for aeration, SJR flow modification, and oxygen demand source control beyond that needed to adequately protect the designated beneficial uses of the DWSC.

Impact of SJR Head of Old River Flow Diversions on Low DO Problem

Beginning on page 33 of the staff report is a discussion of the impact of SJR Head of Old River flow diversions associated with the export pumping of South Delta water by the state and federal projects on the low-DO problem. While references made to a discussion of this issue in the synthesis report, there is considerable additional information on this issue in supplements to the synthesis report and in special reports that have been completed in 2003 and 2004 by Lee and Jones-Lee. The additional information clearly documents that the state and federal export projects drawing SJR Vernalis water into the South Delta is a major cause of low DO problems in the DWSC. The references that should be added to the Basin Plan Amendment discussing this issue include Lee 2003a,c, Lee (2004a), Lee and Jones-Lee (2003a,b, 2004c).

Loading Capacity

Page 37 of the staff report presents two oxygen demand loading diagrams which relate the allowable loading of oxygen demand to the DWSC as a function of SJR DWSC flow and temperature. As discussed in the past comments, these diagrams are in error at the upper flows since at these flows much of the oxygen demand added to the DWSC is exported via Turner Cut and Columbia Cut. As the flows increase through the DWSC, higher oxygen demand loads can be added to the DWSC without causing DO WQO violations. This is the reason why at SJr DWSC flows above about 1,500 cfs violations of the DO WQO do not occur in the DWSC.

Coordinated TMDL Efforts

Lee and Jones-Lee (2004f) have developed a comprehensive review of the current water quality problems in the Delta as evidence by existing TMDLs. As they discuss several of these TMDLs are impacted by the state and federal South Delta export projects. These issues need to be addressed by the SWRCB as part of its D 1641 water rights review. Included within this review

should be consideration of the requirements imposed by the U.S. Congress (2004) passage of HR 2828 Water Supply Reliability and Environmental Improvement Act. Included within this review should be consideration of the requirements imposed by the U.S. Congress (2004) passage of HR 2828 Water Supply Reliability and Environmental Improvement Act. HR 2828, states,

"*D) PROGRAM TO MEET STANDARDS-*

> *(i) IN GENERAL- Prior to increasing export limits from the Delta for the purposes of conveying water to south-of-Delta Central Valley Project contractors or increasing deliveries through an intertie, the Secretary shall, not later than 1 year after the date of enactment of this Act, in consultation with the Governor, develop and initiate implementation of a program to meet all existing water quality standards and objectives for which the Central Valley Project has responsibility.*"

Lee and Jones-Lee (2004) have discussed how the export projects are impacting WQO violations in the Delta. There is need to begin to address these issues as part of any further water diversions/flow manipulation in the Delta and its tributaries. Appendix A presents a summary of the issues that need to be addressed in a coordinated effort by the CVRWQCB and the SWRCB on the slides, "Current Investigative Effort not Adequate to Meet Needs."

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Appendix A

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San Joaquin River Deep Water Ship Channel Low DO Problem and Its Control

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Characteristics of SJR DWSC Low DO Problem

- Occurrence of Low DO
- Cause of Low DO & Sources of Oxygen Demand
- Factors Influencing Low DO

Management Approaches

- Recommended Approach

(Presented at SETAC World Congress Portland, OR, November 2004, Updated December 2004)

Abstract
San Joaquin River Deep Water Ship Channel Low-DO Problem
- Causes and Remedy -

Dissolved oxygen (DO) concentrations in the seven-mile reach of the San Joaquin River (SJR) Deep Water Ship Channel (DWSC) downstream of the Port of Stockton are chronically below the water quality objectives (WQOs). In addition to being adverse to aquatic life in the DWSC, the low DO is believed to inhibit the homing of the fall-run of Chinook salmon. This has led the California Central Valley Regional Water Quality Control Board to list the DWSC near the Port of Stockton as 303(d) "impaired," which requires the development of a TMDL to control DO depletion to meet the WQOs. Beginning in 1999, about $4 million in studies have been conducted on the occurrence of DO below the WQOs, the factors influencing the depletion of DO below the WQOs, and the sources of oxygen-demand constituents for that critical reach. It has been found that the more than 3-fold greater depth and increased volume of the DWSC compared with the upstream SJR slow the river flow. This reduces the oxygen-demand assimilative capacity of the critical reach of the DWSC by providing more time for the oxygen demand to be exerted there; at times of low SJR flow, the residence time for oxygen demand exertion in the DWSC is almost a month. The flow of the SJR through the DWSC is controlled by reservoir releases and upstream agricultural and domestic water supply diversions. In addition, algae (fed by excessive discharge of algal nutrients from agriculture) that grow in the SJR DWSC watershed die in the DWSC and exert an oxygen demand; ammonia from Stockton domestic wastewater also contributes to the oxygen demand.

Those interests that benefit from the existence of the Port of Stockton/DWSC or the flow diversions, as well as oxygen-demand dischargers are responsible for the impacts of the DWSC dissolved oxygen depletion below the WQOs. The TMDL for solving the SJR DWSC low-DO problem should include:

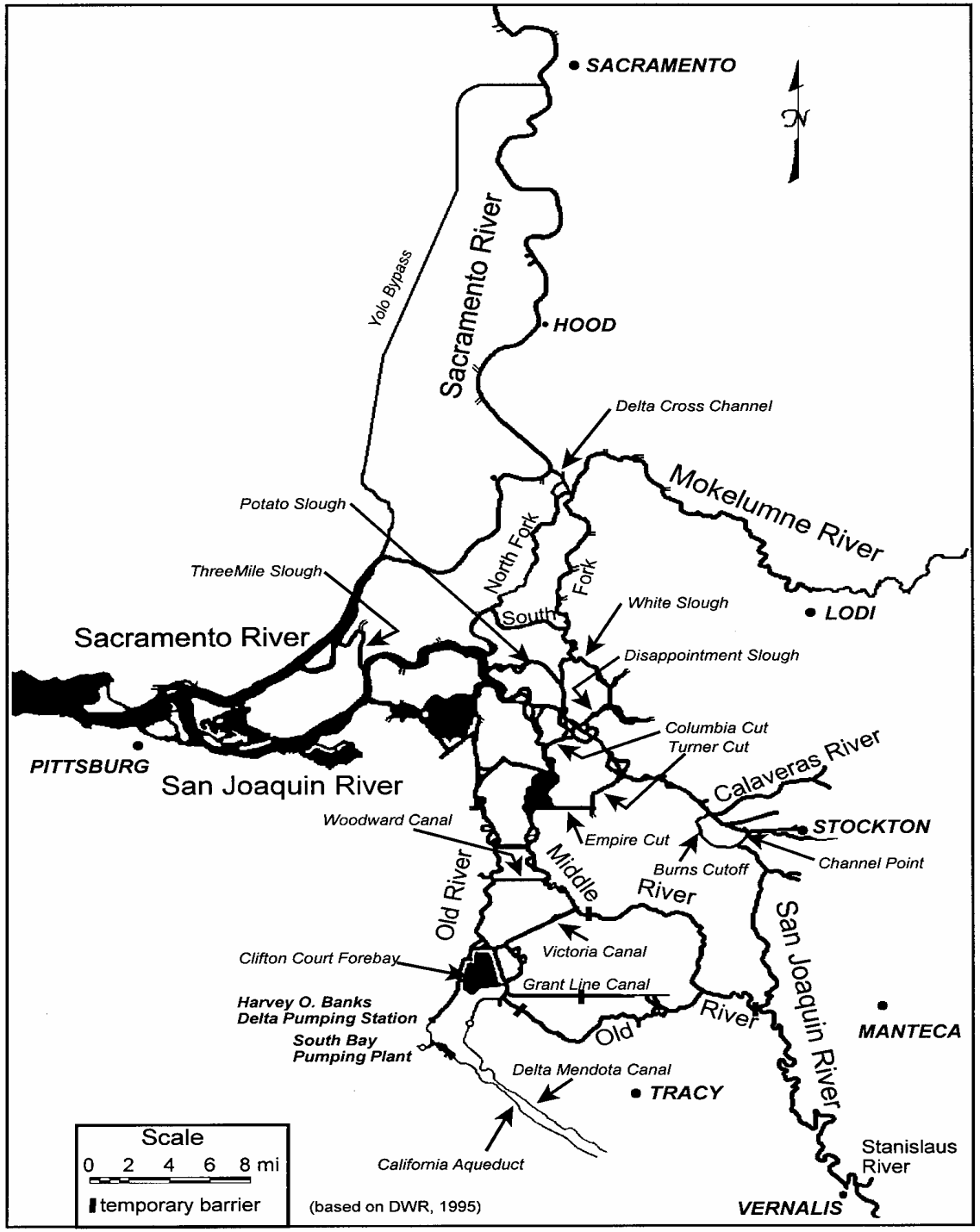
- Maximizing the minimum flow of the SJR through the DWSC,
- Evaluating the cost of aeration of the DWSC at various SJR DWSC flow levels,
- Obtaining federal and other funding to mitigate for the development and maintenance of the DWSC,
- Evaluating the potential for controlling the nutrients within the Mud and Salt Slough watersheds that support the growth of algae in those watersheds that subsequently contribute to the oxygen demand in the DWSC that decreases the DO concentrations below the WQO,
- Controlling the city of Stockton's domestic wastewater ammonia discharges.

Information on each of these aspects is presented, as well as an approach for integrating these components into a TMDL to solve the low-DO problem in the DWSC.

Definitions

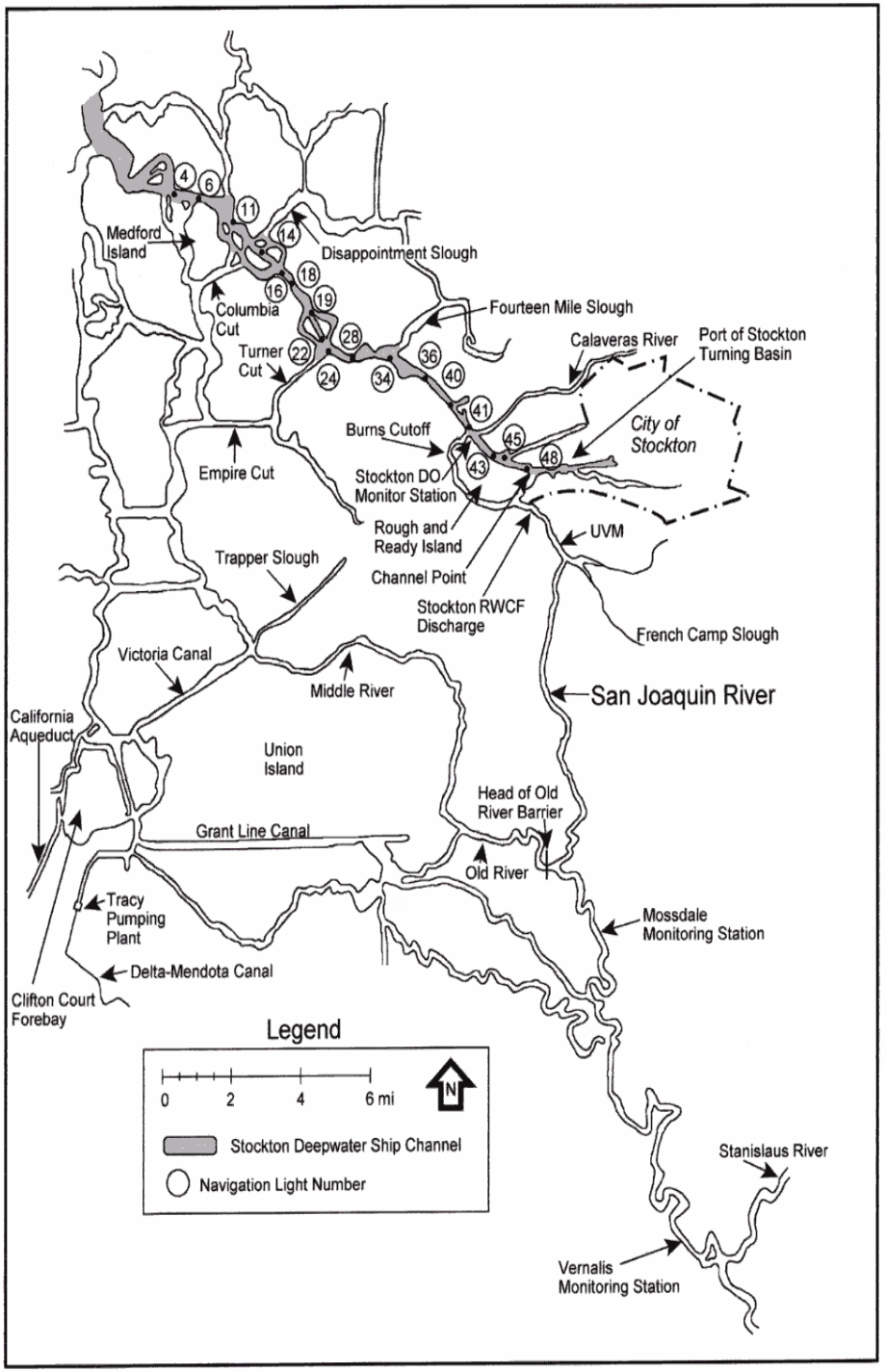
- SJR — San Joaquin River
- DWSC — Deep Water Ship Channel
- DO — Dissolved Oxygen
- WQO — Water Quality Objective
- CVRWQCB — Central Valley Regional Water Quality Control Board
- TMDL — Total Maximum Daily Load
- CWA — Clean Water Act
- DIP — Delta Improvement Package

Sacramento River San Joaquin River Delta



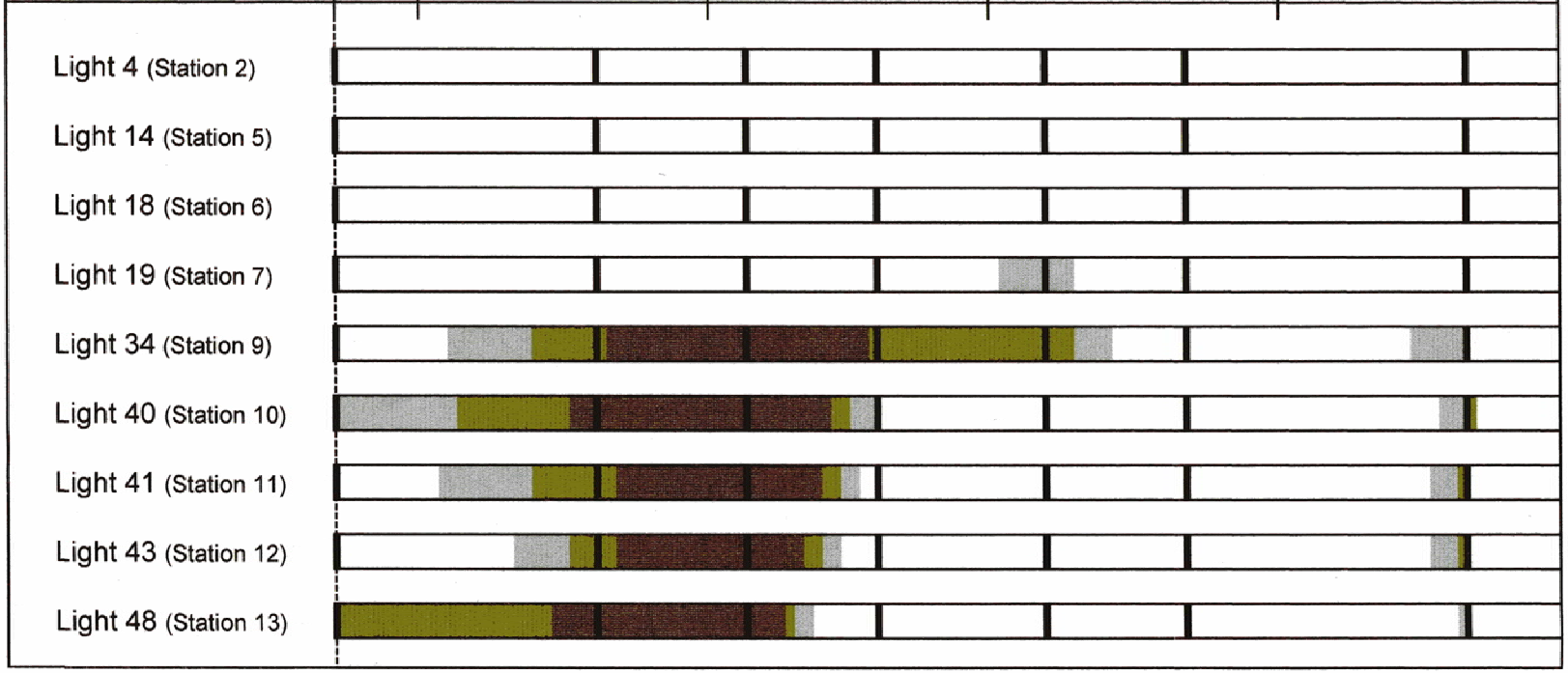
San Joaquin River Deep Water Ship Channel

Critical Low-DO Reach



Incidence of Dissolved Oxygen below WQO
Surface Water 2002

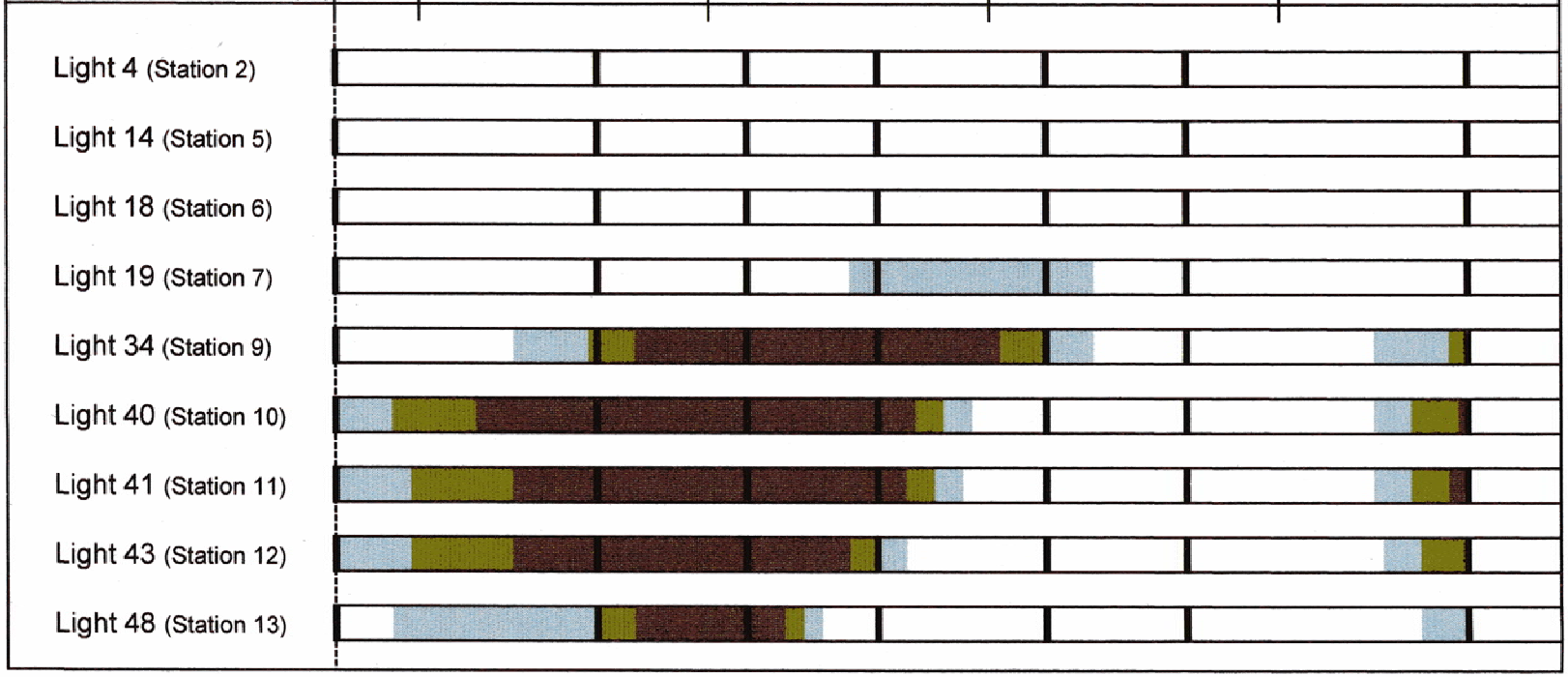
Location	July	August	September	October	November
Avg. BODu Load to DWSC (lb/day)					
Flow of SJR to DWSC (cfs)	200-700	100 -- 800	500 -- 1000	1000 -- 1800	85 -- 1700



	Monitoring Period and Sampling Event
	DO 0 to 0.5 mg/L below Water Quality Objective
	DO 0.5 to 1 mg/L below Water Quality Objective
	DO more than 1 mg/L below Water Quality Objective

Incidence of Dissolved Oxygen below WQO
Bottom Water 2002

Location	July	August	September	October	November
Avg. BODu Load to DWSC (lb/day)					
Flow of SJR to DWSC (cfs)	200-700	100 -- 800	500 -- 1000	1000 -- 1800	85 -- 1700



	Monitoring Period and Sampling Event
	DO 0 to 0.5 mg/L below Water Quality Objective
	DO 0.5 to 1 mg/L below Water Quality Objective
	DO more than 1 mg/L below Water Quality Objective

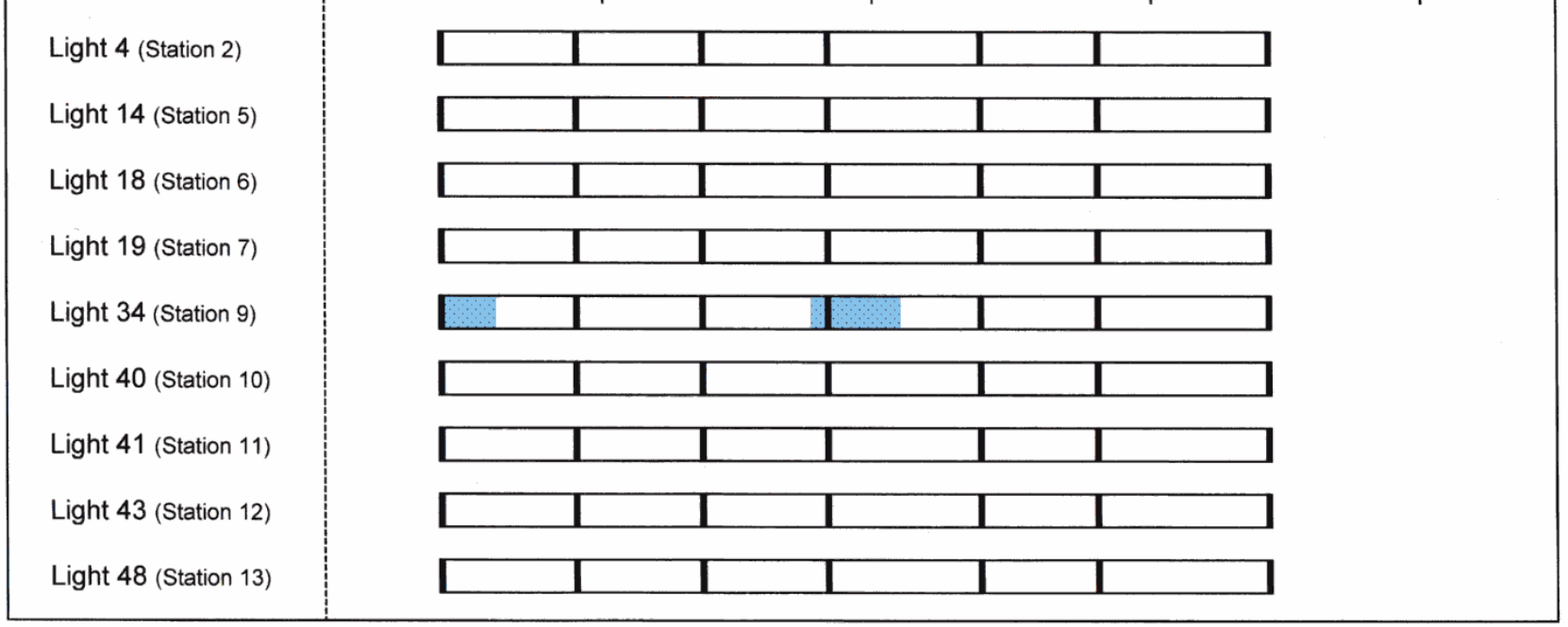
Incidence of Dissolved Oxygen below WQO
Surface Water 2000

Location	August	September	October	November	Dec.
Avg. BODu Load to DWSC (lb/day)	43,000	40,000	51,000 → 125,000 → 27,000		
Avg. Flow of SJR to DWSC (cfs)	770 → 1,350	1,300	1,900 → 600		
Light 4 (Station 2)					
Light 14 (Station 5)					
Light 18 (Station 6)					
Light 19 (Station 7)					
Light 34 (Station 9)					
Light 40 (Station 10)					
Light 41 (Station 11)					
Light 43 (Station 12)					
Light 48 (Station 13)					

	Monitoring Period and Sampling Event
	DO 0 to 0.5 mg/L below Water Quality Objective
	DO 0.5 to 1 mg/L below Water Quality Objective
	DO more than 1 mg/L below Water Quality Objective

Incidence of Dissolved Oxygen below WQO
Bottom Water 2000

Location	August	September	October	November	Dec.
Avg. BODu Load to DWSC (lb/day)	43,000	40,000	51,000 → 125,000 → 27,000		
Avg. Flow of SJR to DWSC (cfs)	770 → 1,350	1,300	1,900 → 600		



	Monitoring Period and Sampling Event
	DO 0 to 0.5 mg/L below Water Quality Objective
	DO 0.5 to 1 mg/L below Water Quality Objective
	DO more than 1 mg/L below Water Quality Objective

Oxygen Demand Constituents

C-BOD — Carbonaceous Biochemical Oxygen Demand

$$\text{Organic} + O_2 \xrightarrow{\textit{Bacteria}} CO_2 + H_2O \qquad \textit{Respiration}$$

N-BOD — Nitrogenous Biochemical Oxygen Demand

$$NH_3 + O_2 \xrightarrow{\textit{Bacteria}} NO_3^- \qquad \textit{Nitrification}$$

$$\text{Organic N} \xrightarrow{\textit{Bacteria}} NH_3 \qquad \textit{Ammonification}$$

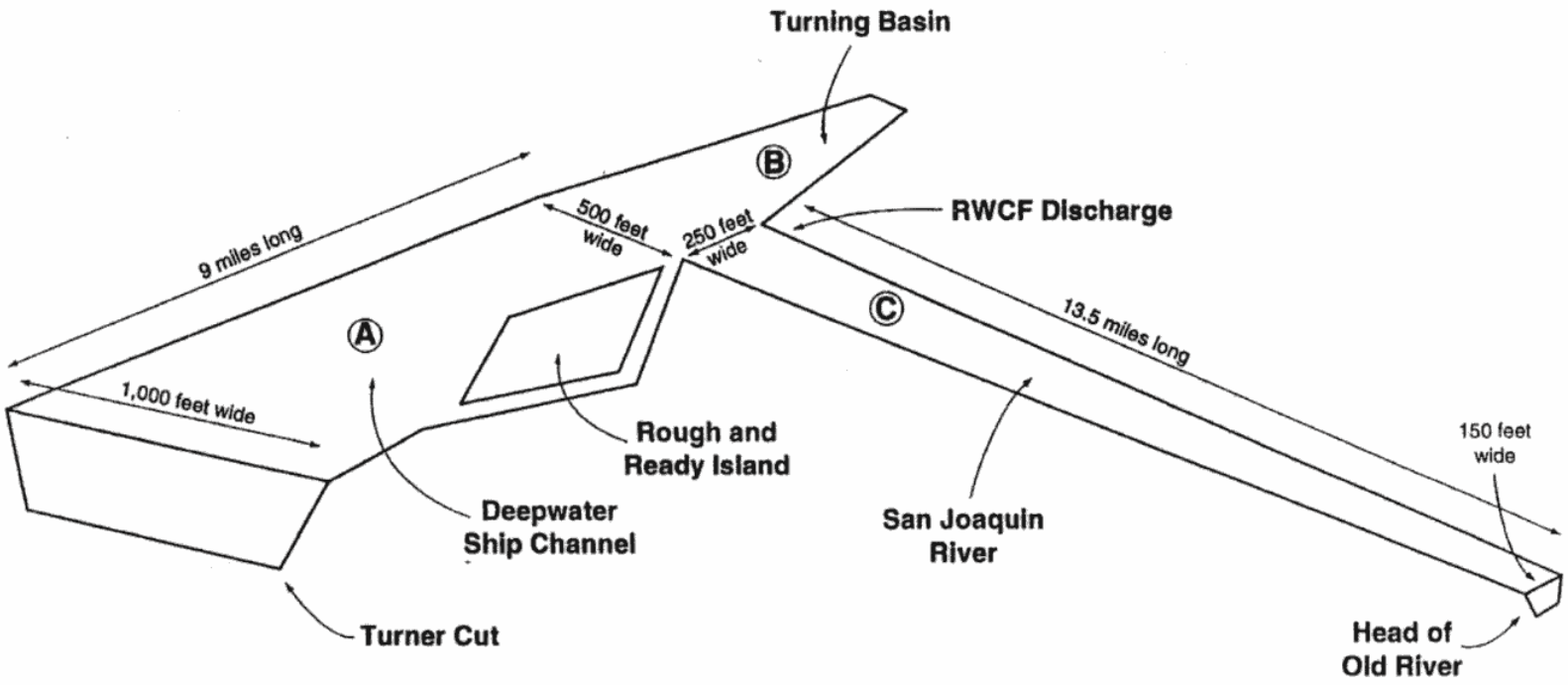
$$\text{Algae} \xrightarrow{\textit{Death}} + O_2 \longrightarrow CO_2 + H_2O \qquad \textit{Respiration}$$

SOD — Sediment Oxygen Demand

$$\text{Inorganic} + O_2 \xrightarrow{\text{Abiotic}} Fe_3^{+} + SO_4^{=}$$

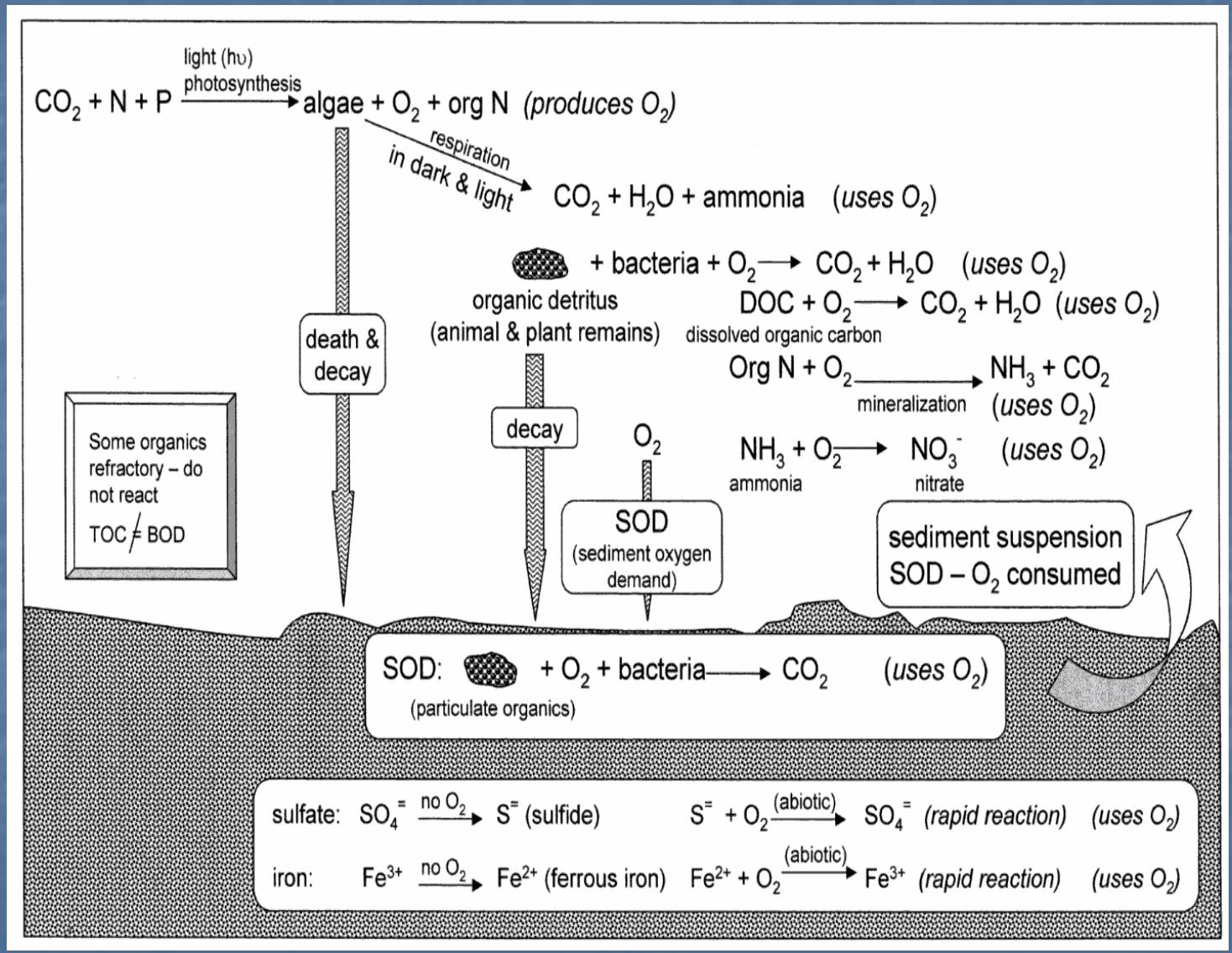
$$\text{Organic} + O_2 \xrightarrow{\text{Biotic}} CO_2 + H_2O$$

Characteristics of the Deep Water Ship Channel (DWSC)



from Jones & Stokes (1998)

Oxygen Demand Reactions and Processes



Nature of Low DO Problem
DWSC First 7 Miles

- DO Less Than Water Quality Objectives
  - Downstream of Port of Stockton
  - Summer, Fall, Some Winters
- Listed by CVRWQCB as CWA Section 303(d) “Impaired”
  - Requires Development of TMDL to Control DO WQO Violations
- Studies Started in 1999 with CALFED Support to Characterize Low DO Problem: Cause, Extent, Magnitude
- 2000 & 2001 Studies Included Upstream Sources of Oxygen Demand in SJR DWSC Watershed
  - > $4 million over 4 years
- Synthesis Report by Lee & Jones-Lee Spring 2003 and Supplements
  - Available from www.gfredlee.com

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

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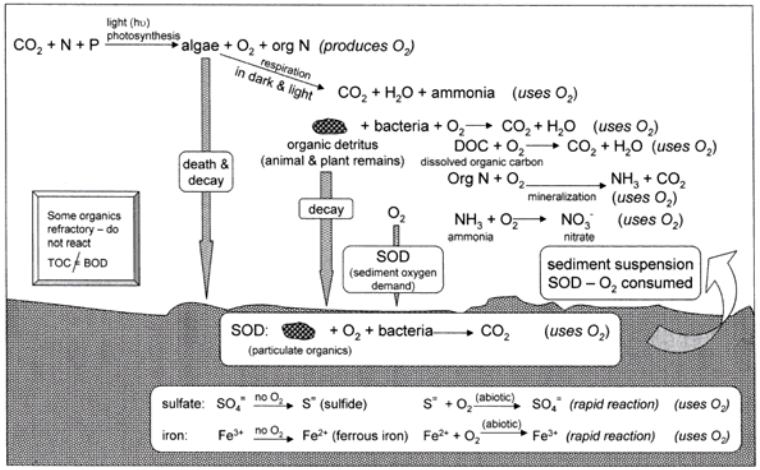


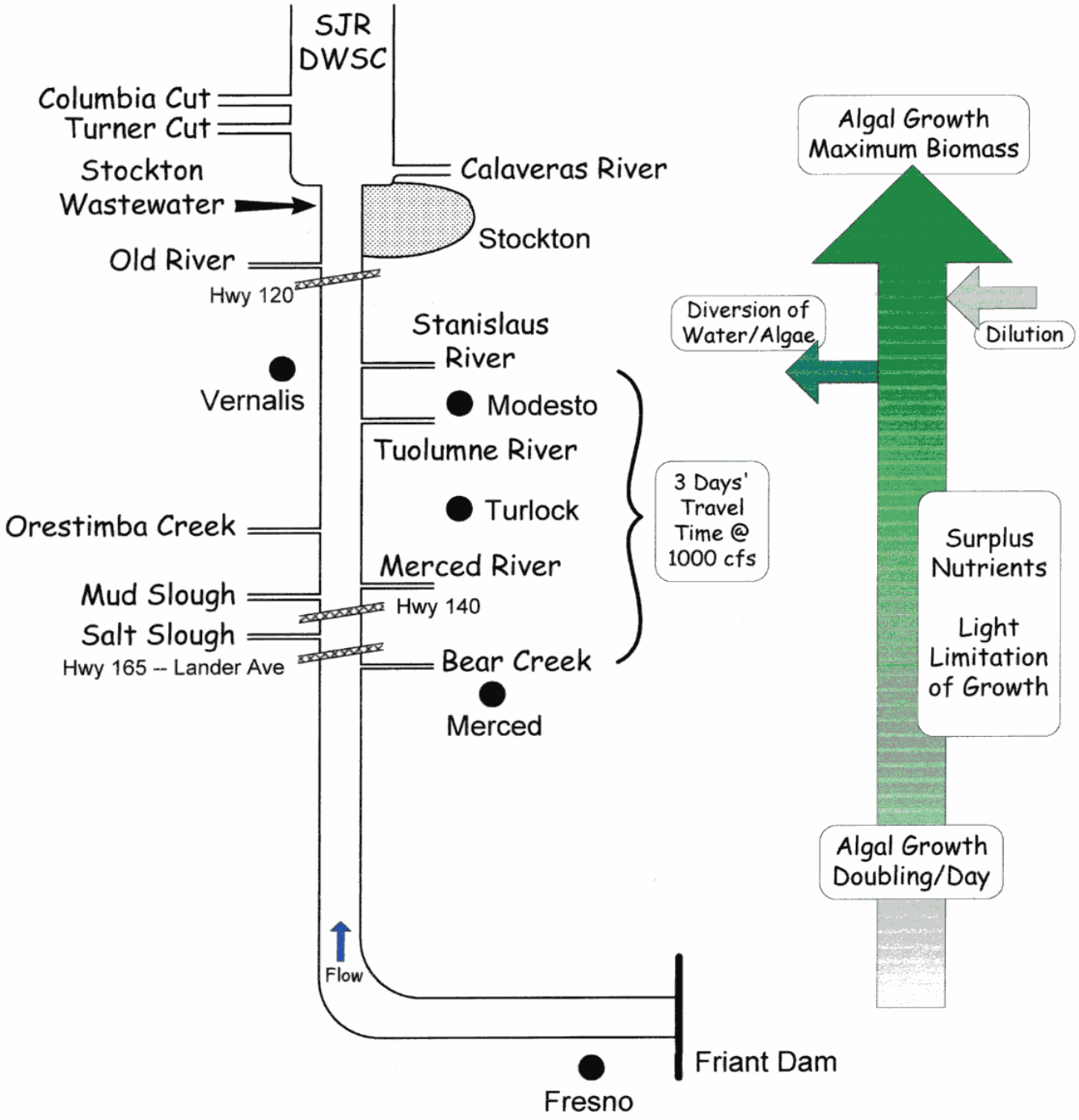
Conceptual Model of DO Depletion Reactions in the SJR DWSC

Report Submitted to
SJR DO TMDL Steering Committee/Technical Advisory Committee
and
CALFED Bay-Delta Program
March 2003

Nature of DWSC Low DO Problem

- Problem Only in First 7 Miles of DWSC Downstream of Port of Stockton
  - Downstream Extent Limited by State & Federal South Delta Water Export's Drawing Sacramento River Water to South Delta for Export
- Oxygen Demand Due Primarily to
  - Ammonia in Stockton Wastewater Discharge
    - Nitrification Reactions
  - Algae That Enter DWSC from Watershed, Die & Exert Oxygen Demand during Decomposition

Upstream Algal Oxygen Demand



Non Typical TMDL

- Typical TMDL Involves
  - Defining Sources of Pollutant Loads, and
  - Allocation of Responsibility for Control to the Dischargers of Pollutants
- SJR DWSC DO TMDL Has to Include Impact of
  - Altered SJR Geometry - Development of the DWSC
  - Altered DWSC Oxygen-Demand Assimilative Capacity - Hydromodification of the SJR

Allocation of Responsibility

- Who Has to Pay for Control?
- CVRWQCB – One-Third to Each:
  - Port of Stockton Deep Water Ship Channel
  - Reduced Flows in DWSC by Upstream Diversions
  - Oxygen Demand Loads
- Joint and Several Responsibility – All Are Equally Responsible
  - Work Out Control & Costs among Responsible Parties
- Dischargers Do Not Want to Have to Control Nutrients
  - Be Named Responsible Party
- Irrigation Districts - No SJR Flow/Diversion Alterations Required
  - Water Rights Issues

Impact of Development of DWSC on DO Problem

- SJR Upstream of DWSC
  - Same Algal Oxygen Demand Load/Concentration
  - No Low DO Problem
- DWSC Deeper Than Upstream SJR
  - SJR 8 – 12 ft; DWSC 35 ft
  - Greatly Slows Transport of Oxygen Demand through Channel
    - More Time for Oxygen Demand to Be Exerted
  - If DWSC Not Periodically Dredged, Channel Would Shoal-in
    - Low DO Problem Would Eventually Be Reduced/Eliminated
  - Primary Responsible Party for Low DO Problem
    - Port of Stockton and Those Who Benefit from Maintenance Dredging of DWSC

Nature of DWSC Low DO Problem

Oxygen Demand Constituents

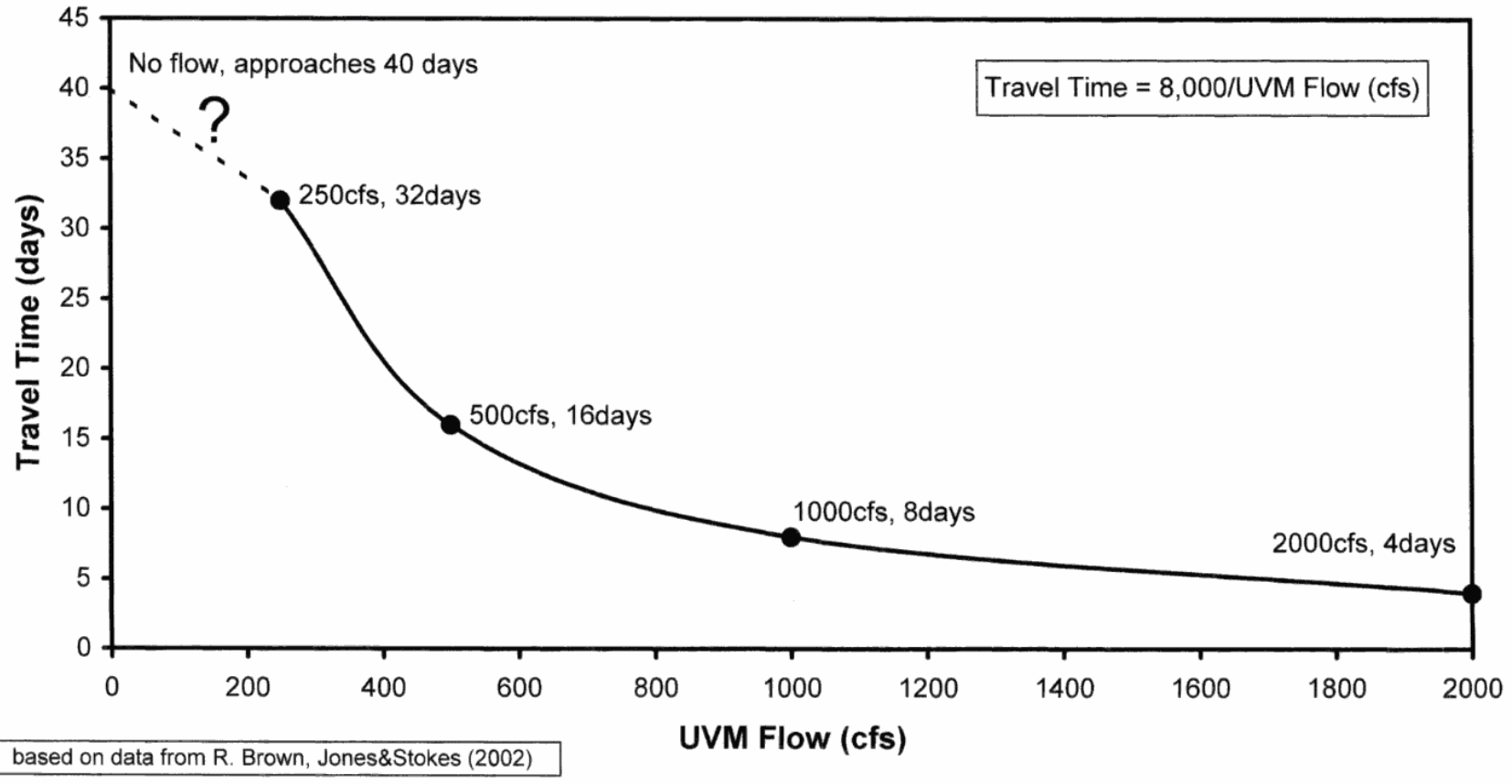
- City of Stockton Wastewater Ammonia
- Algae that Develop Upstream of DWSC

- Relative Significance of Each Source Depends on Flow of SJR through DWSC and Season,
  - Rarely Exceeded 50% of the DWSC Oxygen Demand Load
  - City of Stockton Ammonia Load Depends on Season and other Factors
  - Low SJR DWSC Flow - Low Algae & Possibly Higher Ammonia Loads

Impact of SJR DWSC Flow

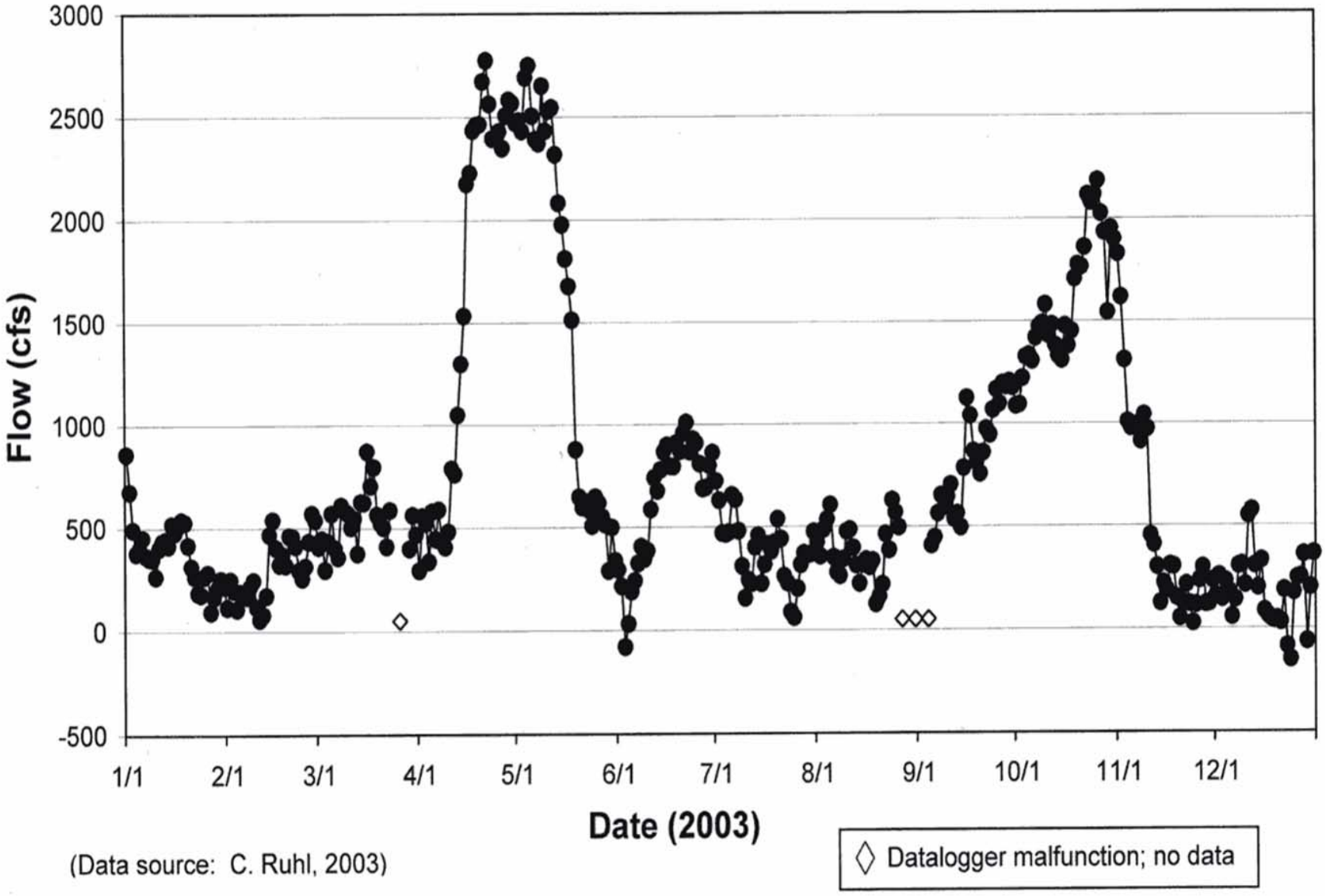
- At Higher SJR Flow through DWSC – No Low DO Problem
  - Travel Time of Oxygen Demand through DWSC Too Short for Appreciable Exertion of Oxygen Demand in DWSC
  - DWSC Water Mixes with Sacramento River Water Discharged into Turner Cut
    - Does Not Appear to Cause Low DO in Central Delta, Turner Cut, or Middle River – Needs Study

Travel Time: DWSC (Channel Point) to Turner Cut as a Function of SJR DWSC Flow



based on data from R. Brown, Jones&Stokes (2002)

SJR DWSC Flow 2003



(Data source: C. Ruhl, 2003)

Importance of SJR Flow Through the DWSC-

- SJR Flow through DWSC Variable:
  - Negative Flow (Upstream Flow) to Head of Old River to Several Thousand cfs Downstream
    - Depends on Upstream Diversions of SJR Water for Central Valley Irrigation & Domestic Water Supply for Southern CA and Bay Region
- Flow through DWSC >1500 cfs Can Eliminate or Greatly Reduce Magnitude of Low DO Problem
- If Substantial Amount of SJR Vernalis Flow Allowed to Pass through DWSC before Export to Central & Southern CA and Bay Area, Few or No Violations of DO WQOs

Oxygen Demand Sources

- City of Stockton Ammonia Discharge Problem
  - Will Be Greatly Reduced by Advanced Treatment for Ammonia Removal
  - Reduce Ammonia from Current 25 – 30 mg/L to 2 mg/L
    - 2 mg/L Ammonia Monthly Average Can Still Cause Low DO Problems in DWSC under Low-SJR-Flow Conditions
      - Need to Keep SJR DWSC Flows Elevated to Reduce Cost of Aeration to Control Oxygen Demand
- Algae as Source of Oxygen Demand – Difficult to Control
  - Algal Growth Driven by Nutrients from Agricultural Runoff & Discharges in Mud and Salt Slough Watersheds
  - May Not Be Economically Feasible to Significantly Reduce Algal Oxygen Demand Load
    - Must Be Evaluated after Salt Load Control Established

Phosphorus Control

- Typical Deterministic Modeling Predicts That Because of Large-Surplus of Algal-Available N and P, Small Reduction in N and/or P Loads/Concentrations Will Have No Impact on Oxygen Demand Load
- However, Rhine River and OECD Eutrophication Study Results Show That Reduced Phosphorus Loads to Waterbodies with Large Surplus of Available P Resulted in Reduced Algae Biomass and Improved Water Quality
- Impact of P Control Must be Evaluated as Part of Developing SJR DWSC Low DO Control Approach

Nutrient Control Issues

- N vs P, or Both
  - N/P Ratios – Great Surplus of N in SJR DWSC Watershed
    - Must Focus on Potential for P Control
- P Control Goal
  - Not Total Annual P Load
    - Much of P Load Does Not Impact DWSC Low-DO Problem
      - Short Hydraulic Residence Time
  - Focus on P Loads over Limited Periods of Time That Lead to Algae That Cause DO Concentrations < WQO
    - Summer & Fall
    - Most Important: P Loads Entering SJR & Tributaries at Greatest Distance from DWSC
      - Greatest Time for Algal Growth
    - Focus on P Loads That Develop Seed Algae That Lead to High Algal Loads in Upper SJR
      - Must Be Reliably Studied to Develop Credible TMDL

How to Proceed to Develop Nutrient Control Program Evaluation

- Current CBDA-Funded Upstream SJR Studies Do Not Adequately Address Issues of Concern
  - Funds Should be Reprogrammed to Develop Needed Information
- Appoint and Support Independent Advisory Panel to Guide Program Development, Implementation and Reporting
  - Panel Members Should Not be Dischargers, Irrigation Districts or Investigators
    - Avoid Conflict of Interest
  - Consider Both Technical Feasibility of P Control & Costs Associated with Various Degrees of P Control
    - Must Consider How Implementation of Salt TMDL will Impact Oxygen Demand Loads and SJR DWSC Flows

Deficiencies In SJR Oxygen Demand Modeling Effort

- While Deterministic Model May Be Tuned to a Data Set, Such a Tuned Model May Have Limited Predictive Capability for Altered Conditions
  - The Data Set upon Which HydroQual Model Being Tuned to Represent Algal Oxygen Demand in SJR Upstream of the DWSC, May Render Model of Limited Reliability for Conditions That Will Exist When the Salt TMDL Is Implemented
  - Dahlgren Studies on SJR Algal Dynamics (as Presented at SETAC Portland, OR Mtg) Show That the Data Base Developed in the 2000 and 2001 Studies Not Adequate to Develop a Potentially Reliable Model

Suggested Approach for Solving Low DO Problem in SJR DWSC

- Contact US Congressional Delegation in Delta Area
  - Obtain Federal Support for Control as Part of Mitigation of Impact of DWSC Maintenance Dredging on DO Problem
- Work with Those Responsible for Controlling Flow of SJR through DWSC to Maximize Minimum Flow through DWSC
  - Current SJRWQMG and DIP Approaches Not Adequately Addressing This Issue
- Evaluate Potential to Control Sources of Nutrients That Develop into Seed Algae That Cause High Oxygen Demand Loads Discharged by Mud & Salt Sloughs to SJR
- Evaluate Feasibility of Controlling DO Depletion by Aeration
  - Need to Evaluate Possible Secondary Impacts of Aeration & Other Control Approaches – Fish Gas Bubble Disease

Control of Low DO Problem by Aeration of DWSC

- Aeration Can Eliminate Low DO Problem
  - Difficult & Expensive
    - CALFED/CBDA Has $30million to Help Solve the Low DO Problem
    - Need Funding for Operation & Maintenance, Forever
  - Should Work toward
    - Increasing SJR DWSC Flows
    - Eliminating Flow Variability to the Maximum Extent Possible
    - Reducing Oxygen Demand Loads to Reduce the Amount of Money Needed for Aeration

DO Water Quality Objectives & Issues

- 5 mg/L December 1 – August 31
  - US EPA National Criterion
- 6 mg/L September 1 – November 30
  - Block Chinook Salmon Homing – Need Studies to Verify
- DO WQO Applicable at Any Time, Any Place
  - No Averaging (Daily, with Depth)
    - DO Varies as Much as 6 mg/L over Diel Cycle
    - DO near Bottom Typically 1 – 2 mg/L Lower
  - Only 1 DO WQO Violation Allowed Every 3 Yrs
    - Difficult to Achieve
    - Requires Comprehensive DWSC Monitoring Program
      - Currently Proposed Monitoring Not Adequate

Ultimate Control Approaches Depend on Variety of Factors/Policies

- Water Rights Issues
  - Restoration of Flows, Which Causes Water Quality Problem, Allowed in CWA
    - More Than Just meeting SJR Excessive Salt Problem
- Not Being Named Responsible Party
  - Sources of Nutrients Loads That Lead to Algal Oxygen Demand Need to Be Identified & Where Possible, Controlled to Maximum Extent Economical Possible
- SJR Watershed Salt TMDL
  - Upstream SJR Salt Control will Need to be More than Just Meeting 700 µmhos/cm at Vernalis to Protect Agricultural Interests in the South Delta
    - Will Need More SJR Watershed Salt Control Than Being Discussed by SJRWQMG

Problems with Aeration-Only Control

- Turn the SJR DWSC into Treatment Plant for Upstream Oxygen Demand Loads
  - Rapidly Expanding Urban Populations in DWSC Watershed
    - Add Additional Oxygen Demand Loads
    - Increased Water Diversions

Control of Low DO Problem

- Ultimately, Control of the SJR DWSC Low DO Problem Will Likely Determined by Courts
- Role of Technical Information May Be of Limited Importance
  - Often, TMDL Allocation of Responsibility Not Technically Valid
    - Controlled by Politics and Other Factors

Effect of Implementation of Other TMDLs

- Could Greatly Impact Low DO Problem
  - Salt TMDL Implementation Will Likely Greatly Alter Oxygen Demand Loads and Impact Low DO Problem
    - Control of Salt from Mud and Salt Sloughs Will Impact Oxygen Demand (Algae) Discharges to Upstream SJR
      - Will Also Impact SJR DWSC Flows
      - SJR Watershed and Delta TMDLs Could Impact Low DO Problem Management
      - In Accord with HR 2828 CBDA DIP, Attempts to Increase Exports to 8,500 cfs at Banks Will Require Developing Program to Eliminate Water Quality Objective Violations in the Delta
        - This Will Likely Impact Low DO Problem Solution
- Solving the Water Quality and Water Level Problems in the South Delta Will Impact the Solution of the Low DO Problem in the SJR DWSC

Overview of Sacramento-San Joaquin River Delta Water Quality Issues

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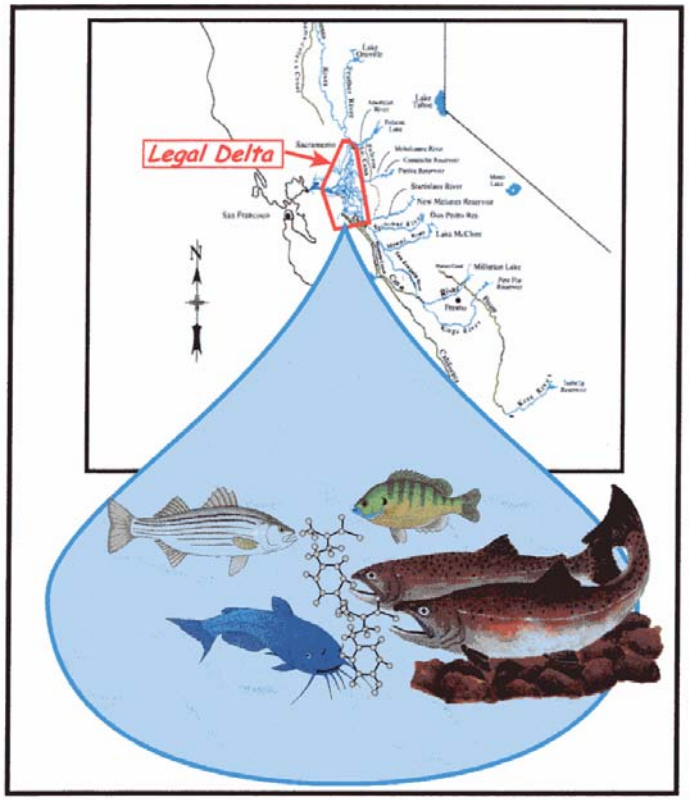

Adapted in part from images in SJRGA (2000)

June 22, 2004

Available on the internet at:
http://www.members.aol.com/apple27298/Delta-WQ-IssuesRpt.pdf

Impact of Export Projects on Water Quality Problems in the DWSC

- Export of South Delta Water by State and Federal Export Projects Is Impacting Water Quality in South and Central Delta
  - Impacting Several Delta TMDLs
  - Will Need to Be Corrected in Accord with HR 2828

Current Investigative Efforts Not Adequate to Meet Information Needs

Issues That Need More Comprehensive Attention:

- SJRWQMG Approach to Controlling Violations of Salt TMDL – Too Limited in Scope
  - Need to Establish EC Objective at SJR Vernalis to Protect Interests of South Delta Irrigated Agriculture
    - 700 μmhos/cm at Vernalis Not Protective of South Delta Ag
    - Will Lead to Violations of EC WQO in South Delta
  - Should Also Consider Impact of Salt & Flow Control on Control of TOC/DOC and Nutrients in SJR Watershed
  - Recirculation of DMC Water to SJR
    - Limited by Pumping Capacity
    - Has Potential Impacts on Fisheries
      - Will Recirculation Lead to New or Enhanced SJR Water Quality Problems/Toxicity?

Current Investigative Efforts Not Adequate to Meet Information Needs

Issues That Need More Comprehensive Attention:

- Must Address Low Water Level & Water Quality Problems in South Delta as Part of Proposed Changes in SJR Flows to Meet TMDL WQOs for Salt
  - DWR Should More Adequately Evaluate Low-Head Reverse-Flow Pumping across South Delta Permanent Barriers
- Should Not Assume That DIP Can Be Implemented to Allow Banks to Export 8,500 cfs as Part of TMDL for Solving Salt Problem in SJR
  - Existing South Delta WQOs/TMDLs Will Be Impacted by Increased Banks Exports
- Should Not Assume That Release of New Melones Water Can Be Changed as Result of Changing DO WQO for Part of Stanislaus River

Current Investigative Efforts Not Adequate to Meet Information Needs

Issues That Need More Comprehensive Attention:

- City of Stockton Wastewater Ammonia Discharges
  - 2 mg/L Monthly Average
  - Can Lead to Violations of DO WQO When SJR DWSC Flow Low
- SWRCB Proposed D1641 Review
  - Scope Too Limited to Address Impact of SJR Flow Diversions on Water Quality Problems in Delta
- DWR SDIP Must Adequately Address Full Range of Water Quality Problems in South Delta and DWSC
- Impact of SJR DWSC Flow on Other Upper DWSC Water Quality Problems Caused by Stockton
  - Must Provide Adequate SJR DWSC Flow for Initial Dilution & Rapid Transport to Turner Cut for Further Dilution by Sacramento River Water

Current Investigative Efforts Not Adequate to Meet Information Needs

Issues That Need More Comprehensive Attention:

- Potential for Aeration with Pure Oxygen to Cause Gas Bubble Disease in Fish
- Proposed DWSC Monitoring of Aeration Inadequate to Detect WQO Violations
- Impact of SJR Flow Diversions on Chemical Signals That Impact Homing or Straying of Chinook Salmon
- Discharges of TOC/DOC from Refuges/Duck Clubs as Influenced by Implementation of Salt TMDL
- Impact of Friant Dam Releases on Flows & Water Quality in SJR at Vernalis

Failure to Adequately & Reliably Address These Issues Could Lead to Litigation That Will Prevent Implementation of SJR DWSC DO TMDL & DWSC Watershed Water Quality Improvements

Further Information

Consult Website of
Drs. G. Fred Lee and Anne Jones-Lee

http://www.gfredlee.com

www.gfredlee.com

Publications on:

- Landfills-Groundwater Quality
- Surface Water Quality
- Hazardous Chemical Sites
- Mine Waste Impacts
- Contaminated Sediment
- Domestic Water Supply
- Excessive Fertilization
- Reclaimed Wastewater
- Watershed Studies San Joaquin River Watershed & Delta
- Stormwater Newsletter

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