Ecosystem Restoration Program Independent Review Panel

The San Joaquin River Stockton Deep Water Ship Channel
Dissolved Oxygen Total Maximum Daily Load - WARMF and Link-Node Models

Charge to Panel Document

BACKGROUND

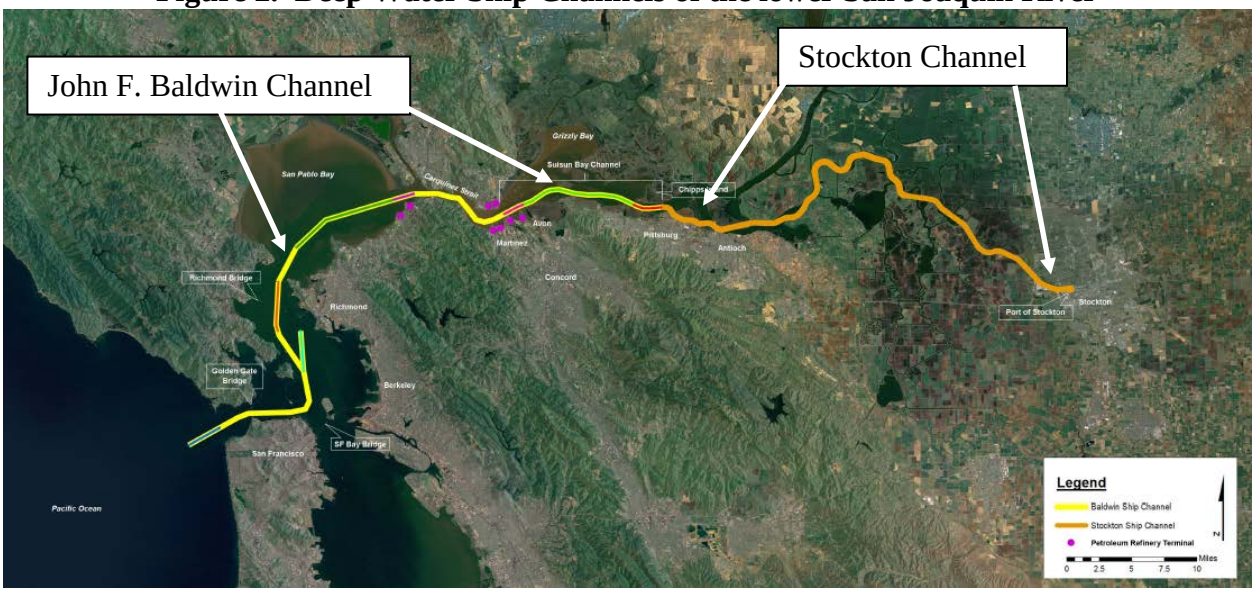
San Joaquin River Watershed

The San Joaquin River is the largest river in Central California. The 366-mile long river starts in the high Sierra Nevada mountain range and travels northwest through the San Joaquin Valley where it meets the Sacramento River at the Sacramento-San Joaquin Delta and then flows out toward the Pacific Ocean (Figure 1). The San Joaquin River is relatively shallow (~8-15 feet) upstream of the City of Stockton. Starting at Stockton and heading west to San Francisco Bay, the river has been dredged and forms the Stockton Deep Water Ship Channel (DWSC; Figure 2).

Figure 1. San Joaquin River Watershed

The Stockton DWSC is a navigation channel used by ocean going cargo vessels to transport goods to and from the Port of Stockton. It begins at Stockton and heads westward where it merges with the John F. Baldwin Channel near Antioch (Figure 2). Depths in the DWSC can vary between 35-45 feet depending on location.

Figure 2. Deep Water Ship Channels of the lower San Joaquin River



Dissolved Oxygen Impairment

Historically, the lower San Joaquin River in the first 14 miles of the Stockton DWSC experienced regular periods of low dissolved oxygen (DO) concentrations from the City of Stockton to Disappointment Slough (Figure 3). More recently with upgrades to the City of Stockton's wastewater treatment plant, the impairment now occurs only within the first 7 miles of the DWSC from the City of Stockton downstream to Turner Cut. The location where the DO depression is greatest is downstream of Stockton next to Rough and Ready Island.

The low DO conditions in the Stockton DWSC often violate the DO water quality objectives. The objectives are contained in the *Water Quality Control Plan for the Sacramento River Basin and the San Joaquin River Basin* (Basin Plan, Fourth edition - 1998). There are two parts to the Basin Plan DO objectives that apply to the lower San Joaquin River. The first part of the objective is 5.0 milligrams per liter (mg/L) at all times in the river within the Delta (excluding the section of the river west of the Antioch Bridge). The second part of the objective is a site specific objective of 6.0 mg/L, applied only in the fall from 01 September to 30 November to the stretch of river from Stockton downstream to Turner Cut.

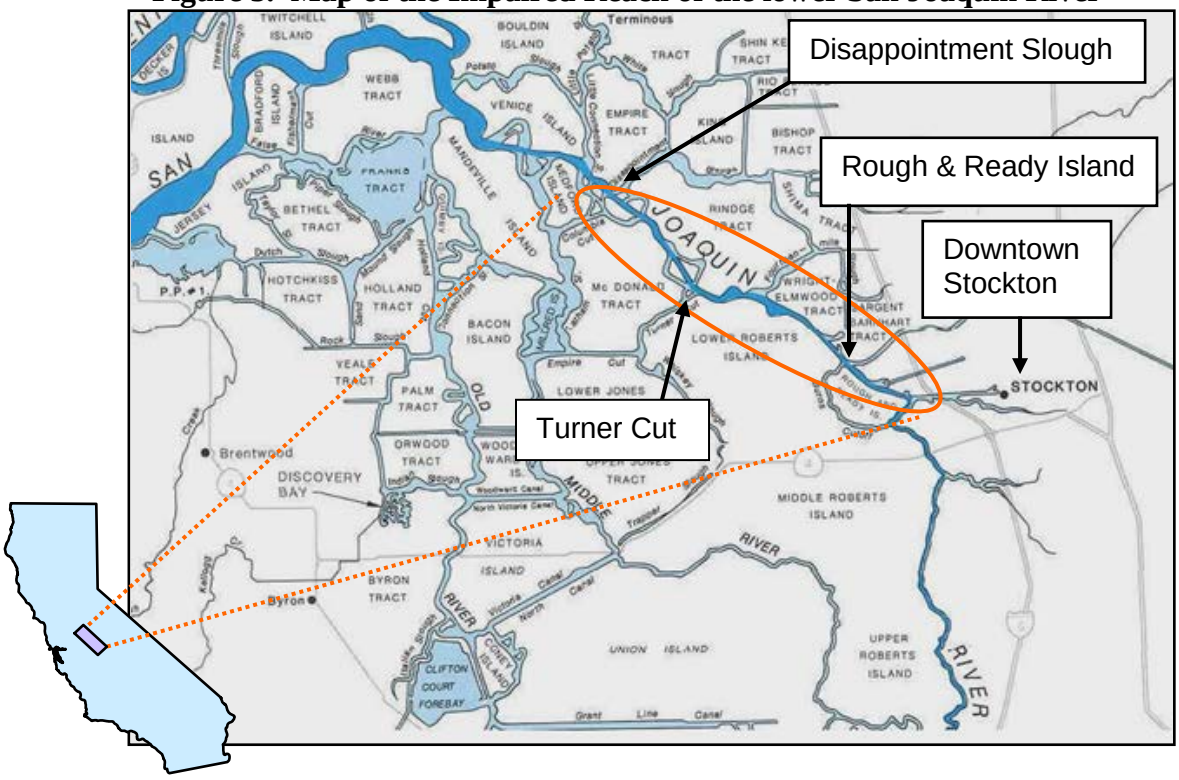
TMDL Control Program

In January 1998, the State Water Resources Control Board first adopted a Clean Water Act Section 303(d) list that identified the low DO impairment and ranked it as a high priority for correction. This initiated the need for the Central Valley Regional Water Quality Control Board

(Central Valley Water Board) to develop a Total Maximum Daily Load (TMDL) to identify the factors contributing to the impairment and apportion responsibility for correcting the problem. In January 2005, the Central Valley Water Board adopted a TMDL that identified three contributing factors:

- Loads of oxygen demanding substances from upstream sources and from the City of Stockton Wastewater Treatment Plant
- Geometry of the DWSC
- Reduced flow through the DWSC

Figure 3. Map of the Impaired Reach of the lower San Joaquin River

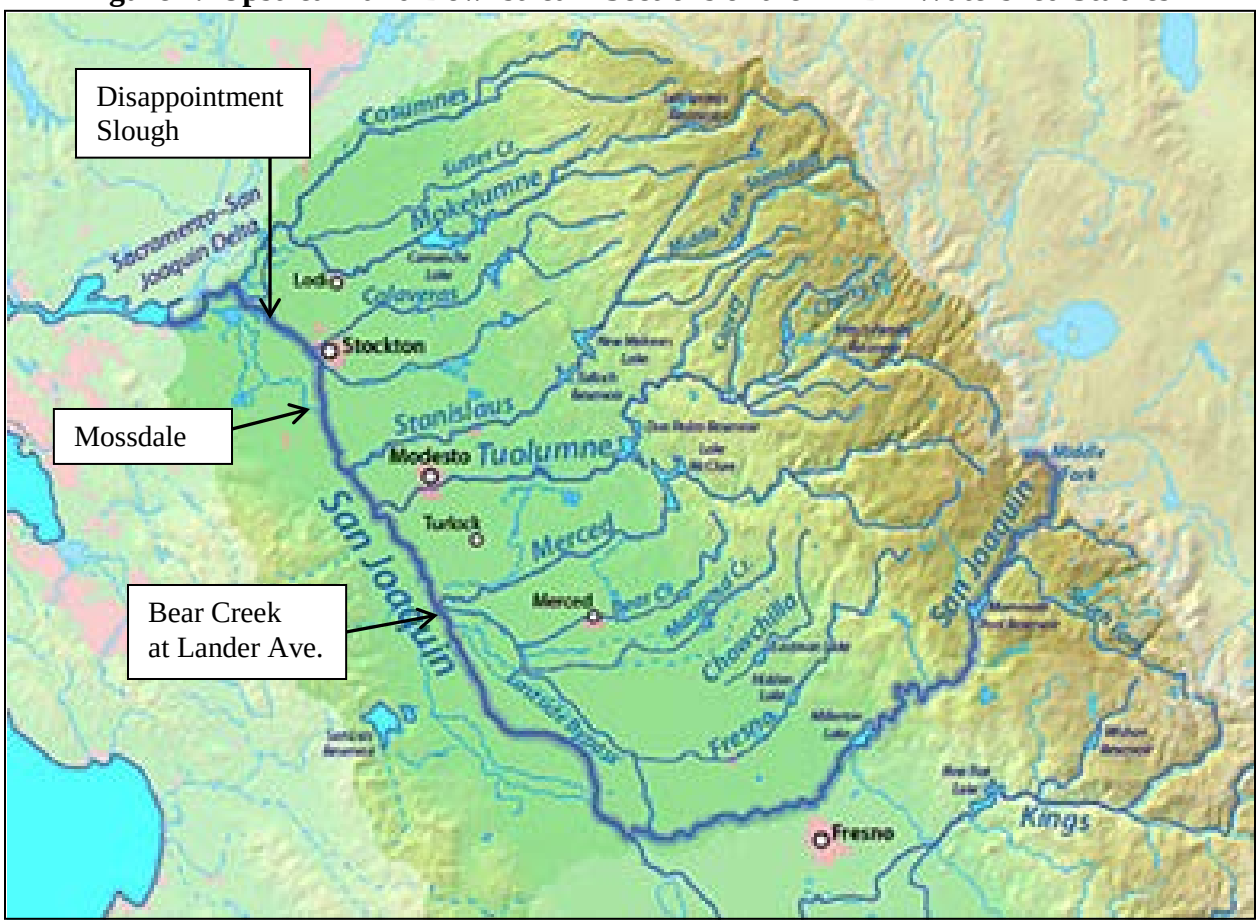


The TMDL recognized that more studies were necessary to better understand the sources, transport and fate of the oxygen demanding substances from the upstream watershed, and the downstream impacts once these substances were transported into the DWSC. The first of these studies were initiated in 2005 and the final studies were completed in 2012.

TMDL Control Program Studies

For the TMDL studies, the San Joaquin River watershed was broken down into two sections – the upstream, riverine watershed from Mossdale to its confluence with Bear Creek at Lander Avenue, and the downstream, estuarine watershed from Mossdale to Disappointment Slough (Figure 4). The watershed upstream of Mossdale is non-tidal, while the downstream portion is tidally-influenced.

Figure 4. Upstream and Downstream Sections of the TMDL Watershed Studies



The upstream studies focused on measuring all major and most minor non-point source discharges to the San Joaquin River, identifying and quantifying oxygen demanding substances and their precursors and developing a water quality model (WARMF) to describe their fate and transport from the upper basin to Mossdale. This included a description of changes in algal biomass as it moved down river.

The downstream studies focused on collecting and analyzing data on the sources of nutrients, phytoplankton, and oxygen-consuming materials, and developing a water quality model (Link-Node) describing how the decay of all oxidizable material influenced DO concentrations in the tidal river between Mossdale and Disappointment Slough.

TMDL Models – WARMF and Link-Node

Two models for the watershed have been developed as part of the DO TMDL – the Watershed Analysis Risk Management Framework (WARMF) Model and the Link-Node Model.

The WARMF[1] model is a US EPA supported model that was developed as a decision support system for watershed management. The scientific underpinnings of the model have undergone several peer reviews by independent experts under US EPA guidelines and the model has been used by the States as a tool to calculate TMDLs for most conventional pollutants (e.g., nutrients, BOD, and TSS coliform). The WARMF model is a GIS-based watershed model that calculates daily runoff, shallow ground water flow, hydrology, and water quality of a river basin.

Link-Node hydrodynamic models have been used in the Bay-Delta since the 1960's. A link-node model was first developed and used by the Water Resources Engineers and the California Department of Water Resources for the San Francisco Bay-Delta in the late 1960's. In 1983, the Sacramento District of the U.S. Army Corps of Engineers used a link-node model to determine the effects on water quality from deepening the Stockton DWSC. In 1993, Systech Water Resources, Inc. developed a Link-Node model for the City of Stockton to assist them in developing their National Pollutant Discharge Elimination System (NPDES) permit renewal for the Central Valley Water Board. Since then, Systech has continually refined the model for TMDL purposes to track and output the daily fluxes of various processes that contribute to the sink or source of DO in the DWSC.

One of the primary goals of completing the watershed studies was to develop a unified water quality model encompassing the San Joaquin River from its confluence with Bear Creek to Disappointment Slough. The unified model is the integration of the WARMF model and Link-Node model. The vision was that this fully integrated model would be useful for managing the DO TMDL and in reevaluating TMDL loads and waste load allocations. In addition, the Regional Board is hoping to use the integrated model to forecast periods of time when the DO would be less than DO objectives so as to inform aeration operations, and to ascertain the effects on DO concentrations with proposed future channel deepening projects or potential changes in river flow.

Independent Review Panel Charge

The upstream and downstream studies represent five years' worth of data collection in the San Joaquin River. Thus, the purpose of this independent scientific review is to examine the integrated model that was created from both the upstream and downstream studies, and evaluate if it is scientifically sound and robust enough to be used in managing the DO TMDL control program.

The Central Valley Water Board staff would like to know from the independent review panel (Panel) if the integrated model is sufficient to answer specific questions related to loads, assimilative capacity, future alterations to the geometry of the channel, and flow through it. It is also important to Regional Board staff that the Panelevaluate the validity of using a single compliance point in the DWSC to represent oxygen concentrations throughout the channel, and using the model to forecast periods of excursion from the DO objective to inform aeration operations. Detailed questions are in the next section.

[1] More information on the WARMF model can be found on US EPA's website: http://www.epa.gov/athens/wwqtsc/html/warmf.html

QUESTIONS

I. San Joaquin River DO TMDL Model (WARMF/Link-Node): Development, Assumptions, Calibration, and Error

The integrated San Joaquin River DO TMDL Model (integrated model) is composed of both the upstream, non-tidal WARMF model and the downstream, estuarine, tidally-influenced Link-Node Model. This integrated model will be used by the Central Valley Water Board for four main purposes – 1) Better understand the factors that control DO concentrations in the DWSC, 2) Develop final TMDL load and waste load allocations for responsible parties, 3) Determine if the model can be used to improve the operations plan for the Aeration Facility at Rough & Ready Island, and 4) Use the model to understand changes in DWSC DO concentrations caused from specific actions such as the BDCP[2] that will change flow through the channel, US Army Corp deepening the channel , and implementation of best management practices in the upstream watershed.

Questions for Panel:

a) Discuss the scientific basis for the integrated model. Has the model identified all the major potential sources of oxidizable material in the basin and the processes responsible for its fate and transport into the DWSC?

b) Discuss whether in the future the model can be used to calculate changes in the assimilative capacity of the DWSC as a result of changes in flow, channel morphology, location and operation of the aeration facility, and loads from population growth.

II. Apportioning Responsibility

A key finding of the TMDL studies is that the upstream watersheds contribute to low DO in the Stockton DWSC by exporting oxidizable material, including algae, to the estuarine San Joaquin River. Some of this organic material decays as it is transported down river through the DWSC. In addition, downstream monitoring has assessed the organic load from the Stockton urban sloughs and from the Stockton Wastewater Treatment Plant (WWTP) to the DWSC. The other factor contributing to low DO is the dredging of the San Joaquin River in the DWSC, which increases retention time and decreases reaeration per unit volume. The integrated model has been used to calculate the fraction of DO depletion contributed by all responsible parties above the assimilative capacity of the DWSC. This fraction is important as it may be used to assign responsibility for funding the operation and maintenance of the aeration device and implementation of best management practices to reduce loading.

Questions for Panel:

a. Discuss whether the upstream monitoring and the integrated model have accurately characterized the relative contribution of oxidizable loads from each sub watershed to the downstream DWSC DO problem.

[2] DWR's Bay-Delta Conservation Plan proposes to install new water intakes in the Sacramento River which will require less reliance on the Delta pumping plants. This project will change how water flows down the San Joaquin River and through the DWSC.

b. Discuss whether the model accurately represents the effect of DWSC channel deepening on DO concentration.
c. In 2002, an Independent Review Panel for the original TMDL concluded that algal concentrations entering the DWSC could not be effectively controlled by nutrient reductions in the upper San Joaquin Basin because the nutrient concentrations were too high. Does this Panel still agree with that assessment?
d. Discuss whether it is appropriate to use the estimates of DO depletion from these sources as a basis for calculating the relative responsibility of all parties to fund aeration?

III. TMDL Compliance Point(s)

The final TMDL will require a telemetered compliance point(s). The purpose of the compliance point(s) would be to mandate collection of the water quality information needed to run the integrated model and predict the amount of aeration needed to meet the water quality objective. A water quality monitoring station was established in 1983 at the western end of Rough & Ready Island to measure water quality parameters[3] such as temperature, pH, DO, chl-a, and turbidity. This monitoring station is located in the section of the channel where the lowest DO concentrations have historically been observed (aside from the Turning Basin). Since 2008, two additional DO sondes have been added to the station. The original DO sonde was located 1-meter below the surface and the new sondes are at 3-meters and 6-meters. In addition, since 1983 DWR has conducted twice monthly boat cruises usually between June and November along the length of the channel (Antioch to the Turning Basin) and measured oxygen concentrations at 1 meter below the surface and 1 meter off the bottom. The demonstration project for the Aeration Facility and DWR's boat cruises have demonstrated that some locations in the DWSC, including the Turning Basin, do not meet the water quality objective even under aeration.

Questions for Panel:

a. Discuss whether Rough and Ready Island is a suitable compliance point. Is the monitoring being conducted at Rough and Ready Island in combination with model output predictive of the amount of oxygen needed from the aeration device to ensure that the DO objective is met throughout the DWSC?
b. What modifications in the location and size of the aeration facilities might be made to ensure that the entire DWSC is in compliance with the water quality objective?

IV. TMDL Margin of Safety

The final TMDL will require a margin of safety to ensure that the DWSC will not be impaired for fish migration after implementation of the TMDL and load allocations. The Margin of Safety may be accounted for explicitly as a part of load allocations, or it may be included implicitly in the assumptions of the TMDL process.

Questions for Panel:

[3] Parameters measured at RRI site include: River Stage, Flow, Velocity, Air Temperature, Wind Speed, Wind Direction, Electrical Conductivity, Chl-a, pH, Water Temperature, Turbidity, Dissolved Oxygen, and Solar Radiation.

a. Is the previously calculated Margin of Safety[4] appropriate for a TMDL and load allocation calculated with the Link-Node and WARMF models?
b. How do modeling errors relate to errors in TMDL and load allocation? Would errors in load allocations lead to non-attainment of water quality criteria?
c. What are other sources of error and implicit components of Margin of Safety?

V. Using the Model

The TMDL assigned load and waste load allocations to parties responsible for contributing oxygen demanding substances. The City of Stockton WWTP was assigned a 30% waste load allocation. Since adoption of the TMDL the City of Stockton has upgraded its facility to include advanced nitrification. The model was used by the contractors to determine if the City of Stockton is meeting its waste load allocation.

Question for Panel:

a. Should discharge data or model simulations be used to determine of the City of Stockton is meeting its waste load allocation?

b. If modeling is to be used to assess compliance with the load allocation, discuss whether the model results are scientifically robust and accurately assess the impact of the City of Stockton WWTP discharge.

c. Discuss the limitations of the Integrated Model. What should it not be used for?

VI. Predicting Blue-Green Algae in South Delta

Blue-green algae blooms have been documented to periodically occur in the Delta since 1999 and recent research indicates that the blooms may be originating in the San Joaquin River (Central Delta) between June and September. Ambient microcystin concentrations during bloom conditions may impact the growth and survival of zooplankton and fish in the estuary and could contribute to the pelagic organism decline by reducing the amount of high quality food at the base of the food chain. Data was to be collected to assess the abundance and distribution of blue green algae and their toxins in the south delta, but blue-green algae are not explicitly simulated by the model.

Question for Panel:

a. Discuss the limitations of the integrated model's simplified representation of phytoplankton and whether additional measures should be taken to consider the impact of blue-green algae on the TMDL and load allocations.

[4] All TMDLs require a MOS term in order to be legal. There are several ways we might calculate MOS here. For a start everyone might review the 2004 staff report on page 38 where MOS is defined. http://www.waterboards.ca.gov/centralvalley/water_issues/tmdl/central_valley_projects/san_joaquin_oxygen/12-2004_draft_basin_plan_amendment/dec_draft_final_staff_rpt.pdf.

REFERENCE MATERIAL

The Panel will use available information for its review of the models, including the following listed materials:

REQUIRED READING

1) 2005 Staff Report and Basin Plan Amendment and Control Program for the San Joaquin River DO TMDL. 104 p. Chapters 1, 2, and 4 (http://www.waterboards.ca.gov/centralvalley/water_issues/tmdl/central_valley_projects/san_joaquin_oxygen/final_staff_report/do_tmdl_final_draft.pdf)
2) Draft San Joaquin River DO TMDL Studies Report, July 2013 (Downstream Studies report)
3) Final Report Stockton Deep Water Ship Channel Demonstration Dissolved Oxygen Aeration Facility Project. 2010. 144 p. http://baydeltaoffice.water.ca.gov/sdb/af/docs/Stockton%20DWSC%20DO%20AF%20Final%20December%202010.pdf

ADDITIONAL REFERENCE MATERIAL

1) 2005 Staff Report and Basin Plan Amendment and Control Program for the San Joaquin River DO TMDL. 104 p. Remaining Chapters (http://www.waterboards.ca.gov/centralvalley/water_issues/tmdl/central_valley_projects/san_joaquin_oxygen/final_staff_report/do_tmdl_final_draft.pdf)
1) Stockton Deep Water Ship Channel Operations Report. 2008.84 p. http://baydeltaoffice.water.ca.gov/sdb/af/docs/2008%20Operations%20Performance%20Report.pdf
2) Stockton Deep Water Ship Channel Operations Report. 2008. Appendix A. *San Carlos* DO Surveys and the DWSC Dissolved Oxygen Model. 42 p. http://baydeltaoffice.water.ca.gov/sdb/af/docs/2008%20Operations%20Performance%20Report%20Appendix%20A.pdf
3) Stockton Deep Water Ship Channel Operations Report. 2008. Appendix B. Monitoring of the Aeration Facility Effects and Calculated DO Increments in the Stockton DWSC. 56p. http://baydeltaoffice.water.ca.gov/sdb/af/docs/2008%20Operations%20Performance%20Report%20Appendix%20B.pdf
4) Effects of the Head of Old River Barrier on Flow and Water Quality in the San Joaquin River and Stockton DWSC. 2010. 65 p. http://baydeltaoffice.water.ca.gov/sdb/af/docs/HORB_Report_Final_3-17-2010.pdf
5) Synthesis and Discussion of Findings on the Cause and Factors Influencing Low DO in the San Joaquin River Deep Water Ship Channel Near Stockton, CA. 2003. G. Fred Lee and Associates, El Macero, CA. http://cdm16658.contentdm.oclc.org/cdm/singleitem/collection/p267501ccp2/id/1374/rec/11
6) The User's Manual for the WARMF Model
7) The User's Manual for the Link-Node Model

TIMELINE

Early Sept 9-10: Project Workshop

Day 1 Morning: The Panel convenes at UC Davis and receives presentations from the Project Team and other appropriate individuals.

Day 1 Afternoon: The Panel convenes at UC Davis to discuss the Model, review the charge, identify work assignments, and start review of model and underlying documentation.

Day 2 Morning: Panel convenes at UC Davis to begin synthesizing review with goal of developing a peer review outline.

Day 2 Early Afternoon: Panel reports out initial findings, asks final questions.

Mid-Sept to Early October (5 weeks): The Panel continues review of the material and response to questions. The Panel will communicate via email and phone as needed.

Early to mid-October: The Panel provides report.

PANEL MEMBERSHIP

The Independent Review Panel consists of five (5) scientists and engineers who together cover the breadth of relevant issues needed to ensure a thorough evaluation of the models and their use. The members were selected for their expertise and reputation in freshwater and estuarine phycology, water quality modeling, estuarine hydrodynamics, nutrients, and local hydrodynamics. Panel members were screened for conflict of interest and bias to ensure a balanced and objective review.