CALIFORNIA
BAY-DELTA
AUTHORITY

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Agenda Item: 14A
Meeting Date: June 9, 2005

CONSIDERATION OF A RESOLUTION RECOMMENDING TO THE DEPARTMENT OF WATER RESOURCES THAT IT PROCEED TO AWARD A CONTRACT TO CONSTRUCT AN AERATION DEMONSTRATION PROJECT TO IMPROVE LOW DISSOLVED OXYGEN LEVELS IN THE STOCKTON DEEP WATER SHIP CHANNEL

Summary: The California Department of Water Resources (DWR) is proposing to seek contractors that can construct an aeration demonstration project as a way to improve low dissolved oxygen levels in the Stockton Deep Water Ship Channel. This demonstration project has been designed by DWR based on recommendations from technical and scientific advice and stakeholder input.

Recommended Action: The Authority adopt the attached Resolution 05-06-01, which would recommend the Department of Water Resource that it award a contract to the most qualified bidder for the construction of the aeration demonstration project, expected to cost not more than $3 million.

Background

The San Joaquin River experiences regular periods of low dissolved oxygen (DO) concentrations in the first few miles of the Stockton Deep Water Ship Channel (DWSC) downstream from the City of Stockton. These conditions often violate the water quality objectives for DO in the DWSC as contained in the Water Quality Control Plan for the Sacramento River Basin and San Joaquin River Basin (Basin Plan), create a barrier to salmon passage to the San Joaquin River and may stress and kill other aquatic organisms.. In January 2005 the Regional Water Quality Control Board (RWQCB) adopted a Total Maximum Daily Load (TMDL) and Basin Plan Amendment for the Control Program for Factors Contributing to the Dissolved Oxygen Impairment in the Stockton Deep Water Ship Channel. This control program recognizes that alternate measures, such as aeration, may be useful to address the impairment.

Demonstration Project

An aeration demonstration project was recommended as part of the 2001 studies that were funded by the CALFED Program to investigate causes of low DO in the Stockton DWSC. Following those peer-reviewed studies, CALFED staff worked with several stakeholders, including the San Joaquin River Dissolved Oxygen Steering Committee, to investigate various aeration technologies; prepare a feasibility study; and

collaboratively settled on the currently preferred aeration method. A basis of design was prepared, and DWR is preparing designs and specifications for the construction of an aeration system that will deliver 10,000 lbs/day of oxygen to the DWSC over the next two years as a demonstration of the efficacy of using aeration to improve DO conditions in the DWSC.

Extent of Water Quality Impairment

The DO water quality objective (the minimum DO concentration) for the San Joaquin River, from Turner Cut to Stockton, is 6 milligrams per liter (mg/l) from September 1 to November 30, to protect migrating adult Chinook salmon, and 5 mg/l throughout the rest of the year. However, water quality monitoring data have indicated that the DWSC frequently has DO levels lower than the water quality objectives.

A DO deficit, defined here, as the quantity of oxygen that must be added to the DWSC to meet the water quality objectives, was calculated using DO and flow data from 2001 as an example. Based on the daily minimum DO concentrations at the California Department of Water Resources (DWR) Rough and Ready Island station and the daily net flow measured at the Stockton UVM flow station, about 1 million pounds (lbs) of oxygen would have been needed in the summer of 2001. This calculation includes a 0.5-mg/l DO buffer added to the water quality objective as a margin of safety to allow for small variations within the DWSC compared to the DO monitoring data. An aeration or oxygenation device that delivered about 10,000 lbs/day might have satisfied the measured DO deficit during the summer of 2001. It should be noted that water year 2001 was a slightly below-normal year and that during a dry or critical year with lower river flows the oxygen deficit could at times be greater than 10,000 lbs/day. The annual deficit may also vary from year to year.

California Environmental Quality Act (CEQA) Documentation and Issues Raised

Delivery of 10,000 lbs/day of DO to the DWSC requires careful consideration regarding the method and potential consequences of this action. An initial Study/ Mitigated Negative Declaration was prepared for the project, and the subsequent comment period ended on March 11, 2005. Only two comment letters were received raising concerns over the demonstration project, with one referred to by the other. Most comments provided were in support of the demonstration project. The most serious concern raised was the potential for gas bubble disease because of the perception that the project would exceed the EPA Gold Book criteria for total dissolved gas concentration of 110%. The issue of creating oxygen-derived free radicals that could harm fish was also expressed among other, less technical comments.

Addressing Issues

Gas bubble disease in fish is akin to what divers experience as the "bends" when ascending too quickly after long, deep dives. In fish, this is a concern when the organisms are subject to water that has a total dissolved gas content above 110%, and is most worrisome when total dissolved nitrogen is increased. The U-tube oxygenation device is designed to produce an O_2 concentration similar to the saturation concentration of pure oxygen gas (100% partial pressure) at 1.5 m (i.e., 56 mg/l) within the device. However, the strong jet mixing that will occur near the diffuser jets, will produce a rapid dilution of about 10:1 within about 10 jet diameters (i.e., 5-10 feet) once oxygenated water is delivered to the DWSC. In this case the nitrogen partial pressure is 54% (i.e., 15.7/29.1), and the oxygen partial pressure at the edge of the jet-mixing zone is about 21% (12/56.4). The total gas saturation is just 75%, which is well below the EPA criterion of 110%. The use of pure oxygen as a gas source, rather than atmospheric oxygen, prevents nitrogen from becoming an issue.

Oxygen-derived free radicals are formed by the mitochondria within cells. Although the commenter was incorrect regarding the nature of possibly increasing the concentrations of oxygen-derived free radicals within the DWSC by use of pure oxygen in the U-tube, we have investigated the possibility of increasing free radical formation through use of this technology and found the possibility for free radical formation to be remote at best. In order to determine the ability for free radical formation, DWR measured the oxidation-reduction potential (ORP) of water in the DWSC prior to being aerated, and after being aerated. The ORP was also measured after using peroxide, a free radical and intense oxidizer, to provide some additional background for the use of the ORP measurement to predict free radical formation. DWR is currently conducting these tests, and hopes to have the answers by the time the Authority meets on June 8 and 9.

Fiscal Information

Article 3, Section 79190(d)(2)(B) of Proposition 13 identifies six activities. Subsection (ii) authorized the construction of facilities to improve low DO levels in the lower San Joaquin and south delta. Funding provided through Prop 13 for this activity is $40M.

Costs for the demonstration project are expected to be $4 million to plan, design, construct and operate for two years.($800,000 to operate Year 1 and $500,000 to operate Year 2.)

List of Attachments

Attachment 1 – Dissolved Oxygen informational brochure
Attachment 2 – Additional background information
Resolution 05-06-01

Contact

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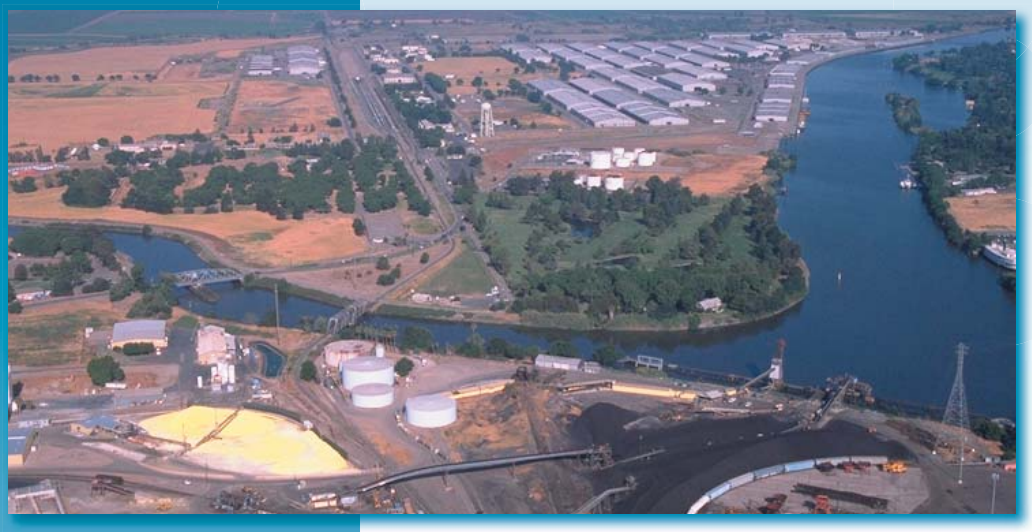
Senior Authority Advisor

Aeration Demonstration Project in the Stockton Deep Water Ship Channel



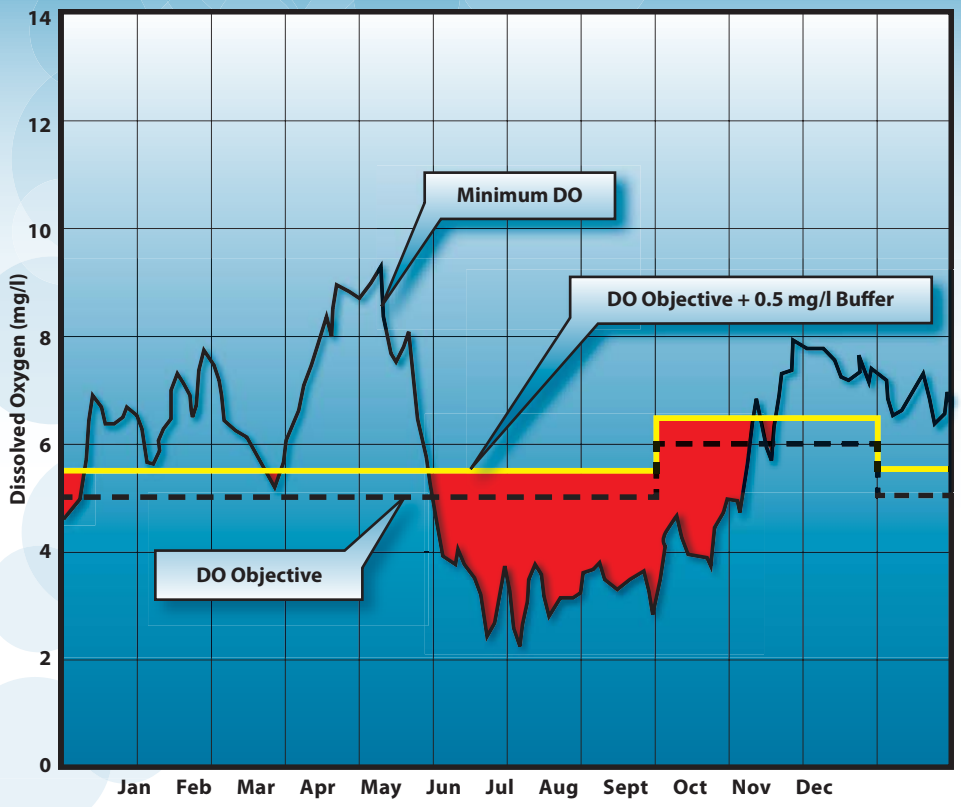
CALIFORNIA BAY–DELTA AUTHORITY

DEPARTMENT OF WATER RESOURCES STATE OF CALIFORNIA

The Stockton Deep Water Ship Channel (DWSC) is a maintained (i.e., dredged) portion of the San Joaquin River that begins at the mouth of the river near Antioch and terminates in Stockton, California. It is used as a shipping channel allowing large vessels access to the interior of the Central Valley from the open sea. The shipping channel ends at the Port of Stockton East Complex turning basin where vessels can reverse their orientation before departing. The DWSC is dredged annually to a depth of at least 35 feet measured at the lowest low diurnal tidal cycle (mean lower low water).

The concentration of dissolved oxygen (DO) in the DWSC is a function of three primary factors: change in flow conditions in the San Joaquin River, the depth and width of the DWSC, and upstream contributions of algae and other oxygen-depleting substances. High flows in the River, greater than 2,000 cubic feet per second (cfs), can prevent decreases in DO concentrations by diluting and transporting oxygen-depleting substances more quickly through the DWSC. At lower flows, the volume of the DWSC significantly increases the time it takes water to flow through the DWSC. This allows algae and other oxygen-depleting substances to settle to the bottom of the channel. Sunlight only penetrates the top few feet of the water column in the DWSC, limiting algal growth to the few feet near the surface. As algae and other oxygen-depleting substances settle to the bottom of the channel under low flow conditions, they decay. The growing algae at the surface does provide DO to the DWSC through photosynthesis, but the net effect of decaying algae is a reduction in DO levels as the algae respire and bacteria decompose the dead algae.

Aeration of the Stockton Deep Water Ship Channel



Dissolved Oxygen Deficit in the Deep Water Ship Channel • 2001

The DO Deficit

Water quality objectives are established by the Regional Water Quality Control Boards (RWQCBs) to protect the beneficial uses of water bodies in California. The DO water quality objective (the minimum DO concentration) for the San Joaquin River, from Turner Cut to Stockton, is 6 milligrams per liter (mg/l) from September 1 to November 30 and 5 mg/l throughout the rest of the year. However, water quality monitoring data have indicated that the DWSC frequently has DO levels that are lower than the water quality objectives.

A DO deficit, defined here as the quantity of oxygen that must be added to the DWSC to meet the water quality objectives, was calculated using DO and flow data from 2001. Based on the daily minimum DO concentrations at the DWR Rough & Ready Island station and the daily net flow measured at the Stockton UVM flow station, about 1 million lbs of oxygen would have been needed in the summer of 2001. This includes a 0.5-mg/l DO buffer added to the water quality objective. An aeration or oxygenation device that delivered about 10,000 lbs per day, operating for 100 days, may have satisfied the measured DO deficit during the summer of 2001. It should be noted that water year 2001 was a slightly below-normal year and that during a dry or critical year with lower river flows the oxygen deficit could be much larger.

In 2001, the oxygen deficit was calculated to be 10,000 lbs per day

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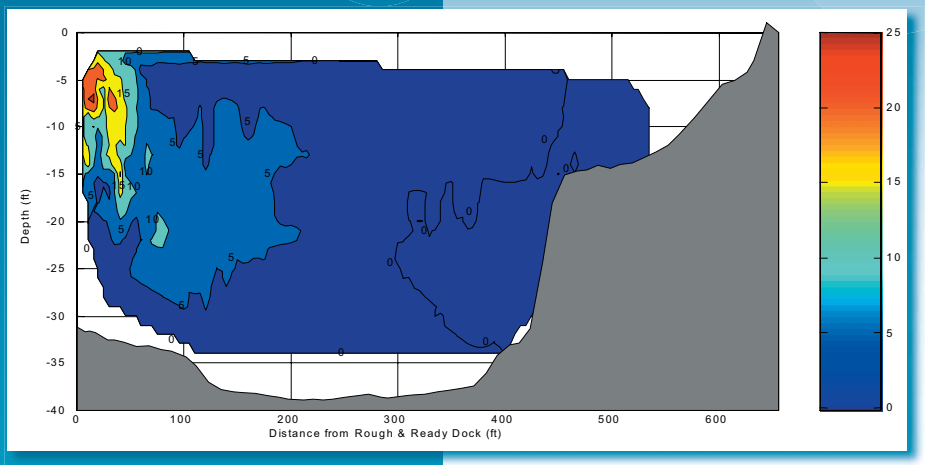
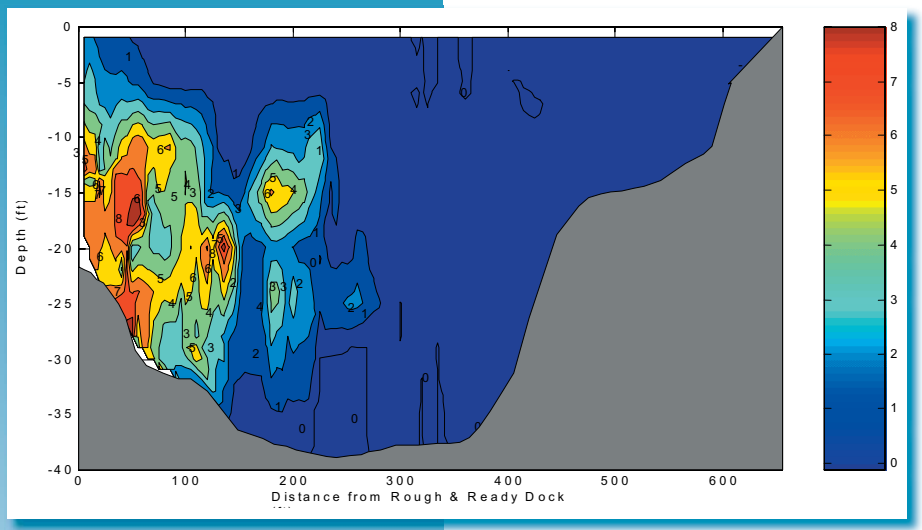
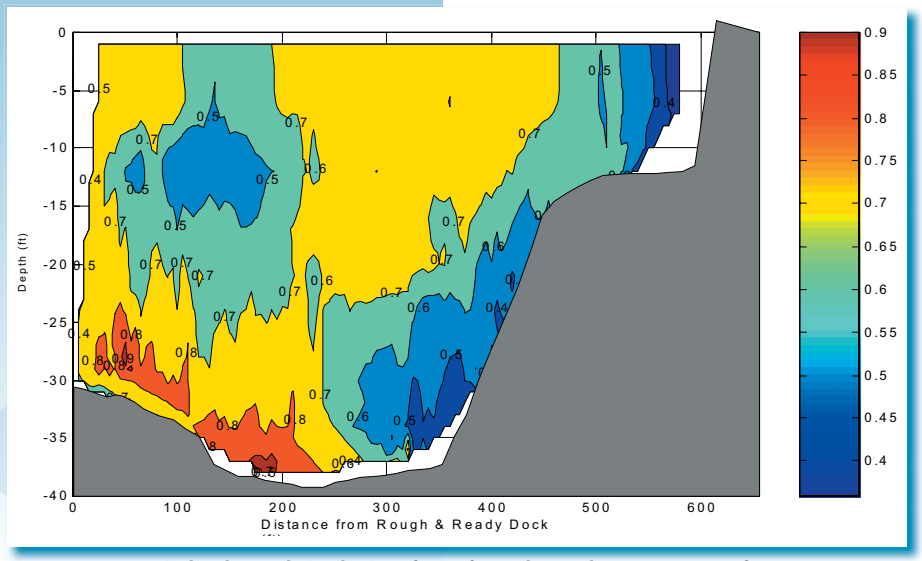


Vertical and Lateral Distribution of Dye at 1-hour after Injection (upstream 1,000 feet)



Vertical and Lateral Distribution of Dye after 6 hours (downstream 500 feet)

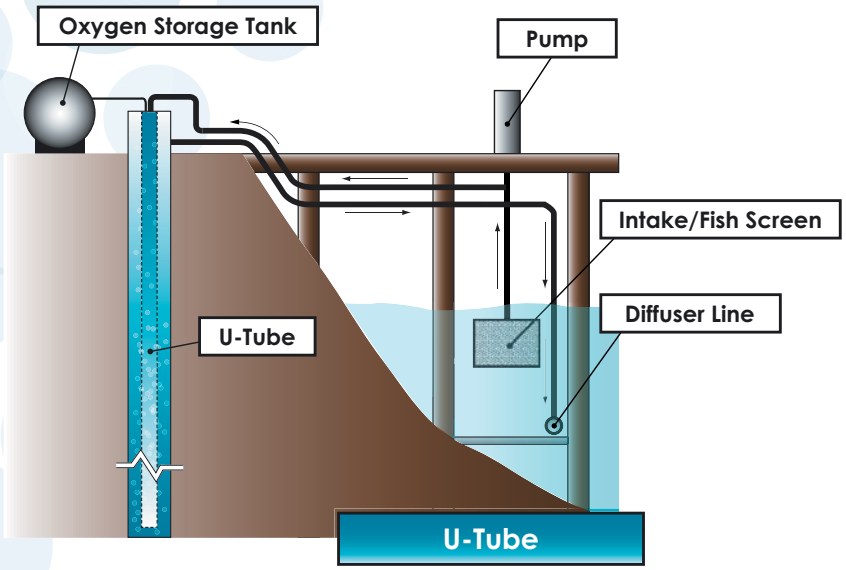


Vertical and Lateral Distribution of Dye after 24 hours (downstream 1,000 feet)

Natural Mixing Characteristics

On November 26, 2002, a study was performed to evaluate how rapidly dye would spread from an oxygenation device at the Rough & Ready Island dock across the DWSC to the opposite shore. Researchers reasoned that lateral spreading and mixing of the dye would indicate how well an aeration or oxygen injection system would spread water with an increased DO concentration across and throughout the DWSC. Approximately 500 feet wide, the DWSC has a mean depth of 30 feet, resulting in a cross-section area of about 15,000 square feet. Water moves upstream about 1 mile during a three-foot tidal variance twice each day.

On the day of the study, the measured lateral mixing from tidal flow dispersion was nearly complete by the end of the day. While lateral mixing was minimal during the first 6 hours after dye injection when tidal flow was low, tidal mixing was sufficient to yield nearly uniform lateral dye concentrations after 24 hours. This study demonstrated that tidal flows strongly influence lateral dispersion in the DWSC near Rough & Ready Island. It also showed that lateral mixing is sufficient to allow the aeration or oxygenation system to be installed under the Rough & Ready Island dock and still maintain improved DO concentrations throughout the DWSC.



Demonstration Project

Delivering 10,000 lbs per day of dissolved oxygen to the DWSC can be accomplished using a number of artificial aeration techniques. These techniques range from mechanical mixing to submerged bubble column systems. Jones & Stokes evaluated several of these technologies in 2003 and 2004. Through this work, it was determined that a U-Tube aeration system could provide the needed quantity of oxygen most efficiently.

The U-Tube works by injecting oxygen into water that is being pumped through a deep well. By subjecting the oxygen bubbles to increased pressure, more oxygen can be dissolve into the water. This oxygen rich water is then delivered to the DWSC through a submerged diffuser that relies on natural mixing characteristics to ensure thorough mixing.

Use of a U-Tube aeration system situated at Rough & Ready Island will allow testing of this aeration technology in a natural tidal system that regularly experiences low dissolved oxygen levels. The basic hypothesis to be tested is whether or not providing 10,000 lbs per day of oxygen to the DWSC will have an appreciable effect on the dissolved oxygen levels. A demonstration project, which will be performed over a two-year period, will also allow assessment of various operational parameters for the U-Tube technology. Along with ascertaining the effectiveness of the U-Tube for aerating the channel, this demonstration will allow for the examination of other, possibly unintended consequences of large-scale aeration prior to using this technology on a more permanent basis.

Project Timeline

August 2004
Aeration Technology Engineering Feasibility Study

August-October 2004
DWSC Aeration Technology Tests

August 2004-March 2005
Design Aeration Technology

Fall 2005
Construct Pilot Aeration Device

Summer 2006-Summer 2007
Pilot Testing and Adaptive Management

AERATION DEMONSTRATION PROJECT TO IMPROVE LOW DISSOLVED OXYGEN LEVELS IN THE STOCKTON DEEP WATER SHIP CHANNEL

BACKGROUND INFORMATION

The San Joaquin River experiences regular periods of low dissolved oxygen (DO) concentrations in the first few miles of the Stockton Deep Water Ship Channel (DWSC) downstream from the City of Stockton. These conditions often violate the water quality objectives for DO in the DWSC as contained in the Water Quality Control Plan for the Central Valley-Sacramento River and San Joaquin River Basins (Basin Plan). In January 1998, the State Water Resources Control Board (SWRCB) first adopted a Clean Water Act (CWA) Section 303(d) list that identified this impairment and ranked it as a high priority for correction. Inclusion on this list initiated the need under the CWA for the Central Valley Regional Water Quality Control Board (CVRWQCB) to develop a Total Maximum Daily Load (TMDL) that identifies the factors contributing to the DO impairment and apportions responsibility for correcting the problem. It also initiated the need under the Porter-Cologne Water Quality Control Act to develop a program of implementation for the TMDL consisting of actions that the CVRWQCB will take to implement this TMDL and to bring the impaired reach of the DWSC into compliance with the Basin Plan DO objectives. The TMDL and program of implementation must be incorporated as an amendment to the Basin Plan to satisfy both of these requirements. In addition, the SWRCB Water Right Decision 1641 instructed the CVRWQCB to develop a TMDL for this impairment before they would take further water rights actions to implement the DO water quality objectives.

The DO water quality objective (the minimum DO concentration) for the San Joaquin River, from Turner Cut to Stockton, is 6 milligrams per liter (mg/l) from September 1 to November 30, to protect migrating adult Chinook salmon, and 5 mg/l throughout the rest of the year. However, water quality monitoring data have indicated that the DWSC frequently has DO levels lower than the water quality objectives.

The CALFED Bay-Delta Program Record of Decision (ROD) identified low DO as an important water quality issue that impacts ecosystems within the Bay-Delta system. Commitments to improving DO conditions in the San Joaquin River near Stockton are priority actions in both CALFED Water Quality and Ecosystem Restoration Programs. Actions identified in the Ecosystem Restoration Program Plan to improve DO conditions in the San Joaquin River near Stockton include:

- Simultaneous investigation of specific causes as well as investigation of innovative methods to reduce problem pollutants in the river
- Finalize investigation of methods to reduce constituents that cause low DO to be included in the TMDL recommendation to the RWQCB
- Finalize State Basin Plan Amendment and TMDL for constituents that cause low DO in the San Joaquin River
- Begin implementation of appropriate source controls and other controls as recommended in the TMDL

An objective of the CALFED Water Quality Program Plan is to correct the causes of oxygen depletion in affected areas, to reduce incidences of low DO, and to reduce the impairment of beneficial uses. The plan outlines priority actions and information needed to support ongoing and future activities. The Delta Improvements Package Implementation Plan re-affirms the ROD commitments to improving Delta water quality and directs agencies to develop and implement a comprehensive strategy to improve DO in the DWSC.

Numerous monitoring and research studies have been performed in recent years by various agencies, academic institutions, and interest groups to better understand the causes of the DO impairment. Most of these studies were peer reviewed by an independent science panel convened by CALFED in June 2002 (URS Corporation 2002). The results of these studies indicate that many factors influence low DO in the DWSC, including growth of algae within the DWSC, City of Stockton wastewater discharge, sediment oxygen demand, low light penetration, nutrient loading, temperature, low San Joaquin River flows through the DWSC (transport velocities), and construction and maintenance of the DWSC. The nature and extent of the DO impairment is described in more detail in the technical TMDL report (RWQCB 2004) and the draft Basin Plan Amendment (RWQCB 2004).

Additional studies are required to better understand the sources of oxygen demanding substances and their precursors in the watershed and their linkage to the DO impairment. Specifically these studies must identify and quantify the following:

- Mechanisms, sources of nutrients, and environmental variables that control the creation of algae in the watershed and its transformation before entering the DWSC
- Sources of other oxygen demanding substances in the watershed and the mechanisms and variables that control their transformation before entering the DWSC
- Mechanisms and environmental variables that control how algae and other oxygen demanding substances impact dissolved oxygen concentrations in the DWSC under a range of environmental conditions, including consideration of the effects of chemical, biological, and physical mechanisms that add or remove dissolved oxygen from the water column

Numerous watershed stakeholders are currently under contract with CBDA for a three-year monitoring and analysis program of the upstream sources of oxygen demanding substances and their precursors. The study, as proposed, should provide much of the information required to identify and quantify sources and transformation of oxygen demanding substances in the watershed. Two other studies have been started by CBDA to develop multi-dimensional water quality models of the DWSC within two years. Together these studies should provide much of the information needed. Additional monitoring and studies of specific issues will likely be required based on the preliminary findings of these studies.

An aeration demonstration project was recommended as part of the 2001 studies that were funded by CBDA to investigate causes of low dissolved oxygen (DO) in the Stockton Deep Water Ship Channel (DWSC). Following those peer-reviewed studies, CBDA investigated various aeration technologies, prepared a feasibility study, and in cooperation with several stakeholders settled on the currently preferred aeration method. A basis of design was prepared, and DWR is preparing designs and specifications for the construction of an aeration system that will deliver 10,000 lbs/day of oxygen to the DWSC over the next two years as a demonstration of the efficacy of using aeration to improve dissolved oxygen conditions in the DWSC.

Additional studies will be required to fully understand the impacts of solving the DO impairment in the DWSC. Upcoming solicitations will be focused on gaining information on the transport and fate of oxygen demanding substances within the DWSC, and what ecosystem impacts might occur in the DWSC or the Delta from controlling algae or other oxygen demanding substances.

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Agenda Item: 14A
Meeting Dates: June 8 and 9, 2005

CALIFORNIA BAY-DELTA AUTHORITY

RESOLUTION 05-06-01

RECOMMENDING THE DEPARTMENT OF WATER RESOURCES PROCEED TO AWARD A CONTRACT TO CONSTRUCT AND OPERATE THE AERATION DEMONSTRATION PROJECT

WHEREAS, The dissolved oxygen (DO) water quality objective (the minimum DO concentration) for the San Joaquin River, from Turner Cut to Stockton, is 6 milligrams per liter (mg/l) from September 1 to November 30, to protect migrating adult Chinook salmon, and 5 mg/l throughout the rest of the year; and

WHEREAS, The San Joaquin River experiences regular periods of low DO that often violate these water quality objectives for DO in the DWSC; and

WHEREAS, These conditions as contained in the Water Quality Control Plan for the Sacramento River Basin and San Joaquin River Basin (Basin Plan); and

WHEREAS, An aeration demonstration project was recommended as part of the 2001 studies that were funded by the CALFED Program to investigate causes of low DO in the Stockton Deep Water Ship Channel (DWSC); and

WHEREAS, DWR is preparing designs and specifications for the construction of an aeration system that will deliver 10,000 lbs/day of oxygen to the DWSC over the next two years as a demonstration of the efficacy of using aeration to improve DO conditions in the DWSC; and

WHEREAS, Construction and operation of the aeration demonstration project is consistent with the CALFED Record of Decision; and

WHEREAS, Construction and operation of the aeration demonstration project is consistent with the intent and purposes of Proposition 13; and

WHEREAS, Proposition 13 appropriated $40 million toward constructing facilities that improve DO conditions in the San Joaquin River; and

WHEREAS, Addressing the low DO situation in the DWSC is paramount to continuing forward on implementation of the Delta Improvement Package; and

WHEREAS, a group of stakeholders has stepped forward to own and operate the aeration facility after the demonstration period if proven effective.

NOW, THEREFORE, BE IT RESOLVED that the California Bay-Delta Authority recommends the Department of Water Resources proceed to award a contract to the most qualified bidder for the construction of the aeration demonstration project, expected to cost not more than $3 million.

IT IS FURTHER RESOLVED that the Authority supports the efforts of the Department of Water Resources, and the affected stakeholders, to address and solve the DO impairment in the Stockton Deep Water Ship Channel.

CERTIFICATION

The undersigned Assistant to the California Bay-Delta Authority does hereby certify that the foregoing is a full, true, and correct copy of a resolution duly and regularly adopted at a meeting of the Authority held on June 9, 2005.

Dated: _____

_____

Olene Chard
Assistant to the California Bay-Delta Authority