Adaptive Real-Time Forecasting and Sustainable Management of Dissolved Oxygen in the San Joaquin River and Stockton Deep Water Ship Channel

Project Information

1. **Proposal Title:**

   Adaptive Real-Time Forecasting and Sustainable Management of Dissolved Oxygen in the San Joaquin River and Stockton Deep Water Ship Channel

2. **Proposal applicants:**

   Alex Horne, University of California, Berkeley
   Nigel Quinn, UC Berkeley
   Carl Chen, Systech Inc.
   William Stringfellow, Lawrence Berkeley National Laboratory
   Paul Hutton, Department of Water Resources
   Karl Jacobs, Department of Water Resources

3. **Corresponding Contact Person:**

   Jyl Baldwin
   University of California, Berkeley
   Sponsored Projects Office Berkeley CA 94720-5940
   510 642-8114
   jbaldwin@uclink.berkeley.edu

4. **Project Keywords:**

   Aquatic Ecology
   Water Quality Assessment & Monitoring
   Water Quality Management

5. **Type of project:**

   Research

6. **Does the project involve land acquisition, either in fee or through a conservation easement?**

   No

7. **Topic Area**:

   Ecosystem Water and Sediment Quality

8. **Type of applicant:**

   University

9. **Location - GIS coordinates:**

   Latitude: 37.98476

   Longitude: -121.30611

   Datum:

   Describe project location using information such as water bodies, river miles, road intersections, landmarks, and size in acres.

   San Joaquin River between Lander Avenue and the Stockton Deep Water Ship Channel

10. **Location - Ecozone:**

    12.1 Vernalis to Merced River, 12.2 Merced River to Mendota Pool, 13.1 Stanislaus River, 13.2 Tuolumne River, 13.3 Merced River, West San Joaquin Basin, 1.3 South Delta

11. **Location - County:**

    Madera, Merced, San Joaquin, Stanislaus

12. **Location - City:**

    Does your project fall within a city jurisdiction?

    Yes

    If yes, please list the city: Stockton

13. **Location - Tribal Lands:**

    Does your project fall on or adjacent to tribal lands?

    No

14. **Location - Congressional District:**

    15th

15. **Location:**

    California State Senate District Number: 5

    California Assembly District Number: 17

16. **How many years of funding are you requesting?**

    2

17. **Requested Funds:**
    a) Are your overhead rates different depending on whether funds are state or federal?

Yes

If yes, list the different overhead rates and total requested funds:

State Overhead Rate: 10%

Total State Funds: $821,295

Federal Overhead Rate: 50.40%

Total Federal Funds: $980,310

b) Do you have cost share partners already identified?

No

c) Do you have potential cost share partners?

Yes

If yes, list partners and amount contributed by each:

Department of Water Resources none

Grassland Area Farmers none

U.S. Bureau of Reclamation none

d) Are you specifically seeking non-federal cost share funds through this solicitation?

No

If the total non-federal cost share funds requested above does not match the total state funds requested in 17a, please explain the difference:

18. **Is this proposal for next-phase funding of an ongoing project funded by CALFED?**

No

Have you previously received funding from CALFED for other projects not listed above?

No

19. **Is this proposal for next-phase funding of an ongoing project funded by CVPIA?**

No

Have you previously received funding from CVPIA for other projects not listed above?

No

20. **Is this proposal for next-phase funding of an ongoing project funded by an entity other than CALFED or CVPIA?**

No

Please list suggested reviewers for your proposal. (optional)

Prof. William Oswald	**UC Berkeley**	**510-231-9438**	**wjo@uclink4.berkeley.edu**
Alex Hildebrand	**South Delta Water Agency**	**n/a**	
Les Grober	**Central Valley Regional Water Quality Control Board**	**916-255-3091**	**groberl@rb5s.swrcb.ca.gov**

21. **Comments:**

Environmental Compliance Checklist

Adaptive Real-Time Forecasting and Sustainable Management of Dissolved Oxygen in the San Joaquin River and Stockton Deep Water Ship Channel

1. **CEQA or NEPA Compliance**
   a) Will this project require compliance with CEQA?

      No

   b) Will this project require compliance with NEPA?

      No

   c) If neither CEQA or NEPA compliance is required, please explain why compliance is not required for the actions in this proposal.

      Project includes both monitoring and modeling. Monitoring will occur at existing DWR, USBR sites.

2. **If the project will require CEQA and/or NEPA compliance, identify the lead agency(ies).** *If not applicable, put "None".*

   <u>CEQA Lead Agency:</u>
   <u>NEPA Lead Agency (or co-lead:)</u>
   <u>NEPA Co-Lead Agency (if applicable):</u>

3. **Please check which type of CEQA/NEPA documentation is anticipated.**

   CEQA
   -Categorical Exemption
   -Negative Declaration or Mitigated Negative Declaration
   -EIR
   Xnone

   NEPA
   -Categorical Exclusion
   -Environmental Assessment/FONSI
   -EIS
   Xnone

   If you anticipate relying on either the Categorical Exemption or Categorical Exclusion for this project, please specifically identify the exemption and/or exclusion that you believe covers this project.

4. **CEQA/NEPA Process**
   a) Is the CEQA/NEPA process complete?

      Not Applicable

   b) If the CEQA/NEPA document has been completed, please list document name(s):

5. **Environmental Permitting and Approvals** (*If a permit is not required, leave both Required? and Obtained? check boxes blank.*)

LOCAL PERMITS AND APPROVALS

Conditional use permit

Variance

Subdivision Map Act

Grading Permit

General Plan Amendment

Specific Plan Approval

Rezone

Williamson Act Contract Cancellation

Other

STATE PERMITS AND APPROVALS

Scientific Collecting Permit

CESA Compliance: 2081

CESA Compliance: NCCP

1601/03

CWA 401 certification

Coastal Development Permit

Reclamation Board Approval

Notification of DPC or BCDC

Other

FEDERAL PERMITS AND APPROVALS

ESA Compliance Section 7 Consultation

ESA Compliance Section 10 Permit

Rivers and Harbors Act

CWA 404

Other

PERMISSION TO ACCESS PROPERTY

Permission to access city, county or other local agency land.
Agency Name:

Permission to access state land.
Agency Name:

Permission to access federal land.
Agency Name:

Permission to access private land.
Landowner Name:

6. **Comments.**

Land Use Checklist

Adaptive Real-Time Forecasting and Sustainable Management of Dissolved Oxygen in the San Joaquin River and Stockton Deep Water Ship Channel

1. **Does the project involve land acquisition, either in fee or through a conservation easement?**

   No

2. **Will the applicant require access across public or private property that the applicant does not own to accomplish the activities in the proposal?**

   Yes

3. **Do the actions in the proposal involve physical changes in the land use?**

   No

   If you answered no to #3, explain what type of actions are involved in the proposal (i.e., research only, planning only).

   Research only

4. **Comments.**

Conflict of Interest Checklist

Adaptive Real-Time Forecasting and Sustainable Management of Dissolved Oxygen in the San Joaquin River and Stockton Deep Water Ship Channel

Please list below the full names and organizations of all individuals in the following categories:

- Applicants listed in the proposal who wrote the proposal, will be performing the tasks listed in the proposal or who will benefit financially if the proposal is funded.
- Subcontractors listed in the proposal who will perform some tasks listed in the proposal and will benefit financially if the proposal is funded.
- Individuals not listed in the proposal who helped with proposal development, for example by reviewing drafts, or by providing critical suggestions or ideas contained within the proposal.

The information provided on this form will be used to select appropriate and unbiased reviewers for your proposal.

Applicant(s):

Alex Horne, University of California, Berkeley
Nigel Quinn, UC Berkeley
Carl Chen, Systech Inc.
William Stringfellow, Lawrence Berkeley National Laboratory
Paul Hutton, Department of Water Resources
Karl Jacobs, Department of Water Resources

Subcontractor(s):

Are specific subcontractors identified in this proposal? Yes

If yes, please list the name(s) and organization(s):

Paul Hutton	California Department of Water Resources
Carl Chen	Systech Engineering
Will Stringfellow	Lawrence Berkeley National Laboratory
None	None
None	None
None	None
None	None

Helped with proposal development:

Are there persons who helped with proposal development?

Yes

If yes, please list the name(s) and organization(s):

Alex Horne UC Berkeley

Nigel Horne UC Berkeley

Comments:

Budget Summary

Adaptive Real-Time Forecasting and Sustainable Management of Dissolved Oxygen in the San Joaquin River and Stockton Deep Water Ship Channel

Please provide a detailed budget for each year of requested funds, indicating on the form whether the indirect costs are based on the Federal overhead rate, State overhead rate, or are independent of fund source.

Federal Funds

Year 1												
Task No.	**Task Description**	**Direct Labor Hours**	**Salary** ***(per year)***	**Benefits** ***(per year)***	**Travel**	**Supplies & Expendables**	**Services or Consultants**	**Equipment**	**Other Direct Costs**	**Total Direct Costs**	**Indirect Costs**	**Total Cost**
a	Review data collected by the SJR Low DO TMDL Project research team, together with supportive data to develop relationships between continuous monitors and those factors that are not amenable to continuous monitoring but are important for modeling algal nutrient loading, algal load dynamics and dissolved oxygen depletion in the San Joaquin River Deep Water Channel	675	12977	2719	1000	480	0	10500	0	27676.0	23456	51132.00
b	Select key monitoring stations to be upgraded to include continuous measurement of turbidity, temperature, EC, pH, dissolved oxygen and chlorophyll	1957	40628	8037	1000	480	60000	10500	0	120645.0	23456	144101.00

c	Develop and improve the existing DSM-2 model using continuous monitoring data as a forecasting tool for dissolved ogygen depletion in the SJR DWSC	116	4833	822	1000	480	40000	10500	0	57635.0	23456	81091.00
d	Perform weekly forecasts of dissolved oxygen in the San Joaquin River and Ship Channel with DSM-2 model using protocols developed by the SJRMP Water Quality Subcommittee during typical periods of non-compliance during summer and fall	1378	38210	5926	1000	480	40000	10500	0	96116.0	23456	119572.00
e	Based on Tasks (a) through (d), the PIs will work with the Steering and Technical Advisory Committees of the SJR DO TMDL process to develop and evaluate different management strategies for potentail future operations	1442.25	38611	6612	1000	480	60000	10500	0	117203.0	23455	140658.00
		5568	135259.00	24116.00	5000.00	2400.00	200000.00	52500.00	0.00	419275.00	117279.00	536554.00

Year 2													
Task No.	**Task Description**	**Direct Labor Hours**	**Salary** ***(per year)***	**Benefits** ***(per year)***	**Travel**	**Supplies & Expendables**	**Services or Consultants**	**Equipment**	**Other Direct Costs**	**Total Direct Costs**	**Indirect Costs**	**Total Cost**
a	Review data collected by the SJR Low DO TMDL Project research team, together with supportive data to develop relationships between continuous monitors and those factors that are not amenable to continuous monitoring but are important for modeling algal nutrient loading, algal load dynamics and dissolved oxygen depletion in the San Joaquin River Deep Water Channel		13236	2773	1000	520	0	10500	0	28029.0	16219	44248.00
b	Select key monitoring stations to be upgraded to include continuous measurement of turbidity, temperature, EC, pH, dissolved oxygen and chlorophyll		41441	8198	1000	520		10500	0	61659.0	16219	77878.00
c	Develop and improve the existing DSM-2 model using continuous monitoring data as a forecasting tool for dissolved ogygen depletion in the SJR DWSC		4930	838	1000	520	40000	10500	0	57788.0	16219	74007.00

d	Perform weekly forecasts of dissolved oxygen in the San Joaquin River and Ship Channel with DSM-2 model using protocols developed by the SJRMP Water Quality Subcommittee during typical periods of non-compliance during summer and fall		38974	6044	1000	520	40000	10500	0	97038.0	16219	113257.00
e	Based on Tasks (a) through (d), the PIs will work with the Steering and Technical Advisory Committees of the SJR DO TMDL process to develop and evaluate different management strategies for potentail future operations		39383	6744	1000	520	60000	10500	0	118147.0	16219	134366.00
		0	137964.00	24597.00	5000.00	2600.00	140000.00	52500.00	0.00	362661.00	81095.00	443756.00

Year 3												
Task No.	**Task Description**	**Direct Labor Hours**	**Salary *(per year)***	**Benefits *(per year)***	**Travel**	**Supplies & Expendables**	**Services or Consultants**	**Equipment**	**Other Direct Costs**	**Total Direct Costs**	**Indirect Costs**	**Total Cost**
		0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Grand Total=980310.00

Comments.

Budget Justification

Adaptive Real-Time Forecasting and Sustainable Management of Dissolved Oxygen in the San Joaquin River and Stockton Deep Water Ship Channel

Direct Labor Hours. Provide estimated hours proposed for each individual.

Prof. Alex Horne, PI: 348 hrs. Dr. Nigel Quinn: 522 hrs. Visiting Postdoc. Researcher: 2088 hrs. (2) Graduate Student Researchers: 2610 hrs.

Salary. Provide estimated rate of compensation proposed for each individual.

Prof. Horne, PI: $188/hr. Dr. Nigel Quinn: $98/hr. Visiting Postdoc Researcher: $45/hr. Graduate Student Researchers: $18/hr. avg.

Benefits. Provide the overall benefit rate applicable to each category of employee proposed in the project.

Professional Investigator: summer research 12.70% Other Academic Personnel (Assoc. Research Engineer, Visiting Postdoc.): 17% calendar year salary Graudate Student Researcher, academic year salary: 1.30% Graduate Student Researcher, summer salary: 3.0% Full in-state Fee Remission for Calif. residents/per semester per student: $2269 Spring 2002-Spring 2003 Full in-state Fee Remission for Calif. residents/per semester per student: $2314 Spring 2003-Spring 2004

Travel. Provide purpose and estimate costs for all non-local travel.

Four (4) round trips to conferences, locations to be determined (Airfare: $700, hotel: $125, per diem: 2 days @ $85/day, registration: $175, grd. transportation: $70) x 4 RT = $5000 per yr. x 2 yrs.: $10,000 total

Supplies & Expendables. Indicate separately the amounts proposed for office, laboratory, computing, and field supplies.

Materials and supplies: $2400 per year

Services or Consultants. Identify the specific tasks for which these services would be used. Estimate amount of time required and the hourly or daily rate.

Department of Water Resources: 1800 hrs. @ $67/hr. Systech Engineering: Modeling, 1600 hrs. @ $100/hr. LBNL: 1392 hrs. @ $44/hr.

Equipment. Identify non-expendable personal property having a useful life of more than one (1) year and an acquisition cost of more than $5,000 per unit. If fabrication of equipment is proposed, list parts and materials required for each, and show costs separately from the other items.

Water Quality Monitoring Sensors: $45,000 per year Computing Charges: $7500 per year

Project Management. Describe the specific costs associated with insuring accomplishment of a specific project, such as inspection of work in progress, validation of costs, report preparation, giving presentatons, reponse to project specific questions and necessary costs directly associated with specific project oversight.

Because the University of California is a teaching/research university there is an infrastructure to support research through administrative services and direct professional investigator involvement as part of their academic mission.

Other Direct Costs. Provide any other direct costs not already covered.

none

Indirect Costs. Explain what is encompassed in the overhead rate (indirect costs). Overhead should include costs associated with general office requirements such as rent, phones, furniture, general office staff, etc., generally distributed by a predetermined percentage (or surcharge) of specific costs.

The predetermined rate of 50.40% is used on grants, contracts and other agreements with the Federal Government for on-campus sponsored research. Base: modified total direct costs, consisting of all salaries and wages, fringe benefits, materials, supplies, services, travel and subgrants and subcontracts up to the first $25,000 of each subgrant or subcontract. Modified total direct costs shall exclude equipment, capital expenditures, charges for patient care, tuition remission, rental costs of off-site facilities, scholarships and fellowships as well as the portion of each subgrant and subcontract in excess of $25,000. Line items other than indirect costs will remain the same for Federal or State funding sources.

Executive Summary

Adaptive Real-Time Forecasting and Sustainable Management of Dissolved Oxygen in the San Joaquin River and Stockton Deep Water Ship Channel

The goal of this project is to develop a forecasting tool to improve sustainable management of episodes of dissolved oxygen (DO) depletion below water quality standards/objectives in the San Joaquin River (SJR) Deep Water Ship Channel (DWSC). The project will help to integrate the monitoring and modeling components of three currently funded CALFED water quality projects in the San Joaquin River Basin and Delta. This will be achieved by (a) installing state-of-the-art water quality monitors and sensors at existing monitoring stations and adding new stations where necessary and cost-effective; (b) by using satellite telemetry to automate data collection and data reduction in cooperation with the California Data Exchange (CDEC) and the Interagency Ecological Program (IEP) and (c) by adaptively improving the forecasting capability of the DSM-2 hydrodynamic and water quality model of the Delta and San Joaquin River, to predict DO depletion. Management options for control of the DO depletion will be evaluated using the model as directed by stakeholders through the SJR DO Steering Committee (SC) and Technical Advisory Committee (TAC). The SC and TAC will provide detailed information on these management scenarios which may include channel aeration, increased SJR flow through the DWSC and reduced oxygen demand loads from various sources within the SJR. Forecasts of water quality conditions made using the DSM-2 model will be made available to the SC as they are developed to assist in developing an improved management plan for controlling low DO in the SJR DWSC.

Proposal

University of California, Berkeley

Adaptive Real-Time Forecasting and Sustainable Management of Dissolved Oxygen in the San Joaquin River and Stockton Deep Water Ship Channel

Alex Horne, University of California, Berkeley
Nigel Quinn, UC Berkeley
Carl Chen, Systech Inc.
William Stringfellow, Lawrence Berkeley National Laboratory
Paul Hutton, Department of Water Resources
Karl Jacobs, Department of Water Resources

ADAPTIVE REAL-TIME FORECASTING AND SUSTAINABLE MANAGEMENT OF DISSOLVED OXYGEN IN THE SAN JOAQUIN RIVER DEEP WATER SHIP CHANNEL

Submitted by :

Department of Civil and Environmental Engineering
University of California, Berkeley
Berkeley, CA 94720

In collaboration with :

Systech Engineering
San Ramon, CA 94583

Berkeley National Laboratory
1 Cyclotron Road
Berkeley, CA 94720

California Dept. of Water Resources
1416 Ninth Street
Sacramento, CA 95814

Grassland Water District
22759 Mercy Springs Road
Los Banos, CA 93635

Central Valley Regional Water Quality Control Board
3441 Routier Road, Suite A
Sacramento, CA 95827-3003

September 22, 2001

Title Page

FOCUS AREA : SJ-5

Project Title : ADAPTIVE REAL-TIME FORECASTING AND SUSTAINABLE MANAGEMENT OF DISSOLVED OXYGEN IN THE SAN JOAQUIN RIVER DEEP WATER SHIP CHANNEL

Principal Investigator

Alex Horne, Professor
University of California, Berkeley
Berkeley, CA 94720

Key Personnel

Nigel Quinn, Research Engineer
University of California, Berkeley
Berkeley, CA 94720

Collaborators

Carl Chen, President
Systech Engineering
San Ramon, CA 94583

Paul Hutton, Section Chief
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1416 Ninth Street
Sacramento, CA 95816

William Stringfellow
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1 Cyclotron Road, 70A-3317
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Karl Jacobs, IEP Data Manager
Department of Water Resources
3251 S Street
Sacramento, CA 95814

Scott Lower
Grassland Water District
22759 Mercy Springs Road
Los Banos, CA 93635

San Joaquin River Dissolved Oxygen TMDL Steering Committee
San Joaquin River Dissolved Oxygen Technical Advisory Committee
San Joaquin River Management Program – Water Quality Subcommittee

Technical Contact Person

Professor Alex Horne
Department of Ecological Engineering
412 O'Brien Hall
University of California, Berkeley
Berkeley, CA 94720

Financial Contact Person

Ms Laurie Holland
412 O'Brien Hall
University of California, Berkeley
Berkeley, CA 94720

Project Title : ADAPTIVE REAL-TIME FORECASTING AND SUSTAINABLE MANAGEMENT OF DISSOLVED OXYGEN IN THE SAN JOAQUIN RIVER DEEP WATER SHIP CHANNEL

A. PROJECT DESCRIPTION : Project Goals and Scope of Work

The goal of this project is to develop a forecasting tool to improve sustainable management of episodes of dissolved oxygen depletion below water quality standards/objectives in the San Joaquin River (SJR) Deep Water Ship Channel (DWSC). The project will help to integrate the monitoring and modeling components of three currently-funded CALFED water quality projects in the San Joaquin River Basin and Delta. These projects are the Real-Time San Joaquin Water Quality Management Project, currently in its last year, the SJR Low-DO Project and the Grasslands Adaptive Water Quality Management Project. This purpose will be achieved by (a) installing state-of-the art water quality monitors and sensors at existing monitoring stations and adding new stations where necessary and cost-effective; (b) by using satellite telemetry to automate data collection and data reduction in cooperation with the California Data Exchange (CDEC) and the Interagency Ecological Program (IEP) and (c) by adaptively improving the forecasting capability of the DSM-2 hydrodynamic and water quality model of the Delta and San Joaquin River, to predict dissolved oxygen sag in the Stockton Deep Water Ship Channel. Management options for control of the oxygen sag will be investigated and compared through a review of existing scientific literature. This review will concentrate on low cost, robust and sustainable technologies that can be integrated with the proposed real-time dissolved oxygen forecasting system in the San Joaquin River and Stockton Deep Water Ship Channel.

This project will complement the goals of the Central Valley Regional Water Quality Control Board (CVRWQCB) which has held workshops with water districts, wetland managers, municipal treatment plant operators, dairies and riparian landowners laying the groundwork for salinity and oxygen demand TMDL's (Total Maximum Daily Load), a mechanism to encourage compliance with water quality objectives in the San Joaquin River and the Deep Water Ship Channel. The CVRWQCB has organized a stakeholder-based San Joaquin DO TMDL Steering Committee (SC) and a Technical Advisory Committee (TAC). The SC and TAC will develop a number of low DO potential management scenarios such as channel aeration, increased SJR flow through the DWSC and reduced oxygen demand loads from various sources within the SJR watershed in different water year types for evaluation through the use of the real-time forecasting model that is to be developed in this project. The forecasts of water quality conditions made using the DSM-2 model will be made available to the SC as they are developed to assist in developing an improved management plan for controlling low DO in the SJR DWSC.

This project proposal is linked conceptually with separate proposals by Stringfellow and Lehman which deal with algal growth and transformation within the San Luis Drain and with the development of relationships between model parameters and readily measureable field phenomena. Although the project will benefit from the funding of these linked proposals it does not require that these projects be funded to succeed.

Location of Project

The San Joaquin River Deep Water Ship Channel is located on the San Joaquin River approximately 30 miles north of Vernalis, the most downstream station on the San Joaquin River that is not subject to tidal influence (Figure 1).

1. Problem statement

Oxygen demanding substances contributed by upstream agricultural, wetland and municipal sources together with algal biomaximum produced within the San Joaquin River combine to exacerbate a dissolved oxygen sag within the Stockton Deep Water Ship Channel. The problem is compounded by a transition in hydraulic residence time as river water passes from the shallow well-oxygenated San Joaquin River to the deep, wide ship channel, a transition which promotes settling of suspended material including algae and encourages occasional channel stratification. Under low dissolved oxygen conditions the Stockton Deep Water Ship Channel acts as a barrier to migrating salmon. Management solutions to address this problem involve (1) recognition of the relative contribution to the problem by agricultural, wetland and municipal sources; (2) coordinated continuous monitoring of the factors contributing to low dissolved oxygen in the SDWSC; and (3) development of a decision support and management tool that allows forecasting of future dissolved oxygen conditions in the SDWSC and will assist real-time management of techniques to address the problem when it develops. A goal of real-time forecasting of dissolved oxygen in the San Joaquin River will be to improve coordination of activities among those entities that directly benefit from and depend on the resources of the San Joaquin River system leading to an overall improvement in San Joaquin River water quality. There are many implementation options that could provide additional benefit if integrated into a real time management system. These include: operations of South Delta barriers, low head recirculation pumping at the Head of Old River, aeration in the DWSC, release timing of effluent discharge from wastewater treatment plants, release timing of flows from duck clubs, wetlands and wildlife refugees, release timing of flows from urban stormwater holding ponds, and release timing and flow levels from east side tributaries for fall pulse salmon attraction flows.

2. Justification : (including conceptual model and hypotheses)

Theory

Bowie et al (1985) define the factors that are known to influence the rate of CBOD removal from a water column as water temperature, hydraulic factors, stream geometry and the nature of carbonaceous material. CBOD decay occurs at a rate that increases with temperature to the point wher proteins begin to denature. The usual form of this relationship is as follows :

$$k_T = k_{20}\,\theta^{(T-20)}$$

Where : k_T = rate constant at temperature T

k_{20} = rate constant at temperature 20 degrees C

θ = empirical constant

Modelers typically only consider the temperature effect on nitrification (Bowie et al., 1985) – hence temperature effects are most commonly simulated using the follwing expression :

$$k_n = k_{n20}\,\theta^{(T-20)}$$

Where : k_{n20} = rate constant at temperature 20 degrees C

θ = temperature correction factor.

Physical setting

The occurrence of low dissolved conditions in the Stockton Deep Water Ship Channel is attributable to a number of factors which in combination can lead to conditions that create an effective barrier to anadromous fish migration in the San Joaquin River. The most important of these factors are low residence time, high temperatures, vertical mixing, high concentrations and loading of oxygen demanding substances, high nutrient concentrations, phytoplankton growth in the contributing watershed and high summer temperatures. The relative importance of these factors singly or in combination is still relatively unknown owing to a lack of data collected in a systematic fashion. Several theories have been advanced by the scientists who have been working on this problem during the past 2 years. The most cogent of these is that the Stockton Deep Water Ship Channel configuration, whereby a relatively fast moving 100 ft wide, 10ft deep San Joaquin River enters a 500 ft wide, 35 ft deep slow moving water body, subject to tidal action, creating conditions that are adverse to the maintenance of dissolved oxygen concentrations above 5 mg/l. These conditions are most prevalent in the summer and late fall when temperatures rise, lowering the saturation concentration for dissolved oxygen and irrigation return flows diminish, resulting in lower net flows through the Ship channel. The slow moving water column has a high residence time in the Ship Channel, encouraging sedimentation of suspended solids including algae and creates conditions conducive to water column stratification. Occasional mixing of the surface and near bottom water is provided by the passage of large ships which berth in the ship channel and which traverse the ship channel to the Turning basin. Residence time in the reach between Turner Cut and the Turning Basin has been estimated to range between 5 and 25 days.

Conceptual Model

Phytoplankton, when living, produce oxygen during photosynthesis and consume oxygen during respiration. Photosynthesis only occurs when light can penetrate the water column hence oxygenation of the San Joaquin River and the Stockton Deep Water Ship Channel is dependent on turbidity as well as temperature. Experimental findings presented by members of the Stockton Dissolved Oxygen Technical Advisory Committee have shown that mass loading of phytoplankton can be high from upper watershed sources where water is often stagnant for short periods of time and nutrient levels of nitrogen and phosphorus are high, leading to a build-up of aquatic plants including algae. These factors appear to be important early in the summer whereas dissolved oxygen sag caused by nitrogen loading, including both ammonia and non-ammonia TKN is prevalent in the late summer and fall, based on BOD and CBOD experiments (Lehman, 2001).

Oxygen dynamics and fish health.

Over the long term oxygen production by algal photosynthesis and its consumption by bacterial respiration are in balance. In the short term the production and consumption sites are in different locations giving rise to low oxygen that bocks fish migration and may even result in occasional fish kills (Horne, 2001). In the surface waters algae produce much more oxygen by photosynthesis than they consume via respiration. Eutrophic surface waters often exceed 150% of oxygen saturation, more in warm summer water. Even at night when photosynthesis ceases but respiration continues there is usually ample oxygen for fish and other wildlife. However, because oxygen forms bubbles at over 120% saturation, much of the valuable oxygen is lost to the atmosphere leaving a net deficit in the water.

The main problem with algae in shallow waters occurs after they die. Dead and dying algae in the bottom waters and sediments easily overwhelm the small oxygen carrying capacity of water. For example, in air, oxygen comprises about 20% of the volume while in warm water the contribution is almost 40 times lower at about 0.5%.

Although the main features of oxygen sags caused by algae outlined above are clear, in practice it has been very hard to predict the actual oxygen depressions in real situations. Prediction is least reliable in shallow waters such as those in the Ship Canal and throughout the Delta. For example in the deep water or hypolimnion of large reservoirs the oxygen depletion due to algae can be predicted at 0.1 to 0.25 mg/L/d for eutrophic systems. However, recent data in shallow waters in California, Oregon and Minnesota shows that oxygen depletions of over 1 mg/L/d and even more can occur (USBR, 2001 for Upper Klamath Lake). A recent example is shown in Table 1.

Table 1. Rapid diurnal changes in deeper water DO in late summer in Bridgeport Reservoir, a eutrophic system similar to the Ship Channel in several aspects (warm water, depth, high algae, DO impairment listings). Data from Horne, unpublished.

Depth m	**8 am**	**11 am**	**1 pm**	**4:30 pm**	**7 pm**
DO mg/L					
1 m	16	9.8	11.5	12.5	11.3
7 m	4.7	3.7	2.7	2.3	3.6
Temp ^{o}C					
1 m	17.7	17.9	19.7	21.4	18.0
7 m	15.6	15.5	15.4	15.4	15.4
DO change/h – 7 m	-	- 0.33	-0.5	- 0.12	+ 0.5
Temp change/h – 7m	-	+ 0.07	- 0.05	0.0	0.0

Note that while the temperature at 7 m (23 feet) shows hardly any change, and thus no vertical mixing, the DO varies up and down by as much as 2.4 mg/L between morning and late afternoon (Table 1). The expected variations in temperature and DO due to solar heating and photosynthesis occurred in the upper water layer, here shown by the 1 m layer. It is not clear what causes these large DO changes in deep water when vertical mixing is absent. Horizontal fluxes of water are possible but are difficult to model or to measure.

The BOD and COD needed to generate such declines has not been well characterized. Recent studies of storm water showed only very small BOD of < 2 mg/L/5 days and usually < 3 mg/L over 30 days (Horne, 2001). The only sources of high short-term BOD are the sediments, inflows from natural or human wastes, or extra-cellular production from algae that is not measured by conventional means. Another alternative is the lack of a process that supplies DO such as the decrease in vertical mixing that accompanies calm weather or even a change in wind direction from the long to the short axis of the water body. Most of these variables can be incorporated into a conventional DO model but local parameters are important, especially in very dynamic shallow waters (Chapra & Reckhow, 1983). In fully mixed models (e. G. Geider et al., 1998) only light, nutrients and temperature are used but this approach in only ideal in deeper water where all action occurs above the thermocline. In the Ship Canal area the thermocline may reach the bottom on cooler windy days but be present everywhere in very warm calm days. Lemckert & Imberger, 1998; Saggio & Imberger 2001).

Failure to fully anticipate the oxygen demands of lakes and shallow estuaries has led to a burst of research and deployment of oxygenation systems (see review by Beutel & Horne, 1999). In a current development, the USBR is supporting a congressionally mandated oxygenation experiment in Upper Klamath Lake (Horne, 2001). This mostly shallow system with deep pockets of up to 35 feet deep and with strong wind current stirring has strong similarities with parts of the Ship Canal and surrounding waters. Oxygeanation or aeration is a good potential cure to remove impairment to beneficial uses in the Ship Channel until the TMDL process in the watershed can remove sufficient nutrients to reduce algal growth. However, oxygenation could be expensive but cost would be reduced dramatically if real-time monitoring could be accomplished. The concept has been tried in the River Thames estuary where a large barge that generates oxygen moves to spots in the river where oxygen sensors detect low DO (see Horne Goldman, 1994 pg. 419). Although successful at times the "Thames Bubbler" deployment would be much more efficient with a better monitoring and low DO detection system.

Dissolved oxygen modeling

Models for dissolved oxygen concentrations in rivers and estuaries have been around for over a century. The mathematical and biochemical basis for dissolved oxygen analysis was formulated by O'Connor (1960) and Thomann (1963) who recognized that the process of stabilization of oxidizable material led to a reduction of dissolved oxygen in streams. Perhaps the most commonly used model for dissolved oxygen sag is the Streeter-Phelps equation which represents the dissolved oxygen response to a single point discharge of a pollutant (Thomann and Mueller, 1987).

Chen and Tsai (2000) developed a dissolved oxygen model for the City of Stockton in 1993 which utilizes a link-node formulation of the San Joaquin River and South Delta. The model accounts for the solubility of dissolved oxygen as a function of temperature and considers sinks due to BOD decay, ammonia oxidation and algae respiration. The model was calibrated with 1991 data including real-time meteorological data, tide and waste load discharge data from the City of Stockton. Results from the model simulations showed reasonable match to water quality observed during the months of August and September.

The Delta Simulation Model 2 (DSM2) is a computer model of river, estuary, and land processes that are combined in a package of three main modules: Hydrodynamics (Hydro), water quality (Qual), and particle tracking (PTM). The three modules share a common input and output system, and hydrodynamic information from Hydro is passed to Qual and PTM via a Fortran binary file which contains instantaneous and time-averaged stage and flow data (DWR web site http://modeling.water.ca.gov/delta/reports/annrpt/1997/chap2.html). The Delta Simulation Model (DSM-2) is the primary tool used by the Department of Water Resources for delta hydrodynamic studies. The model began as an independent, public-domain application of the original Fisher-Delta model (the first comprehensive model of delta hydrodynamics). The model has evolved to become the most detailed and data intensive simulation tool for the Delta. The DSM-2 model has recently been extended along the San Joaquin River to include the lower river and its major tributaries.

DSM2-Hydro, the hydrodynamics module, is derived from the U.S. Geological Survey's FourPt model. It has been modified by DWR for reservoirs and gates, as well as binary output. DSM2-Qual, the water quality module, is derived from the U.S. Geological Survey's Branched Lagrangian Transport Model, written by Harvey Jobson. It has been extensively modified by Hari Rajbhandari (DWR) to handle multiple, non-conservative constituents and water temperature. The model allows any number of cross sections, with any number of layers; interpolates along the channel before runtime; checks for possible sources of error before the run; and uses output from a Bathymetry Data Display (BDD) program as its input.

DSM2-Qual, the water quality simulator is capable of modeling multiple conservative constituents from different sources. At this time, Qual can simulate conservative constituents from different sources in a single run, and the following non-conservative constituents: water temperature, dissolved oxygen, organic nitrogen, ammonia nitrogen, nitrate nitrogen, nitrite nitrogen, phosphate, phosphorus, organic phosphorus, algae, and biochemical oxygen demand.

Water Quality Module (Qual)

DSM2-PTM is the Particle Tracking Module of DSM2 and is used to simulate fish movement and the migration of other “smart constituents in the Delta”.

DSM2-DICU is the Land Processes Module and is used to estimate drainage water quantity and quality from Delta islands. The model represents the interaction between the water bodies and adjacent agricultural lands.

The reasons for selection of this model for the proposed project are as follows :

- It resides in the public domain and is accessible from DWR’s web site.
- Training classes have been organized by DWR in the past and will be continued to encourage proper use of the model.
- Several individuals within DWR have used the model in planning projects to simulate dissolved oxygen concentrations in the Delta and San Joaquin River in the recent past. DWR will make some preliminary simulations for the Stockton DO technical Advisory Committee during 2001.
- The model is continually under development by a large staff within the department of Water Resources. Hence resources are available to make corrections and improvements to the existing code.
- The model has undergone an extensive preliminary peer review under the auspices of the Bay-Delta Modeling Forum.

BIOLOGICAL/ECOLOGICAL OBJECTIVES

Hypothesis/Question to be Evaluated	Monitoring Parameter(s) and Data Collection Approach	Data Evaluation Approach	Comments/Data Priority
A reliable model can be developed and used to forecast dissolved oxygen conditions in the San Joaquin River and Stockton Deep water Ship Channel	A number of water quality parameters at key sites along the San Joaquin River and in the Stockton deep water Ship Channel including DO, temperature, EC, turbidity, BOD, chlorophyll a.	Analysis will compare forecast and measured values of key parameters. Where systematic errors occur model will be evaluated, recalibrated or reformulated to address discrepancies.	Model development will be adaptive relying on short feedback loops to test each of the conceptual submodels that are contained in the DSM-2 computer code.
Deterministic relationships exist between model parameters and field measurements made using real-time sensors and other rapid analytical methods.	Comparisons will be made between field and laboratory measurements of water quality parameters such as DO, temperature, EC, turbidity, BOD and chlorophll a.	Single parameter sensors and sensors in combination will be tested to ascertain reliable relationships using regression techniques.	Real-time (continuous) sensors may not be reliable in all instances especially for those monitors that are prone to fouling. Other techniques may need to be explored.
Can the DO deficit block to fish migration be overcome by sustainable oxygenation?	DO, algae, water volumes,tidal excursions, wind and solar radiation data	Organize old and new DO/algae data. Calculate DO additions needed Detemine oxygenation system needed	New solar/wind methods improve efficiency. Worst DO defecit when wind/solar are optimal.
Is integration of model functions separately dealing with EC, temperature and dissolved oxygen feasible and cost-effective.	Predicted and measured values of key parameters will be compared for EC, temperature and dissolved oxygen	Review institutional and logistical aspects of making joint forecasts for EC and dissolved oxygen in the San Joaquin river and SDWSC.	Institutional (management and funding) and logistical impediments (data availability, access) may occur that make this goal difficult to achieve

3. Approach :

Proposed scope of work**:**

a. Review the past three years of data collected by the SJR Low DO TMDL Project research team, together with supportive data to develop relationships between continuous monitors and those factors that are not amenable to continuous monitoring but are important for modeling algal nutrient loading, algal load dynamics and dissolved oxygen depletion in the San Joaquin River Deep Water Ship Channel. (Horne, Quinn, Stringfellow).

1. Review of literature and past experimentation
2. Determine input requirements of the model. Develop relationship between surrogate parameters that can be measured by continuous monitors in the field and input variables needed for model input.
3. Formulate monitoring plan to collect input data for the predictive model.

b Based on an analysis of existing real-time flow and water quality monitoring and in collaboration with the Department of Water Resources (Dr. Peggy Lehman) select key monitoring stations to be upgraded to include continuous measurement of turbidity, temperature, EC, pH, dissolved oxygen and chlorophyll. If cost-share funds are available, the establishment and installation of new stations will be considered. Evaluate specific ion sensors and light absorbance sensors for organic carbon, if reliable continuous sensors can be obtained at reasonable cost. Maintain or assist in maintenance of monitoring stations for two years. Cooperate with the Interagency Ecological Program (IEP) and provide support to ensure real-time access to monitoring data in the IEP database and though the California Data Exchange (CDEC) (Quinn, Stringfellow, Jacobs)

1. Develop Monitoring and Quality Assurance Project Plan.
2. Select water quality monitoring sensor upgrades at key existing real-time monitoring stations. Coordinate monitoring with other CALFED programs including the interagency SJRMP Water Quality Subcommittee that performs weekly EC forecasts for the lower San Joaquin River. Evaluate need for new monitoring stations and seek cost-share.
3. Install and maintain new sensors at existing locations for two years. Cooperate in installation of new monitoring stations.
4. Utilize relationships developed by researchers currently involved in the project and incorporate in model so as to relate factors influencing dissolved oxygen dynamics to continuously monitored parameters.

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Previous research conducted by Horne, Chen, Lee and Lehman will provide a preliminary linkage between the factors important to the model in predicting dissolved oxygen concentrations in the Stockton Deep Water Ship Channel and those parameters that can be reliably monitored using continuous commercial electronic sensors. If CALFED is to transition from monitoring and research of the DO problem to operations and management of potential remedial measures these real-time sensors will become the backbone of this system. Making the system cost-effective and affordable will rely on close cooperation and cost sharing between synergistic programs.

c. Develop and improve the existing DSM-2 model using continuous monitoring data as a forecasting tool for dissolved oxygen depletion in the SJR DWSC (Chen, Hutton)

Improve the existing DSM-2 model with new DO algorithms

1. Improve the DSM-2 model to account for temporary-short term stratification in Deep Water Ship Channel.
2. Calibrate the model using existing data.
3. Modify the improved DSM-2 model into a forecasting tool in consultation with Dr Carl Chen. These improvements will include coding to simulate a 2-D Deep Water Ship Channel potentially using Dr Chen's proposed conceptual model (Figure 2).

4. Review preliminary data from Stringfellow et al. (CALFED proposal entitled " *Understanding and Characterizing Sources of Biological Oxygen Demand in West-Side Tributaries of the San Joaquin River*") and recalibrate model against data set collected under the well-controlled conditions in the San Luis Drain (if proposal is funded).

Dr. Chen of Systech Inc. has developed new algorithms for his DO model of the Deep Water Ship Channel The model generally simulated the time series of the mid-depth DO for all locations and the concentration profile of DO for specific dates. Compared to the observed data of year 2000, the mean relative error of DO prediction for mid-depth values, measured by the City of Stockton stations, was -0.25 mg/l and the mean absolute error was 0.59 mg/l. The new algorithms can be incorporated into DSM2 model for the upstream section of the San Joaquin River.

For the downstream section in the Deep Water Ship Channel, where stratification may develop during the hot summer when the river flow is very low, we propose to incorporate a series of vertical layers into the DSM2 model (see Figure 2). Thus the improved DSM2 will account for the vertical variation of temperature, light, particulate settling, and algae growth, which will result in a vertical variation of DO in the DWSC. This can be accomplished in the water quality module, without changing the tidal hydrodynamic calculations. The hydrodynamic module simulates the tidal flows at a time step of minutes. The hydrodynamic solutions are saved in file for input to the water quality module.

For the water quality module, the total channel flow simulated by the hydrodynamic module will be split into layers. Initially, we may split the flow in proportion to the cross sectional area. Later, we may introduce a weighting factor as a function of temperature and bottom viscosity, if necessary. The DSM2 water quality module uses a Lagrangian technique to track the mass in moving parcels of water, whereas Dr. Chen's model is based on the Euler grid that tracks the mass moving in and out of stationary nodes. The water quality processes, sources, and sinks are otherwise similar. The water quality equations that have been developed in Dr. Chen's DO model can be incorporated into the DSM2 water quality module. The Lagrangian tracking for the separate layers will be modified to account for vertical exchange by settling and turbulence. The layers will be mixed as tidal flow moves into the vertically mixed section of the river.

d. Perform weekly forecasts of dissolved oxygen in the San Joaquin River and Ship Channel with DSM-2 model using protocols developed by the SJRMP Water Quality Subcommittee during typical periods of non-compliance during the summer and fall (Quinn, Horne, Hutton, Chen, Jacobs)
   1. Use results during year one of project to adaptively improve predictive power of DSM-2 hydrodynamic and water quality model.
   2. Develop web site for public dissemination of model forecast during second year of project.

An important element of real time water quality management is to communicate rapidly with stakeholders including water quality managers about the model forecast of impending DO violations and the necessary remedial measures that must be undertaken. One of the most effective media for such purpose is through the creation of a web site. A web site that has been created for the Internet stakeholder process, through which stakeholders can login, see calendar of events, request for model runs, and view model results in graphs and GIS maps.

e. Based on tasks (a) through (d), the PIs will work with the Steering and Technical Advisory Committees of the SJR DO TMDL process to develop and evaluate different management strategies for potential future operations. The Steering Committee will have completed a scope of implementation options and a screening criteria in Spring 2002 (Horne, Quinn, Chen).

By fall when this project will be underway, a wide variety of different options will be evaluated. The project PIs will organize and evaluate these options for synergistic benefits under different integrated options at the direction of the Steering Committee. Management scenarios will likely include but are not limited to aerators in the DWSC, potential operable barriers at the head of the Old River and in the South Delta, pumping of water from South Delta to argument the river flow in San Joaquin River, changes in waste water treatment operations, improvements to agricultural and wetland return flow management practices, and urban stormwater control options. PIs for this project will also supplement where needed the existing literature review done through the CALFED 2000 funded aeration review and the proposed CALFED 2002 PSP Best Management Practice Inventory and Evaluation project (Bill Power).

1. Compare and contrast management strategies to control discharge of organic and inorganic substances and nutrients that affect dissolved oxygen levels in the San Joaquin River and Stockton Deep Water Ship Channel from a technical perspective.
2. At the direction of SJR DO TMDL Steering and Technical Advisory Committees, organize the selected scenarios and help direct the use of the model, where possible, to test these best potential management strategies. Strategies will be evaluated over all year water year types and include analysis on economic and secondary environmental impacts
3. Within the scope of management strategies, develop and evaluate best scenarios for the use of real time forecasting as a management tool.

This work will benefit from the $60,000 CALFED funded review of the literature on different aeration options including their capital and maintenance costs, DO benefits, secondary impacts and other factors. From this literature review, a preferred alternative method of aeration based on the needs of the DWSC is expected to be proposed. This information will provide direction for how aeration options should be modeled and evaluated as part of a stand alone or integrated implementation plan.

In addition, the Steering Committee hopes that the CALFED 2002 PSP will fund the BMP Inventory and Evaluation project (Bill Power). This will provide information on what can be expected in the reduction of nutrient runoff. This information combined with the local watershed assessment and preference that will arise if the Steering Committee funded Restoration Planning for Watersheds proposal is funded should provide additional critically important information to an integrated evaluation of implementation scenarios.

The Real Time Forecasting proposal will supplement the existing reference review to help provide the Steering Committee with the information it will need to help select a set of integrated implementation scenarios to evaluate under different water year types.

4. Feasibility

The concept of real-time coordination of drainage water with San Joaquin River assimilative capacity has been successfully demonstrated by the SJRMP-WQS. The concept of powering oxygenation systems using solar power has been demonstrated in small commercially-available systems for small ponds (but not on a large scale). It is envisaged that any long-term sustainable solution to the current dissolved oxygen problem will be equitable, cost effective and sustainable. Hence this study will not limit the options under review unless explicitly directed by the Steering Committee and Technical Advisory Committee as a result of interaction with stakeholders.

5. Performance measures

The most obvious performance measure is the comparison of forecast dissolved oxygen concentrations in the San Joaquin River and Stockton Ship Channel and actual observations. These comparisons will be made continually during the model forecast periods, which will occur during the late summer and fall months, for the two year term of the project. These comparisons will provide the feedback that constitutes the "adaptive" element of this project – whereby the model is continually calibrated and fine-tuned to improve predictive capability.

Another important performance measure will be the public acceptance of the model and the participation of stakeholders in the forecast modeling process. Some of the groundwork for this has already been laid by the Water Quality Subcommittee of the San Joaquin River Management Program of which Nigel Quinn on the project team is a member. The Stockton DO project has a larger potential stakeholder community and hence outreach will play an important role in ensuring the success of the project and the long-term viability of the concept of real-time water quality management.

6. Data handling and storage

The purpose of real-time forecasting of dissolved oxygen and salinity in the San Joaquin River is to improve coordination of activities among those entities that directly benefit from and depend on the resources of the San Joaquin River system leading to an overall improvement in San Joaquin River water quality. The major part of the project concerns monitoring and modeling - improving automation and cost effectiveness of data collection and coordinating modeling activities to the benefit of all three projects. The primary goal of this proposal is to share data and resources among three existing CALFED water quality projects - leading to greater efficiency and cost effectiveness of data collection.

Activities of these and other monitoring and adaptive management programs will be coordinated through the Stockton DO TAC and the San Joaquin River Management Program. Data will be freely exchanged between the participating agencies, providing the modelers making forecasts of dissolved oxygen on the San Joaquin River with accurate and timely information. The project will expand use of the internet by providing timely forecasts of San Joaquin River water quality and will strive to involve all affected and contributing communities in water quality monitoring. For example the Grassland Water District salinity adaptive management project has a website that attempts to provide private landowners and duck club operators with current information on best management practices (obtained from one of the project sites) that can reduce discharge to the River at critical periods for downstream water quality.

7. Expected products/outcomes

The project will expand use of the internet by providing timely forecasts of San Joaquin River water quality and will strive to involve all affected and contributing communities in water quality monitoring. The automation proposed in the project and the use of shared databases and other resources for enhancing communication between current CALFED projects will result in improved technology transfer and will improve the likelihood that these initiatives will be continued after the current project term has expired. The goal of all watershed projects should be self-sufficiency - whereby CALFED provides resources to overcome initial inertia and obtain evidence of real community benefit after which the local community finds ways to support at a minimum those aspects of the project that are likely to provide a positive benefit stream. The project recipients intend to publish the anticipated success of this project in white papers suitable for publication in both the popular and academic literature so that other might gain from the experience gained.

8. Work schedule

The work schedule is shown in the table below. Five progress reports and two annual project reports will be prepared summarizing the objectives accomplished during the year and results from monitoring and modeling activities.

PROJECT MONTH		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
REPORTS					x				x				xx			x			x			x			xx
TASK a		x	x	x	x	x	x	x	x	x															
TASK b								x	x	x	x	x	x	x	x	x	x	x	x	x	x	x			
TASK c						x	x	x	x	x								x	x	x	x	x			
TASK d						x	x	x	x	x								x	x	x	x	x			
TASK e		x	x	x	x	x	x									x	x	x	x	x	x	x			

B. APPLICABILITY TO CALFED ERP AND SCIENCE PROGRAM GOALS AND IMPLEMENTATION PLAN

1. ERP, Science Program and CVPIA Priorities

Salinity, dissolved oxygen and temperature have been identified by the SJRMP Executive Council as water quality stressors of concern in the San Joaquin River. Low dissolved oxygen concentrations in the San Joaquin River Deep Water Ship Channel may create a barrier to anadromous fish migration during critical periods of their life cycle. The proposed data collection program would create the foundation of an adaptive management strategy that could dovetail with current SJRMP and CALFED-sponsored initiatives on real-time quality management in the San Joaquin River.

2. Relationship to Other Ecosystem Restoration Projects

The data collection suggested as part of this adaptive wetland management proposal is consistent with the current CALFED-sponsored initiative on real-time water quality management in the San Joaquin River and with the Vernalis Adaptive Management Program (VAMP), a multi-agency experiment to improve the San Joaquin River fishery through manipulation of tributary flows and flow release schedules. Attachment 4 shows the linkage of this proposal and the CALFED focus action that concentrates on the main-stem of the San Joaquin River. Other linked projects are :

1. The Coordinated Regional Management Program (CRMP) actions to reduce contaminant loading and sediment erosion produced by ephemeral rainfall runoff events in the Panoche Creek Watershed. Salt and selenium generated by Panoche-Silver Creek affects the assimilative capacity

of the San Joaquin River for salt and selenium and hence the
2. Grassland Bypass Project. This project limits monthly selenium loads from the Grassland agricultural water districts and hence affects the assimilative capacity of the San Joaquin River for salt, selenium and boron.
3. Oxygenation but not in a sustainable mode is needed for the reversal of eutrophication, fish habitat improvement and water quality improvement (eg. Ammonia reduction) in most of the State Water Project Reservoirs including San Luis. Local reservoirs such as those for EBMUD, Contra Costa, San Francisco and Marin are installing oxygenation systems but costs of power are a long-term concern.

3. System Wide Ecosystem Benefits
The proposed project provides a unique opportunity for integration of a number of previously funded CALFED initiatives dealing with water quality management in the San Joaquin River . Although there will undoubtedly be institutional and logistical resistance to this type of integration, especially if it is perceived that the project will require the formation of new institutions to cope with water quality management to satisfy regulatory constraints. However, the project proponents believe strongly that this is inevitable and should not be used as an excuse for inertia if CALFED is to complete its mission and develop a long-term, robust and sustainable plan for the future.

C. APPLICANT QUALIFICATIONS

Alex J. Horne, PhD : Professor, University of California, Berkeley.
Dr. Horne obtained his B.Sc. in 1964 at the University of Bristol, England with a major in Biochemistry (Chemistry & Zoology options) and a Ph.D. in 1969 at the University of Dundee, Scotland with emphasis in Limnology & Oceanography. Dr Horne has been the professor of Ecological Engineering at the Department of Civil & Environmental Engineering at the University of California since 1971. Initial research on algae in lakes, oceans, and wetlands in four continents included the first studies on the eutrophication of Clear Lake California (1970-78). He is an expert in biological and chemical aspects of water and aquatic management including pollution in lakes, reservoirs, wetlands, rivers, streams, estuaries and the open ocean. He has studied lakes, reservoirs, streams, wetlands and oceans in Africa, Antarctica, Alaska, Europe, Australia, Asia, N. & S. America. He has been principal investigator in over 50 research projects and acted as a major consultant or advisor in over 300 water-related projects in California, Nevada, Arizona, Oregon, Washington, Colorado, Florida, New York, as well as Canada, Taiwan, Central America & Australia. Areas of specialty include: toxicity & biostimulation of domestic, industrial, & agricultural waste waters on animals & plants in lakes, reservoirs, wetlands, rivers, estuaries, coastal waters & deep oceans. Environmental effects of large-scale ocean thermal power plants using cold, deep nutrient-rich cooling water with surface disposal. Sewage, oil, heavy metal & selenium pollution. Water reuse and wetlands for heavy metal and nutrient removal. In situ pollution monitoring with bivalves & attached algae. Eutrophication & algal nuisance control in freshwater lakes, rivers, & estuaries. Effects of urban runoff. Design & management of drinking water and recreational reservoirs, taste & odor & algal toxicity problems. Recent projects include large & small constructed wetlands for wastewater treatment and drinking water, copper in urban runoff, reservoir oxygenation for fish health & eutrophication reversal, TOC/DOC and taste & odor reduction in reservoirs, saline lake revival and the restoration of Mountain Lake in San Francisco, Indian Creek Reservoir & Hot Creek near L. Tahoe, Indian Creek Wetlands in Contra Costa Co., Lake Elsinore & Newport Bay-estuary in S. California & saline Walker Lake, Nevada.

Nigel W.T. Quinn, PhD, P.E.: Asst. Research Engineer, UC Berkeley
Dr. Quinn is a Water Resources Engineer and Research Hydrogeologist specializing in the application and development of watershed scale models to solve salinity, selenium and related water quality problems in the San Joaquin Valley of California. Dr Quinn is a Professional Engineer and holds positions at both Lawrence Berkeley National Laboratory and at the University of California, Berkeley. He has worked as a consultant to the US Bureau of Reclamation for the past 13 years and is currently under contract with that institution leading projects on regional groundwater model development and real-time water quality monitoring and modeling of the San Joaquin River and managed wetlands within the Grassland Basin. Dr Quinn is a principal investigator on several CALFED projects including projects dealing with Stockton Deep Water Ship Channel Dissolved Oxygen, San Joaquin River water quality management, Panoche-Silver Creek selenium load management and an EPA-funded project on impacts of Global Climate Change. He has a BSc (Hons) degree from Cranfield Institute of Technology in England, graduating at the top of his class in irrigation and drainage engineering, an MS degree in civil and agricultural engineering from Iowa State University and a PhD from Cornell University in water resource systems engineering. He is the author of over 50 publications in the area of water resource systems engineering.

Carl W. Chen, PhD, P.E. : President, Systech Engineering
Dr Chen received his BS degree in Civil Engineering from the National Taiwan University in 1958 and his MS and PhD from U.C. Berkeley in 1963 and 1968 respectively. From 1983-present he has been President of Systech Engineering, Inc. Dr. Chen has directed the development of a GIS-based decision support system, WARMF, for watershed approach and TMDL calculations. WARMF was applied to numerous basins (Catawba, Cheat, Truckee, Chartier, Oostanaula, Dillion, Mica and Techi). WARMF has been used to calculate TMDLs for nutrients, BOD, coliform, sediment, septic, and metals of acid mine drainage. He is involved in the TMDL study of Lower San Joaquin River, which receives BOD and ammonia loads from point source dischargers and P and N loads from dairies and agricultural farms in the San Joaquin Valley of California. The nutrients promote the growth of algae in the upstream section, which becomes DO sinks in the downstream. Dr. Chen also developed the TMDL of copper discharge to South San Francisco Bay. Between 1973 and 1983 Dr Chen was the Vice President of Tetra Tech, Inc. Dr. Chen established and operated its branch office in Northern California. He developed and supervised such projects as the ecological effects of thermal discharge (316a study), fishery impacts of power plant entrainment (316b study), integrated lake-watershed acidification study, regional planning of nonpoint source pollution (208 study), power plant intake data base, eutrophication modeling of Lake Ontario, impact analyses of ocean outfall (301h study), and dredge disposal study. Dr. Chen has pioneered the development of many models that are used throughout the United States: Storm Water Management (SWMM), Lake Eutrophication (LAKECO), Water Quality for River and Reservoir System (WQRRS), and the Estuary Hydrodynamics Water Quality (Link-Node). Dr. Chen has published 50 papers in professional journals, received 1993 ASCE Greeley Award, held a US Patent (4,863,083), taught classes at the University of California, Berkeley and Davis, and Hydrologic Engineering Center (HEC). He was also a member of the United Nations Mission to Mexico on water resources and water quality.

Paul Hutton, PhD, P.E. : Chief, Delta Modeling Section, Department of Water Resources
Dr. Hutton is a Supervising Engineer with the Department of Water Resources and is Chief of the Department's Delta Modeling Section. Prior to accepting his current

position, Dr. Hutton managed the CALFED Drinking Water Quality Program. He has 17 years of professional experience in the areas of water resources and environmental engineering planning, design, construction and operations. Dr. Hutton is currently a principal investigator on two CALFED projects related to Stockton Deep Water Ship Channel dissolved oxygen. He holds a B.S. degree in Civil Engineering and a M.S. degree in Environmental Engineering, both from the University of Illinois, Champaign-Urbana. He also holds a Ph.D. degree in Civil and Environmental Engineering from the University of California, Davis.

William Stringfellow, PhD : Staff Scientist, Berkeley National Laboratory

William T. Stringfellow received his B. S. in Environmental Health from the University of Georgia (Athens, GA) in 1980. He received his Master's Degree in Microbial Physiology and Aquatic Ecology from Virginia Tech (Blacksburg, VA) in 1984. At the completion of his MS, he worked for Sybron Chemicals Co. as a Research Scientist, investigating the biological treatment of industrial wastes. In this capacity, he was responsible for the development of a patented technology to biologically control algae blooms in waste-water lagoons (Patent No. US1988000191073). During his tenure at Sybron, he provided consulting concerning the biological treatment of industrial wastes in the Eastern U. S. and Europe. His areas of expertise include ammonia oxidation (nitrification) and the biological treatment of petroleum industry wastes. In 1988, he took a position at the Institute Pasteur (Paris, France) as a Pre-Doctoral Fellow developing novel fermentation processes for the production antigenic polysaccharides. During this time, he continued to consult for industrial and municipal waste-water treatment plants in Europe. In 1990, he returned to the U. S. to get his Doctorate. He received his Ph. D. in Environmental Sciences and Engineering from the University of North Carolina at Chapel Hill in 1994 and worked as a Post-Doctoral Fellow in the Civil and Environmental Engineering Department at the University of California at Berkeley. Currently, Dr. Stringfellow is a Research Engineer at Lawrence Berkeley National Laboratory, where his research addresses microbial processes occurring in engineered systems and advanced techniques for waste-water treatment.

D. COST

The proposed project will have a two year term.
Budget Costs : (2 year duration) : Total cost : $ 980,310

TASK NO.	UCB		DWR	SYSTECH	LBNL	TRAVEL / SUPPLIES / EQUIPMENT (UCB)
Task a	95,380					
Task b	221,979				60,000	105,000
Task c	155,098		40,000	100,000		5,000
Task d	232,829		40,000	20,000		5,000
Task e	275,024		40,000	40,000		5,000
TOTALS	980,310		120,000	160,000	60,000	120,000

E. LOCAL INVOLVEMENT

Since the proposed project will fuse the modeling and aspects of data gathering in three existing CALFED implementation projects - CALFED will gain from existing community partnerships that have been developed by all three grant recipients. The CALFED Stockton Dissolved Oxygen project and TMDL initiative has also involved a wide circle of potentially affected stakeholders from the City of Stockton officials to ranchers, dairymen and wetland managers. Outreach from this initiative has been through the Steering Committee. Hence the proposed study will likely enhance existing partnerships between CALFED and the local community by improving access to existing data and scientific findings.

The Real-Time Water Quality Management CALFED project currently works closely with the USBR and the San Joaquin River Management Authority during the VAMP period (April 15 - May 15). This involves working with agencies such as MID, TID , Oakdale ID and the Exchange Contractors to forecast west-side surface and groundwater accretions as well as major diversions from west-side riparian contractors so that fish flows are maintained at target levels for the entire VAMP period.

In the case of the Grassland Water District Adaptive Real-Time Salinity Management Project the water district has used its newsletter to explain the goals and objectives of the CALFED project to the entire waterfowl hunting community that subscribes to their newsletter. An individual Duck Club (Salinas Club) has agreed to participate in the CALFED project and to allow intensive monitoring of individual wetlands within the Club perimeter. An exhibit has been manned for the past two years at the Wild-on-Wetlands event to educate the general public on the purpose of the CALFED project and the various types of monitoring equipment deployed.

The automation proposed in the project and the use of shared databases and other resources for enhancing communication between current CALFED projects will result in improved technology transfer and will improve the likelihood that these initiatives will be continued after the project term has expired. The goal of all watershed projects should be self-sufficiency - whereby CALFED provides resources to overcome initial inertia and obtain evidence of real community benefit after which the local community finds ways to support at a minimum those aspects of the project that are likely to provide a positive benefit stream. The project recipients intend to publish the anticipated success of this project in white papers suitable for publication in both the popular and academic literature so that other might gain from the experience gained.

F. PROJECT PERFORMANCE EVALUATION

Plan for project performance evaluation

This project has research and monitoring components. Oversight of both of these components is maintained by a Technical Advisory Committee (TAC) and a Steering Committee (SC) to the San Joaquin River Dissolved Oxygen Project. The Steering Committee comprises the major stakeholders who are either responsible or directly affected by low dissolved oxygen conditions in the San Joaquin River. The TAC comprises all of the project Principal Investigators on the San Joaquin Dissolved Oxygen Project. The Chair of the TAC, Dr Fred Lee, is also the designated CALFED Principal Investigator on the project. Quarterly progress reports and annual reports are reviewed by the TAC and the project Principal Investigator. Problems or issues raised during this review are brought first to the TAC for resolution and second to the Steering Committee. The evaluation criteria include :

1. Progress toward fulfilling project objectives.
2. Completion of all project sub-tasks.
3. Adherence to quality assurance project plan.
4. Timeliness of project accomplishments.
5. Reports on time and complete.

Narrative description of performance measures to be used

The specific performance measures fall into two categories. First those that relate to monitoring and second those related to forecast modeling. The monitoring performance measures document that the frequency of monitoring and methods used to make measurements are consistent with the proposed monitoring plan and with the quality assurance project plan (QAPP). The QAPP defines protocols to ensure data integrity and to ensure that laboratory methods are accurate and consistent. Failure to meet criteria for standard, split or duplicate samples invokes actions that are spelled out in the QAPP.

The performance measures used to evaluate the modeling comprise of drawing comparisons between forecast values and observed data. For the first year of the project these comparisons will be made as a retrospective analysis, comparing forecasts with real-time sensor data after the event, but not releasing the forecasts to the public. In the second year of the project the forecasts will be made public and it is anticipated will assist stakeholders make wise, cost and energy effective decisions to maintain dissolved oxygen above minimum thresholds in the San Joaquin Deep Water Ship Channel.

G. COMPLIANCE

Applicant takes exception to the "Rights in Data, Acknowledgements, and Peer Review" provision in Chapter 4.2 of the Proposal Solicitation, as well as the following standard clauses from Attachment D of the Proposal Solicitation: Section 2 (Payment Schedule), Section 3 (Performance Retention), Section 6 (Substitution), Section 9 (Rights in Data), Section 11 (Indemnification), and Section 13 (Termination Clause)." We also generally reserve the right to negotiate all termas and conditions ahouls this proposal be funded.

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ATTACHMENTS

Figures

F-1 Map of the San Joaquin River Deep Water Ship Channel
F-2 Conceptual Model of Layered Deep Water Ship Channel

Budgets

Budget Detail with Federal Overhead
Budget Detail with State Overhead (Alternate Budget)

Letter of Support

San Joaquin River Dissolved Oxygen TMDL Steering Committee

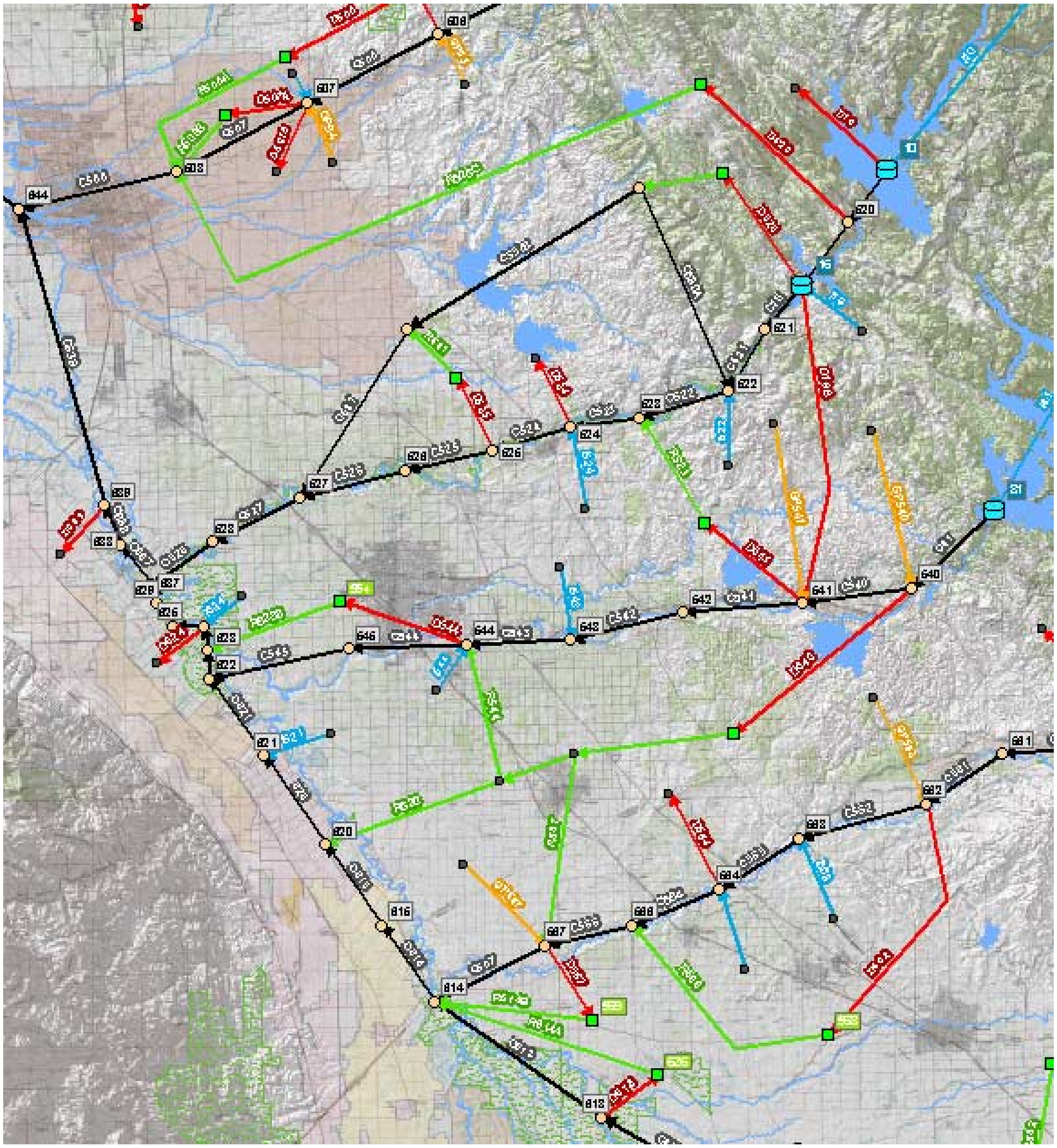

Figure 1. Map of the main stem of the San Joaquin River including the entrance to the Deep Water Ship Channel. Nodal network is for the CALSIM-II model which is currently being linked to the DSM-2 model, described in this proposal. The DSM-2 model currently includes only the Delta and the main stem of the San Joaquin River between Bear Creek and Vernalis.

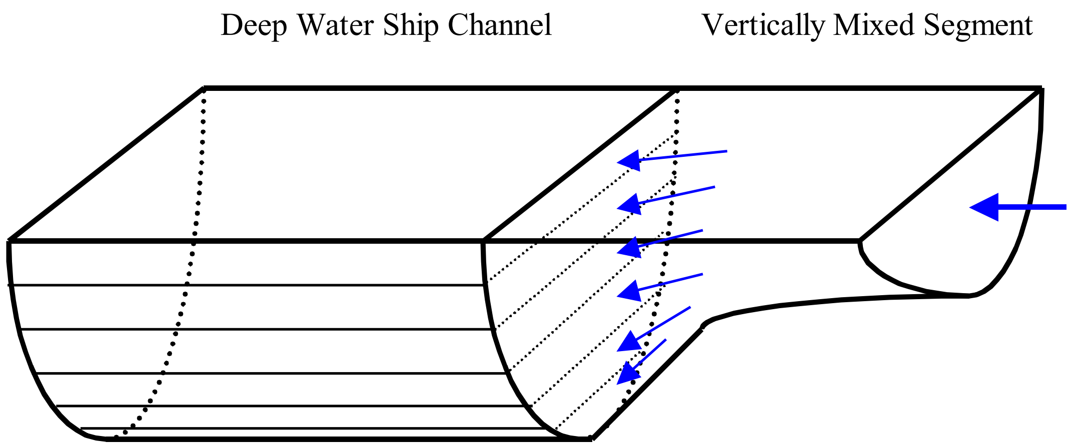

Figure 2. Conceptual model of layered Deep Water Ship Channel, proposed by Dr Carl Chen. In this conceptual model the one dimensional channel segment is divided into a number of evenly divided horizontal layers, each of which can interact with layers above and below.

Budget
April 1, 2002 - March 31, 2004)

	Monthly Rate	No of Months	%	4/1/02 - 3/31/2003	4/1/03 - 3/31/2004
Personnel					
Prof. Horne, Prof. VIII - PI	$14,400	2 summer	100%	$28,800	$29,376 [1]
N. Quinn, Assoc. Res. Eng.	$7,250	3 cal. yr.	100%	$21,750	$22,185 [1]
Visiting Postdoc Res.	$3,333	12 cal. yr.	100%	$40,000	$40,800 [1]
2 GSR III	$2,957	3 ac.yr.	50%	$8,871	$9,048 [1]
	$2,957	3 summer	100%	$17,742	$18,097 [1]
	$3,016	6 ac.yr.	50%	$18,096	$18,458 [1]
TOTAL PERSONNEL				$135,259	$137,964
Employee Benefits	Rates per Period				
Professor, summer research	12.70%	12.70%		$3,658	$3,731
Other Academic Personnel	17.00%	17.00%		$10,498	$10,707
Graduate Student Researcher, ac. yr	1.30%	1.30%		$351	$358
Graduate Student Researcher, smr.	3.00%	3.00%		$532	$543
Full Fee Remission/per semester	$2,269	$2,314		$9,076	$9,258 [2]
TOTAL EMPLOYEE BENEFITS				$24,115	$24,597
TOTAL PERSONNEL & BENEFITS				$159,374	$162,561
Equipment					
Computing Charges				$7,500	$7,500
Water Quality Monitoring Sensors				$45,000	$45,000
TOTAL EQUIPMENT				$52,500	$52,500 [2]
Subcontract					
California DWR				$60,000	$60,000 [3]
Systech Engineering				$80,000	$80,000 [3]
Lawrence Berkeley Laboratory				$60,000	[3]
TOTAL SUBCONTRACT				$200,000	$140,000
Travel					
4 RT/ to conferences, locations TBD				$5,000	$5,000
TOTAL TRAVEL				$5,000	$5,000
Other Direct Costs					
Materials and supplies				$2,400	$2,600
TOTAL OTHER DIRECT COSTS				$2,400	$2,600
TOTAL DIRECT COSTS				$419,274	$362,661
Indirect Costs	MT DC				
50.40% of Modified Total Direct Costs	$232,698	$160,903		$117,280	$81,095
TOTAL AMOUNT REQUESTED PER YEA				$536,554	$443,756
TOTAL AMOUNT REQUESTED					**$980,310**

[1] Salary rates shown include a projected 2% cost of living increase effective each October 1st.
[2] These items are not subject to indirect costs.
[3] Indirect costs only apply to the first $25,000 of each subcontract.

Budget Detail with 50.40% Federal Overhead Rate

Budget
April 1, 2002 - March 31, 2004)

	Monthly Rate	No of Months	%	4/1/02 - 3/31/2003	4/1/03 - 3/31/2004	
Personnel						
Prof. Horne, Prof. VIII - PI	$14,400	2 summer	100%	$28,800	$29,376	1
N. Quinn, Assoc. Res. Eng.	$7,250	3 cal. yr.	100%	$21,750	$22,185	1
Visiting Postdoc Res.	$3,333	12 cal. yr.	100%	$40,000	$40,800	1
2 GSR III	$2,957	3 ac.yr.	50%	$8,871	$9,048	1
	$2,957	3 summer	100%	$17,742	$18,097	1
	$3,016	6 ac.yr.	50%	$18,096	$18,458	1
TOTAL PERSONNEL				$135,259	$137,964	

Employee Benefits	Rates Per Period					
Professor, summer research	12.70%	12.70%	12.70%	$3,658	$3,731	
Other Academic Personnel	17.00%	17.00%	17.00%	$10,498	$10,707	
Graduate Student Researcher, ac. yr	1.30%	1.30%	1.30%	$351	$358	
Graduate Student Researcher, smr.	3.00%	3.00%	3.00%	$532	$543	
Full Fee Remission/per semester	$2,269	$2,314	$2,314	$9,076	$9,258	2
TOTAL EMPLOYEE BENEFITS				$24,115	$24,597	
TOTAL PERSONNEL & BENEFITS				$159,374	$162,561	

Equipment			
Computers	$7,500	$7,500	
Water Quality Monitoring Sensors	$45,000	$45,000	
TOTAL EQUIPMENT	$52,500	$52,500	2
Subcontracts			
California DWR	$60,000	$60,000	3
Systech Engineering	$80,000	$80,000	3
Lawrence Berkeley Laboratory	$60,000		3
TOTAL SUBCONTRACT	$200,000	$140,000	
Travel			
4 RT/ to conferences, location TBD	$5,000	$5,000	
TOTAL TRAVEL	$5,000	$5,000	
Other Direct Costs			
Materials and supplies	$2,400	$2,600	
TOTAL OTHER DIRECT COSTS	$2,400	$2,600	
TOTAL DIRECT COSTS	$419,274	$362,661	

Indirect Costs	MT	DC		
10.0% of Modified Total Direct Costs	$232,698	$160,903	$23,270	$16,090
TOTAL AMOUNT REQUESTED PER YEA			$442,544	$378,751
TOTAL AMOUNT REQUESTED				**$821,295**

[1] Salary rates shown include a projected 2% cost of living increase effective each October 1st.
[2] These items are not subject to indirect costs.
[3] Indirect costs only apply to the first $25,000 of the entire subcontract.

Budget Detail with 10% State Overhead Rate

San Joaquin River Dissolved Oxygen TMDL Steering Committee
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Facilitation: Kevin Wolf <kjwolf@dcn.davis.ca.us> (530) 758-4211

September 27, 2001

Dear PSP Reviewers and CALFED Decision Makers:

This is a letter from the San Joaquin Dissolved Oxygen TMDL Steering Committee in support of the Quinn/Horne CALFED 2002 PSP proposal entitled "Adaptive Real-time Forecasting and Sustainable Management of Dissolved Oxygen in the San Joaquin River Deep Water Ship Channel.

The Steering Committee is a broadly supported, consensus-based stakeholder process authorized by the Central Valley Regional Water Quality Control Board to develop the stakeholder preferred alternative for both a Total Maximum Daily Load allocation and an implementation plan for solving the low dissolved oxygen problem.

The Steering Committee supports this proposal for numerous reasons.

The stakeholders in the areas in which the monitoring and studies would occur have a good working relationship with Nigel Quinn and support his continuing efforts. The monitoring improvements that this project would create will be important to the stakeholders and to managing the watershed as the TMDL is allocated.

There are numerous dissolved oxygen management options which can have their effectiveness increased through a real-time management program. Dr. Quinn has a great deal of experience in real-time forecasting in the San Joaquin watershed.

The computer modeling and forecasting work that would be conducted by Dr. Carl Chen would build off of the modeling work he has already done. The stakeholder's Technical Advisory Committee has been using Dr. Chen's model for two years and wants to continue improving it with data from this project

The stakeholders throughout the watershed will need a strong team such as Drs. Quinn, Horne and Chen to help them work through and evaluate the best individual and integrated options for implementing a plan to meet the dissolved oxygen standard.

So it is with strong support that the Steering Committee endorses this proposal and encourages CALFED to fund it.

Sincerely,

Mary Hildebrand

Mary Hildebrand
Chairperson, San Joaquin River Dissolved Oxygen TMDL Steering Committee