Using FlowCAM Technology To Measure High Frequency Spatial And Temporal Variation In Phytoplankton And Zooplankton Species Composition And Develop State−Of−The−Art Plankton Monitoring Programs

submitted to Science Program 2006

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lead investigators:
Lehman, Peggy
Poulton, Nicole
Mueller−Solger, Anke

Project Information And Executive Summary

Using FlowCAM Technology To Measure High Frequency Spatial And Temporal Variation In Phytoplankton And Zooplankton Species Composition And Develop State−Of−The−Art Plankton Monitoring Programs

This is proposal #0056 for the Science Program 2006 solicitation.

Frequently asked questions and answers for this PSP are now available.

The submission deadline for this proposal has passed. Proposals may not be changed.

Instructions

Please complete the Project Information and Executive Summary Form prior to proceeding to the other forms contained on this website and required to be completed as part of your PSP application submittal. Information provided on this form will automatically support subsequent forms to be completed as part of the Science PSP submission process. Information provided on this form will appear in the Contacts and Project Staff, Task and Budget Summary, and Conflict of Interest forms.

Proposal Title: **Using FlowCAM technology to measure high frequency spatial and temporal variation in phytoplankton and zooplankton species composition and develop state−of−the−art plankton monitoring programs**

This field is limited to 255 characters. All proposal titles must be entered in title case. No abbreviations or acronyms will be accepted.

Applicant Information

Applicant Organization Name: **California Department of Water Resources**

Please provide the name of the organization submitting the application as follows: Davis, California University of; Fish and Game, California Department of; California Waterfowl Association, etc.

Applicant Organization Type:
State agency

eligibility

Below, please provide contact information for the representative of the applicant organization who is authorized to enter into a contractual agreement with the State of California and who has overall responsibility for the operation, management, and reporting requirements of the applicant organization. (This should be the same individual who signs the signature page.)

Salutation: **Ms.**
First Name: **Barbara**
Last Name: **McDonnell**
Street Address: **901 P Street**
City: **Sacramento**
State or Province: **CA**
Zip Code or Mailing Code: **95814**
Telephone: **916−651−9777**
E−mail Address: **bmcdonne@water.ca.gov**

Below, please provide contact information for the primary point of contact for the implementation of the proposal. This person should be the same individual who is serving as the project Lead Investigator/Project Director.

Salutation: **Dr.**
First Name: **Peggy**
Last Name: **Lehman**
Telephone: **916−651−9546**
E−mail Address: **plehman@water.ca.gov**

Proposal Information

Total Amount Requested: $248,289

The figure represented above is provided by the total amount requested on your completed Task and Budget Summary Form. The applicant must ensure the amount indicated above is correct and equal to the total amount requested in the budget document uploaded via the Budget and Justification Form for this project.

Select one primary and up to three secondary topic areas that best apply to this proposal:

Habitat Availability and Response to Change (Primary)

Aquatic Invasive (Exotic) Species

Trends and Patterns of Populations and System Response to a Changing Environment

Select up to five keywords to describe this project.
− ***agriculture***
− ***agricultural economics***
− ***agricultural engineering***
− ***agronomy***
− ***agro−ecology***
− ***benthic invertebrates***
− ***benthos***
− ***biochemistry***
− ***biological indicators***
− ***birds***
− ***channels and sloughs***
X ***climate change***
− ***conservation or agricultural easements***
− ***conservation program management***
− ***database management***
− ***ecotoxicology***
− ***economics***
− ***engineering***
− ***erosion control***
− ***environmental education***
− ***evapotranspiration***
− ***fish biology***
− delta smelt
− salmon and steelhead
− other species
− otoliths
− tagging
− ***fish management and facilities***
− ***flooded islands***
− ***floodplains and bypasses***
− ***forestry***
− ***genetics***
− ***geochemistry***
− ***geographic information systems (GIS)***
− ***geology***
− ***geomorphology***
− ***groundwater***
− ***human health***
− ***hydrodynamics***
− ***hydrology***
− ***insects***
− ***integrated pest management***
− ***integrated resource planning***
X ***invasive species / non−native species / exotic species***
− ***irrigation systems***
− ***land use laws and regulations***
− ***land use management***
− ***land use planning and policy***
− ***levees***
− ***mammals***
− ***microbiology / bacteriology***
− conceptual

– quantitative
– ***oceanography***
– ***performance measures***
X ***phytoplankton***
– ***plants***
– terrestrial
– aquatic
– wetland
– ***remote sensing / imaging***
– ***reptiles***
– ***reservoirs and lakes***
– ***restoration***
– ***riparian zone***
– ***rivers and streams***
– ***sediment***
– ***soil science***
– ***statistics***
– ***subsidence***
– ***sustainable agriculture***
– ***trophic dynamics and food webs***
– ***water operations (diversions, pumps, intakes, exports, barriers, gates, etc.)***
X ***water quality***
– other
– temperature
– contaminants
– nutrients, organic carbon, and oxygen depleting substances
– salinity
– sediment and turbidity
– ***water supply***
– ***watershed assessment***
– ***watershed management***
– ***wetlands***
X ***zooplankton***

Provide the geographic coordinates that best describe the center point of your project. (Note: If your project has more than one site, provide a center point that best captures the central location.)

Example:	Latitude:	38.575; must be between 30 and 45
	Longitude:	−121.488; must be between −120 and −130

Help for finding a geographic location.

Latitude: **38.1**
Longitude: **−121.74**

Provide the number miles radius from the center point provided above, to demonstrate the radius of the entire project.
35

Provide a description of the physical location of your project. Describe the area using information such as water bodies, river miles and road intersections.

This project will encompass the upper San Francisco estuary from Suisun Bay westward, to Hood on the Sacramento River, Stockton on the San Joaquin River, and Clifton Court ForeBay on Old River.

Successful applicants are responsible for complying with all applicable laws and regulations for their projects, including the National Environmental Policy Action (NEPA) and the California Environmental Quality Act (CEQA). Projects funded through this PSP that tier off the CALFED Programmatic EIS/EIR must incorporate applicable mitigation strategies described in the CALFED Programmatic Record of Decision to avoid or minimize the project's adverse environmental impacts. Applicants are encouraged to review the Programmatic EIS/EIR and incorporate the applicable mitigation strategies from Appendix A of these documents for their projects.

If you anticipate your project will require compliance of this nature (ie applications for permits, other environmental documentation), provide below a list of these items, as well as the status of those applications or processes, if applicable. If you believe your project will not require these regulatory actions, please provide one or two lines of text outlining why your proposed project will not be subject to these processes. Further guidance is available in The Guide to Regulatory Compliance for Implementing CALFED Activities.

CEQA and NEPA documentation will not be needed. This study will only sample plankton.

Is this proposal an application for next phase funding of an ongoing project funded by CALFED Science Program?
X No. **–** Yes.

If yes, identify the ongoing project:

Project Title:
CALFED Contract Management Organization:
Amount Funded:
Date Awarded:
Lead Organization:
Project Number:

Have primary staff and/or subcontractors of the project team (those persons listed on the Contacts and Project Staff form) received funding from CALFED for a project *not* listed above?
– No. **X** Yes.

If yes, list the projects below: (only list up to the five most recent projects)

Project Title: **Biomass and toxicity of a newly established bloom of the cyanobacteria Microcystis aeruginosa and its potential impact on beneficial use in the Sacramento–San Joaquin River Delta**
CALFED Contract Management Organization: **CALFED Science**
Amount Funded: **500,000**
Date Awarded: **September 7, 2005**
Lead Organization: **California Department of Water Resources**
Project Number: **SCI–05–C122**

Project Title: **Phytoplankton communities in the San Francisco Estuary: monitoring and management using a submersible spectrofluorometer.**
CALFED Contract Management Organization: **CALFED Science**
Amount Funded: **$159,160**
Date Awarded: **September 2005**
Lead Organization: **California Department of Water Resources**
Project Number: **SCI–05–C332**

Project Title:
CALFED Contract Management Organization:
Amount Funded:
Date Awarded:
Lead Organization:
Project Number:

Project Title:
CALFED Contract Management Organization:
Amount Funded:
Date Awarded:
Lead Organization:
Project Number:

Project Title:
CALFED Contract Management Organization:
Amount Funded:
Date Awarded:
Lead Organization:
Project Number:

Has the Lead Investigator, the applicant organization, or other primary staff or subcontractors of your project team ever submitted a proposal for this effort or a similar effort to any CALFED PSP?
X No. **–** Yes.

If yes, list the submission below: (only list up to the five most recent projects)

Project Title:
CALFED Program:
Date of PSP:

Project Title:
CALFED Program:
Date of PSP:

Project Title:
CALFED Program:
Date of PSP:

Project Title:
CALFED Program:
Date of PSP:

Project Title:
CALFED Program:
Date of PSP:

Project Title:
CALFED Program:
Date of PSP:

Note: Additional information on this or prior applications submitted −− or proposals funded −− may be required of applicants.

List people you feel are qualified to serve as scientific and/or technical reviewers for this proposal and are not associated with your organization or CALFED.

Full Name	Organization	Telephone	E−Mail	Expertise
Alan D. Jassby	University of California at Davis	530−752−3938	adjassby@ucdavis.edu	
Dana Woodruff	Battelle Marine Sciences Laboratory, WA	360−681−3608	dana.woodruff@pnl.gov	
Francis Wilkerson	Romberg Tiburon Center, San Francisco State University	415−338−3519	fwilkers@sfsu.edu	

Provide additional comments, information, etc. here:

Executive Summary

Provide a brief but complete summary description of the proposed project; its geographic location; project objective; project type, approach to implement the proposal; expected outcomes; and adaptive management approach and relationship to the Science Program goals. The Executive Summary should be a concise, informative, stand−alone description of the proposed project and be no longer than one page in length. Please note, this information will be made public on our website shortly after the closing date of this PSP.

The causes of the recent decline in pelagic fish density and long−term decline in fishery resources in the delta and Suisun Bay of the San Francisco Estuary are unknown. It is hypothesized that both total biomass and species composition of phytoplankton and zooplankton at the base of the food web are important contributing factors. Quantifying the density and biomass of phytoplankton and zooplankton species, identifying the presence of exotic plankton species introductions, monitoring the development of harmful algal bloom species, developing predictive and mechanistic models of lower food web dynamics and developing rapid adaptive management of phytoplankton and zooplankton resources is limited by the low frequency spatial and temporal resolution of phytoplankton and zooplankton field sampling and the lengthy processing time and high cost of phytoplankton and zooplankton species samples. This project uses the new imaging−in−flow instrument, FlowCAM®, a portable flow cytometer with confocal microscopy and a chlorophyll fluorescence probe to identify, count and estimate the biomass of plankton organisms in situ. The FlowCAM® will be used 1) in field and laboratory studies in combination with historical data analysis to quantify the high frequency spatial and temporal variation in phytoplankton and zooplankton species composition, density and biomass and determine their relation to each other and to water quality conditions in habitats critical for key pelagic organisms and 2) to develop state−of−the art monitoring methods that provide accurate, reliable and rapid measurement of phytoplankton and zooplankton species composition, density and biomass of in situ and preserved samples. The work addresses four hypotheses: 1) Phytoplankton and zooplankton species vary at high frequency spatial scales in relation to each other and to water quality variables along the longitudinal axis of the estuary such that they form patches with different abiotic and biotic characteristics; 2) Phytoplankton and zooplankton community composition vary at high frequency (e.g., hourly to weekly) temporal scales

in relation to each other and to water quality variables; 3) The FlowCAM® is a more reliable and better indicator of in situ phytoplankton community composition and biomass than the FluoroProbe which measures phytoplankton pigment concentration; 4) The FlowCAM® is an accurate, reliable and more rapid method for identification, enumeration and biomass estimates of phytoplankton and zooplankton species than microscopy for preserved samples. The project relates to PSP Topics 4, 2 and 3 and addresses CALFED and IEP goals to develop monitoring programs in order to adaptively manage critical habitat for fishery production and restoration. Deliverables include progress and final reports, two journal articles, a technical manual for FlowCAM® sampling in the delta, a digital image library of species and presentations at CALFED, national and local meetings. The project is a collaboration between Dr. Lehman and Dr. Mueller−Solger at the CA Department of Water Resources, experts in phytoplankton, zooplankton and water quality in the delta, and Dr. Poulet at Bigelow Laboratory for Ocean Sciences and Fluid Imaging Technologies Inc., an expert in the use of the FlowCAM® to quantify plankton. Student assistants will be provided by Dr. Dahlgren at U.C. Davis.

Schedule: January 2007 to December 2008 Total cost: $248,349

Contacts And Project Staff

This is proposal #0056 for the Science Program 2006 solicitation.

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INSTRUCTIONS

Use this form to provide titles, affiliations, qualifications, and descrptions of roles of the primary and secondary project staff. Include any consultants, subcontractors and/or vendors. The Lead Investigator or Project Director, as identified in the Project Information and Executive Summary Form, is required to upload a PDF version of their resume. To complete the qualification field of this form, please provide a bulleted list of relevant project/field experience and any publications/reports that support your participation in the proposed project.

Information provided on this form will automatically support subsequent forms to be completed as part of the Science Program PSP submission process. Please note tht information you enter in this form will appear in the Task and Budget Summary and Conflict of Interest forms.

Information on subcontractor services must be provided even if the specific service provider has not yet been selected. If the specific subcontractor has not been identified or selected, please list TBD (to be determined) in the last name field and the anticipated service type in the title field (example: Fish Biologist).

Please provide this information before continuing to the Tasks and Deliverables Form.

Applicant

California Department of Water Resources
Ms. Barbara McDonnell
901 P Street
Sacramento CA 95814
916−651−9777
bmcdonne@water.ca.gov

Lead Investigator/Project Director

Salutation: **Dr.**
Last Name: **Lehman**
First Name: **Peggy**
Title: **Staff Environmental Scientist**
Organization: **California Department of Water Resources**
Responsibilities: **lead for ecological studies of delta**
Resume:

You have already uploaded a PDF file for this question. Review the file to verify that appears correctly.

Mailing Address: **901 P Street**
City: **Sacramento**
State: **CA**
Zip: **95814**
Telephone: **916−651−9546**
E−Mail: **plehman@water.ca.gov**

All Other Personnel

Salutation: **Dr.**
Last Name: **Poulton**
First Name: **Nicole**
Title: **Research Scientist**
Organization: **Bigelow Laboratory for Ocean Sciences and Fluid Imaging Technologies Inc.**
Position:

Co-PI
Responsibilities: **Technical applications and review**
Qualifications:

Curriculum Vitae Nicole J. Poulton Bigelow Laboratory for Ocean Sciences Phone: 207-633-9600 180 McKown Point Road Fax: 207-633-9641 P.O Box 475 Email: npoulton@bigelow.org West Boothbay Harbor, ME 04575

EDUCATION:

Ph.D. Massachusetts Institute of Technology/Woods Hole Oceanographic Institution 2001 B.S. Virginia Polytechnic Institute and State University (Biology) 1993

PROFESSIONAL EXPERIENCE:

Research Scientist, 2005-present Bigelow Laboratory for Ocean Sciences, Maine, J.J. MacIsaac Aquatic Cytometry Facility Research focuses primarily on phytoplankton dynamics and marine microbes using a variety of technologies, specifically flow cytometry and imaging-in-flow (FlowCAM®).

Scientific Consultant, 2004-present Fluid Imaging Technologies, Edgecomb, Maine Aid in application development for aquatic applications (freshwater and marine) using the imaging-in-flow system known as the FlowCAM®, also aid in training new users of the FlowCAM®.

Postdoctoral Research Scientist, June 2001-2004 Bigelow Laboratory for Ocean Sciences, Maine. Advisor: Dr. Michael Sieracki Examined the role of bacteria and phytoplankton interactions and associations in conjunction with the J. J. MacIsaac Aquatic Cytometry Facility.

Guest Investigator, Sept 2000- 2001 Woods Hole Oceanographic Institution, Massachusetts. Investigating nutrient physiology and behavior of the harmful algal bloom species, Alexandrium fundyense, within the Gulf of Maine region.

Ph.D. Research, Sept 1994-2000 Woods Hole Oceanographic Institution/MIT, Dr. Donald Anderson (Advisor). Thesis entitled, "Physiological and Behavioral Diagnostics of Nitrogen Limitation for the Toxic Dinoflagellate Alexandrium fundyense."

PUBLICATIONS:

Poulton, N. J., B. A. Keafer, and D. M. Anderson. 2005. Toxin variability in natural population of Alexandrium fundyense in Casco Bay, Maine – evidence of nitrogen limitation. Deep Sea Research II. 52: 2501-2521.

Sieracki, M.E., I. C. Hobson, E. C. Thier, N. J. Poulton, R. Goericke. 2006. Distribution of planktonic aerobic anoxygenic photoheterotrophic bacteria in the northwest Atlantic. Limnology and Oceanography. 51: 38-46.

Poulton, N. J., I. C. Gilg, E.C. Their, M. E. Sieracki. Discrimination between CTC-active bacteria and Prochlorococcus from natural samples using dual beam flow cytometry. (in preparation)

Jasti, S., M. E. Sieracki, N. J. Poulton, M. W. Giewat, J. N. Rooney-Varga. 2005. Phylogenetic diversity and specificity of bacteria associated with Alexandrium spp. and other phytoplankton. Applied Environmental Microbiology. 71: 3483-3494.

Sieracki, M., N. Poulton and N. Crosbie. 2005. Automated isolation Techniques for Microalgae. In: Algal Culture Techniques Ed. R. A. Andersen. Elsevier. p. 450.

Rose, J. M., D. A. Caron, M. E. Sieracki and N. J. Poulton. 2004. Counting heterotrophic nanoplanktonic protists in cultures and in aquatic communities by flow cytometry. Aquatic Microbial Ecology 34: 263-277.

RESEARCH CRUISES:

Scientist, R/V Gulf Challenger, periodically Mar 2005-present Scientist, R/V Cape Hatteras (CH0402), Mar 2002 Scientist, R/V Cape Hatteras (CH1301). Oct 2001 Scientist, R/V Cape Hatteras (CH0901). Aug 2001 Scientist, R/V Gulf Challenger, Spring 1998 Scientist, R/V Columbus Iselin, July 1993

SYNERGISTIC ACTIVITIES:

Lecturer, Marine Biology Deck House School, Edgecomb Maine Feb 2003 – June 2005 Lecturer, Boston College, Department of Geology and Geophysics. Spring 2001 Member, IOC – Intergovernmental Oceanographic Commission – Harmful Algae 1999–Present Member, American Society of Limnology and Oceanography 1997–2002, 2005–present

Collaborators during the Past 48 Months:

Dr. Michael Sieracki (Bigelow Laboratory for Ocean Sciences) Dr. Ramunas Stepanauskas (Bigelow Laboratory for Ocean Sciences) Dr. Juliette Rooney–Varga (University of Massachusetts at Lowell) Dr. Lisa Moore (University of Southern Maine) Dr. Chris Sieracki (Fluid Imaging Technologies)

Ph.D. Advisor: Dr. Donald Anderson (Woods Hole Oceanographic Institution)

List relevant project/field experience and publications/reports.

Salutation: **Dr.**
Last Name: **Mueller–Solger**
First Name: **Anke**
Title: **Staff Environmental Scientist**
Organization: **CA Department of Water Resources**
Position:
Co–PI
Responsibilities: **cost share contributor Fluoroprobe and review**
Qualifications:

CURRICULUM VITAE ANKE B. MUELLER–SOLGER Department of Water Resources Phone:(916) 651–0179 Division of Environmental Services Fax: (916) 651–0209 Office of Water Quality Email: amueller@water.ca.gov 901 P Street, PO Box 942836 Sacramento, CA 95814–6424 Sacramento, CA 95814

EDUCATION 1998: Ph.D. (Ecology), University of California, Davis, USA 1994: M.S. (Diplom, Biology), Georg–August–University, Goettingen, Germany

PROFESSIONAL EXPERIENCE RECORD 2002 – Present: Staff Environmental Scientist, California Department of Water Resources (DWR), Division of Environmental Services 2004 – 2005: Staff Research Associate, Univ. of California, Davis 2000 – 2002: Environmental Specialist/Scientist, California Department of Water Resources (DWR), Division of Environmental Services 1998–2004: Postdoctoral Scientist, Univ. of California, Davis 1993–1997: Field Director, UC Davis Castle Lake Limnological Research Laboratory

PROJECT–RELEVANT EXPERIENCE Managed Castle Lake Long–Term Monitoring Program, 1993–1997 Broad training and experience in ecological and limnological research and monitoring with emphasis on phytoplankton, zooplankton, microbial plankton, food web dynamics and water quality Participation in collaborative, multi–institutional projects at Castle Lake (funded by NSF) and in the San Francisco Estuary (funded by CALFED) DWR Staff (Senior) Scientist with the IEP Environmental Monitoring Program Ongoing CALFED funded research activities at DWR Engaged in many interagency and agency–university activities including active membership in the IEP Pelagic Organism Decline (POD) Management Team and various Co–Chair functions for the CALFED Science Conferences.

AWARDS AND HONORS Co–author of a paper that received the 2004 American Society of Limnology and Oceanography (ASLO) Lindeman Award ASLO DIALOG III Program Participant 1999 U.C. Davis Outstanding Graduate Student Teaching Award 1997–98 Various U.C. Davis Graduate Student Awards and Fellowships 1990–1998 Scholarship for Graduate Studies Abroad awarded by the German Academic Exchange Service (DAAD), Bonn, Germany, 1994–1996.

SELECTED RECENT PUBLICATIONS Hall, C. and A. Müller–Solger. 2005. Culturing Delta Copepods. IEP Newsletter 18(3): 13–16. Jassby, A.D., Müller–Solger, A., and M. Vayssieres. 2005. Subregions of the Sacramento–San Joaquin Delta: Identification and Use. IEP Newsletter 18(2): 46–56. Jassby, A.D., Müller–Solger, A., and M. Vayssieres. 2005. Short–term Variability of Chlorophyll and Implications for Sampling Frequency in the San Joaquin River. IEP Newsletter 18(1): 21–28. Park, S., Brett, M. T., Müller–Solger, A., and C. R. Goldman. 2004. Climatic forcing and primary productivity in a subalpine lake: Interannual variability as a natural experiment. Limnology and Oceanography 49: 614–619. Sommer, T.R., Harrell, W. C., Müller Solger, A.B., Tom, B. and W. Kimmerer. 2004. Effects of flow variation on channel and floodplain biota and habitats of the Sacramento River, California, USA. Aquatic Conservation: Marine and Freshwater Ecosystems 14: 247–261. Schemel, L.E., Sommer, T.R., Müller–Solger,

A.B., and W.C. Harrell. 2004. Hydrologic variability, water chemistry, and phytoplankton biomass in a large floodplain of the Sacramento River, CA, USA. Hydrobiologia 513: 129–139. Triboli, K., Müller–Solger, A., and M. Vayssieres. 2003. The Grind about Sonicated Chlorophyll (or: Did a method change in 1998 affect EMP chlorophyll results?) IEP Newsletter 16: 13–25. Jassby, A.D., Cloern, J. E., and A. Müller–Solger. 2003. Phytoplankton and the food web in Delta waterways. California Agriculture 57: 104–109. Müller–Solger, A. B., A. D. Jassby, and D. C. Müller–Navarra. 2002. Nutritional quality of food resources for zooplankton (Daphnia) in a tidal freshwater system (Sacramento–San Joaquin River Delta, USA). Limnology and Oceanography 47:1468–1476. Sobczak, W. V., J. E. Cloern, A. D. Jassby, and A. B. Müller–Solger. 2002. Bioavailability of organic matter in a highly disturbed estuary: The role of detrital and algal resources. Proceedings of the National Academy of Sciences 99: 8101–8105. (Received ASLO Lindeman Award) Brett, M.T., F.S. Lubnow, M. Villar–Argaiz, C.R. Goldman and A. Müller–Solger. 1998 Nutrient control of bacterioplankton and phytoplankton dynamics. Aquatic Ecology 33: 135–145. Müller–Solger, A., M.T. Brett, C. Luecke, J. Elser and C.R. Goldman. 1997. The effects of planktivorous fish (golden shiners) on the ciliate community of a mesotrophic lake. J. Plankton Res. 19(12):1815–1828.

OTHER QUALIFICATIONS

Professional Memberships: American Society of Limnology and Oceanography Estuarine Research Federation American Geophysical Union International Association of Theoretical and Applied Limnology

Recent Collaborators (Non–DWR And Non–UC Davis): James Cloern, United States Geological Survey Lawrence Schemel, United States Geological Survey Janet Thompson, United States Geological Survey Mary Power, UC Berkeley William Sobczak, College of the Holy Cross Dörthe Müller–Navarra, University of Hamburg, Germany Michael Brett, University of Washington Wim Kimmerer, San Francisco State University San–Kyu Park, Korea Research Institute of Bioscience and Biotechnology

List relevant project/field experience and publications/reports.

Salutation: **Mr**
Last Name: **Santos**
First Name: **Eric**
Title: **Chief Boat operator**
Organization: **CA Department of Water Resources**
Position:
primary staff
Responsibilities: **operate boat**
Qualifications:

Eric Santos has been a boat operator for the Department of Water Resources for over 10 years and is familiar with the boats that will be used in the study

List relevant project/field experience and publications/reports.

Salutation:
Last Name: **unknown**
First Name: **unknown**
Title: **graduate student**
Organization: **University of California at Davis – LAWR Dr. Randy Dahlgren**
Position:
subcontractor
Responsibilities: **graduate student to assist with field collection, laboratory analyses and data analysis**
Qualifications:
List relevant project/field experience and publications/reports.

Salutation: **Mr**
Last Name: **Dempsey**
First Name: **Michael**
Title: **Electrical Engineer**
Organization: **CA Department of Water Resources**

Position:
primary staff
Responsibilities: **assist with deployment and operation of FlowCAM in the field on vessels and at continuous monitoring stations**
Qualifications:

Mike Dempsey has facilitated operation of intruments for in situ continuous field measurements on ships and at continuous monitoring stations for over 20 years at the CA Department of Water Resources

List relevant project/field experience and publications/reports.

Conflict Of Interest

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Instructions

To assist Science Program staff in managing potential conflicts of interest as part of the review and selection process, we are requesting applicants to provide information on who will directly benefit if your proposal is funded. Please provide the names of individuals who fall in the following categories and are not listed in the Personnel Form:

- Persons 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; and/or
- Subcontractors listed in the proposal, who will perform tasks listed in the proposal, or will benefit financially if the proposal is funded.

Applicant
Submittor
Lead Investigator/Project Director
Primary Staff
Secondary Staff
Subcontractor

Provide the list of names and organizations of all individuals not listed in the proposal who helped with proposal development along with any comments.

Last Name	First Name	Organization	Role
Nelson	Haryy	Fluid Imaging Technologies Inc.	technical issues

Task And Budget Summary

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Instructions

Use the table below to delineate the tasks needed to carry out your proposal. Tasks in this form should support the narrative description of your project in your proposal document and the informa tion provided in your detailed budget spreadsheet. Each task and subtask must have a number, title, timeline, list of personnel or subcontractors providing services, and associated budget figure.

When creating subtasks, ensure that each activity is counted only once. Please note, the initial task of your table (Task 1) must present all project management/administrative activities supporting your overall proposal.

For proposals involving multiple agencies or organizations (including subcontractors), the table must clearly state the tasks and subtasks performed by each entity.

Task #	Task Title	Start Month	End Month	Personnel Involved	Description	Task Budget
1	Administration	1	24	Lehman, Peggy	project oversight, contracting, tracking, reporting and accounting	3,528
2	Quantify high frequency spatial variation of phytoplankton and zooplankton community composition along longitudinal gradients in the estuary	5	24	Lehman, Peggy Santos, Eric unknown, unknown Dempsey, Michael	Conduct field study to quantify the high freqency variation of phytoplankton and zooplankton community composition in relation to water quality conditions along the rivers and embayments in the estuary	133,637
3	Quantify the high frequency temporal variation of phytoplankton and zooplankton community composition at fixed stations i the estuary	6	24	Lehman, Peggy unknown, unknown Dempsey, Michael	Conduct field study and data analyses to quantify the high frequency temporal variation of phytoplankton and zooplankton community composition and their relation to water quality conditions	27,292
4	Compare the accuracy of the FlowCAM and FluoroProbe instruments to measure phytoplankton community composition and biomass	6	24	Lehman, Peggy unknown, unknown	Compare the accuracy and efficiency of the FlowCAM and the FluoroProbe to characterize phytoplankton communnity composition and estimate biomass for continuous measurements at 3 continuous monitoring stations in the estuary	8,260
5	Evaluate the speed and accuracy of FlowCAM to identify, enumerate and compute phytoplantkon and zooplankton in preserved samples	6	24	Lehman, Peggy unknown, unknown	Compare the speed and accuracy of laboratory identification, enumeration and biomass estimation for preserved phytoplankton and zooplankton species composition between the FlowCAM and micrscopic techniques	7,260
6	Technical assistance, field sampling, data analysis and journal paper and report writing	6	24	Poulton, Nicole	Provide technical expertise, field assistance, assist with analysis and technical review	44,200
7	Reporting and presentations	6	24	Lehman, Peggy Mueller-Solger, Anke	Analyze data and prepare reports, presentations at scientific meetings and journal articles	24,112

				unknown, unknown		

total budget=$248,289

Detailed Budget Upload And Justification

This is proposal #0056 for the Science Program 2006 solicitation.

Frequently asked questions and answers for this PSP are now available.

The submission deadline for this proposal has passed. Proposals may not be changed.

Using the budget provided via this link as a guide, please complete a budget for your proposal in the software of your choice (e.g. Excel). This document must be in a format and software that can be converted to PDF prior to uploading on the web system.

It is incumbant upon the applicant to fully explain/justify the significant costs represented in the attached budget. This information can be provided either in a text document and uploaded below, or included in your proposal text in a clearly defined budget justification section. If it is not abundantly clear to reviewers what project costs are commensurate with which efforts and benefits, the proposal may receive a poor review and denied funding.

Costs for each task described in the Task and Budget Summary Form and each staff or subcontractor described on the Contacts and Project Staff Form, must be included in your budget. The budget for Task One should represent project management activities, including but not limited to cost verification, environmental compliance, data handling, report preparation, project oversight, and public outreach. The total amount of your budget must equal the total amount represented on your Task and Budget Summary Form and the total budget amount represented on your Project Information and Executive Summary Form.

In a separate text document to be uploaded below, identify any cost share and other matching funds available to support your proposed project. If you identify cost share or matching funds, you must also describe them in the text of your proposal (see explanation of "cost share and other matching funds" in Section Two of the solicitation document).

CBDA may request additional information pertaining to the items, rates and justification of the information presented in your budget. Applications without completed budgets will not be considered for funding.

Uploading The Completed Budget Template

First, convert your completed Budget to a PDF file. Then, use the browse function to locate the PDF version of your document, select the document and click on the upload prompt below.

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Uploading The Completed Budget Justification

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Uploading The Description Of Cost Share/Matching Funds

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Schedule Of Deliverables

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Use the table below to delineate the key deliverables and the time necessary to complete them (in months from the date the project's grant agreement is executed). Each Science Program 2006 PSP grant recipient must provide the required minimum deliverables for each project. The required minimum deliverables for each funded proposal are as follows:

- Semi−annual report(s)
- Final Report
- One page project summary for public audience at beginning of project
- One page project summary for public audience upon project completion
- Project closure summary report or copy of draft manuscript
- Presentation at CALFED Science Conference
- Presentations at other events at request of CALFED Science Program staff
- Copy of all published material resulting from the grant

Deliverable	Description	Delivered By: # (In Months From Project Start Date)
one page project summary	summary of work to be done on project	1
Semi−annual report 1	status of work done in first six months	6
Semi−annual report 2	status of work done in first year	12
Semi−annual report 3	status of work done in first 18 months	18
final report	final summary report on project	24
one page final project summary	summary	24
two draft manuscripts	spatial (1) and temporal (2) analysis of plankton in estuary	24
FlowCAM use manual and species library	manual for use of FlowCAM that describes all procedures and a library of the digital images of the species	24
presentation at CALFED conference	spatial and temporal studies will be presented	24
presentation at CALFED request	summary of results as requested	24
Copy of all published material resulting from grant	manuscripts and manual	36
presentation at national conference	spatial and temporal studies will be presented	24

If you are unable to provide a Schedule of Deliverables as outlined above, please provide your justification of non−compliance in the text box provided below. The Science Program reserves the right to determine a proposal non−eligible based on an applicants inability to provide the materials requested above.

Letters Of Support Form

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Letters Of Support

Should you wish to provide letters of support for your proposed project, you must do so through use of this web form. Letters of support will be provided to independent, panel and public reviewers for reference as part of the overall review process. It is not mandatory to provide letters of support. Failure to do so will in no way affect the review or final determination of your application.

Submission Of These Materials.

To submit Letters of Support, you must do so as .PDF files. To upload these materials, use the browse function to locate the appropriate .PDF version of the documents, select the documents and click on the upload prompt below.

Please ensure your PDF file contains all letters you would like to submit. Individual files (or letters) will not be accepted by the system. The system is designed to receive one single file. Submittal of these documents are not mandatory for your application to be considered under the 2006 Science Program PSP. Failure to submit letters does not impact your ability to compile your proposal along with the supporting forms required for final submission and consideration under the Science Program 2006 PSP.

Letters Of Support *Please upload a PDF version of your letters of support. To upload a document, use the "Browse" button to select the PDF file containing the document.*

1) Project Purpose

This study will use of the new imaging-in-flow instrument FlowCAM® to rapidly and automatically identify, enumerate and estimate biomass for in situ and laboratory phytoplankton and zooplankton species composition samples in the San Francisco Estuary (SFE). The project will have four main tasks 1) Measure and develop the statistical relationships between the high frequency spatial variation of phytoplankton and zooplankton species composition and associated water quality variables along the longitudinal axes of rivers during spring, summer and fall when key fish species use zooplankton as food; 2) Measure and develop the statistical relationships between the high frequency temporal (hour, day and week) variation of phytoplankton and zooplankton species composition and associated water quality variables at fixed stations during spring, summer and fall when key fish species use zooplankton as food; 3) Compare and contrast the accuracy, speed and reliability of FlowCAM® which quantifies phytoplankton species composition and FluoroProbe which quantifies phytoplankton pigments instruments to characterize in situ phytoplankton communities in the delta; and 4) Compare the accuracy and efficiency of the FlowCAM® and microscopy techniques to enumerate, quantify and estimate the biomass of preserved phytoplankton and zooplankton samples.

The new field information will provide information on how phytoplankton and zooplankton species composition respond to water quality variables at high spatial and temporal scales needed to enhance our understanding of how water management scenarios, changing climate and new species introductions may impact lower food web production and affect formation of habitats across the delta. The new laboratory information will assist evaluation of accurate and rapid techniques for identification of phytoplankton and zooplankton communities needed to enable rapid response to changing phytoplankton and zooplankton communities and provide early warning of harmful algal blooms.

2. Background and conceptual model

Some pelagic organisms in SFE have declined in recent years to all time low densities causing great concern for managers and environmentalists. Affected fish include the native delta smelt, longfin smelt, threadfin shad and striped bass (IEP 2005). In addition, there has been a long-term decline in pelagic fish species (Bennett and Moyle 1996; IEP 2005). Survival of these pelagic fish species is hypothesized to be partially dependent on the structure and function of zooplankton species composition and biomass (Orsi 1995; Meng and Orsi 1991; Nobriga et al. 2005) which supports them. In SFE zooplankton biomass is correlated with phytoplankton biomass (Lehman 1992; Mueller-Solger et al. 2002; Kimmerer 2005). Phytoplankton species composition is also important. Zooplankton feeding depends on phytoplankton cell dimension which affects feeding success and carbon availability (Hansen et al. 1994). In SFE, phytoplankton biomass and cell size vary with species composition (Lehman 1996). Diatoms and green algae had the widest spherical diameter and carbon

content among phytoplankton groups and were within the size range (≥10-40 µm spherical cell diameter) utilized by the most abundant copepods in the estuary (Lehman 1996; 2000a). The correlation between phytoplankton community composition and the production of biomass at upper trophic levels was demonstrated for 1975 through 1993 when the loss of diatom biomass throughout the upper estuary was correlated with the decline in total zooplankton and *Neomysis* biomass (Lehman 2004). These changes in phytoplankton community composition were correlated with water quality conditions that varied with streamflow (Lehman and Smith 1991; Lehman 2000b; 2004).

Species introductions have also been a major factor affecting food web structure and function in the estuary and hypothesized to be a contributing factor to the long-term and more recent decline in fishery production. SFE is one of the most invaded estuaries in the world (Cohen and Carlson 1995) and at least 212 new species have been introduced since 1850. Some of these have had a major impact on estuarine productivity. For example, the introduced Asian clam *Corbula amurensis* is attributed with the decline in phytoplankton biomass and loss of the zooplankton *Eurytemora affinis* in Suisun Bay (Kimmerer and Orsi 1996). In fact the zooplankton that are currently most abundant in the estuary were all introduced including *Acanthomysis* sp., *Pseudodiaptomus* sp., *Sinocalanus* sp.and *Limnoithona* sp. (Kimmerer 2004).

Changes in the phytoplankton community in response to exotic species introductions or enhanced growth of existing species can further threaten ecosystem structure and function and ultimately fishery production. Blooms of the toxic cyanobacterium (bluegreen alga) *Microcystis aeruginosa* now occurs yearly throughout the upper estuary since it began in 1999 (Lehman et al. 2005), and its coincident increase with the pelagic organism decline makes it one of the hypothesized causal factors (IEP 2005). Formation of surface scum in some locations this year, suggests the bloom has worsened. *Microcystis aeruginosa* is a harmful algal bloom that contains hepatotoxic compounds called microcystins that cause liver cancer and tumors in both wildlife and humans (Carmichael 1995). *Microcystis* can also affect zooplankton and fish feeding success and food quality (Rohrlack et al. 2005; Malbrouck and Kestemont 2006). High cyanobacterial abundance also affects zooplankton community size structure and was associated with a shift from large to small zooplankton species (Fulton and Pearl 1988; Smith and Gilbert 1995). In addition, a bloom of one cyanobacteria can cause shifts in phytoplankton community composition towards more cyanobacteria through the release of dissolved substances that inhibit the growth and diversity of other phytoplankton (Sedmak and Elerseck 2006). Recent studies suggest other harmful cyanobacteria are present in the estuary including *Planktothrix* sp. (Lehman, unpublished), anabaena sp. and *Cylindrospermopsis* sp. (phytoplankton data files, www.iep.water.ca.gov).

Managing water operations to control residence time, salinity or water temperature for enhanced growth or survival of phytoplankton and zooplankton

species needed to support food web production requires information on how these species vary in response to each other and environmental conditions over space and time. Since these are small organisms and influenced by local gradients, high frequency spatial and temporal variation is important (Hutchinson 1967). In addition only samples collected at high frequency spatial and temporal scales can fully quantify the phytoplankton and zooplankton resource which occurs in patches and varies on the time scale of their growth (e.g., hours to weeks) in response to water quality conditions (Cloern and Nichols 1985). Sampling along longitudinal transects from San Francisco Bay to Rio Vista confirmed the high frequency spatial variability of water quality variables and phytoplankton chlorophyll *a* concentration (Jassby et al. 1997).

However, high frequency spatial and temporal phytoplankton and zooplankton species composition and their association with water quality conditions are difficult to obtain with standard field sampling methodology. Identification, enumeration and biomass estimates of phytoplankton and zooplankton species composition requires microscopy which is time consuming, costly and slow (Utermöhl 1958; zooplankton meta data at www.iep.water.ca.gov). Microscopic techniques also require technical experts to conduct all of the sample analysis. The lengthy process time for these samples reduces the ability of management to track or respond to changes in phytoplankton and zooplankton community composition in a timely fashion. This can be a critical problem when toxic algal blooms such as *Microcystis* are present.

The portable FlowCAM® (Fluid Imaging Technologies, Inc.; www.fluidimaging.com) reduces the time and cost associated with identification, enumeration and estimation of biomass for phytoplankton and zooplankton species (Fig. 1). The FlowCAM® combines flow cytometry, confocal microscopy, digital imagery and a chlorophyll fluorescence probe to count, identify and estimate biovolume of live phytoplankton and zooplankton in situ and can be used to process preserved plankton samples in the laboratory (Sieracki et al. 1998; Culverhouse et al. 2006). The FlowCAM® uses a digital imagery library to identify phytoplankton and zooplankton to genera or species. The accuracy of the identifications for a given location increases quickly as the library is refined with use. The FlowCAM® is equipped with different flow cell objectives (2X, 4X, 10X and 20X) that allow identification of phytoplankton with a wide range of cell dimensions from $\geq$4 µm to $\leq$300 µm and zooplankton from $\geq$700 µm to $\leq$1 mm. An important feature of the FlowCAM® is its ability to detect live and dead phytoplankton cells in situ using a chlorophyll fluorescence probe that detects natural chlorophyll fluorescence. The digital imagery also separates phytoplankton and zooplankton cells from suspended sediment particles (Sterling et al. 2004). The FlowCAM® is relatively new in aquatic sciences and journal publications are few, but it was shown to be effective for monitoring mixed phytoplankton communities and harmful algal bloom species (Babin et al. 2005; See et al. 2005; Buskey and Hyatt, in press).

The ability of the FlowCAM® to identify phytoplankton and zooplankton species, enumerate their abundance and compute biomass is unique. For in situ phytoplankton community assessment, there are flow cytometers or flow cytometers linked to fluorescence sensors. CALFED recently funded Dr. Mueller-Solger to asses the use of the FluoroProbe for phytoplankton sampling. This instrument characterizes phytoplankton classes using the relative fluorescence of pigment concentrations in the algae. However, separation of some common phytoplankton classes is poor because the pigments are similar and some classes cannot be separated at all such as diatoms and dinoflagellates (See et al. 2005). The ability of the FlowCAM® to fully characterize the phytoplankton community is also limited somewhat by size range because it does not identify phytoplankton cells in the smallest (picoplankton 1 µm) size range (See et al. 2005). Although this may limit fully characterizing the phytoplankton community, it may not affect our ability to characterize the availability of phytoplankton available to copepods, the most critical food for fish. Copepods in the delta eat phytoplankton cells in the 10-40 µm size range (Hansen et al. 1994; Lehman 2000a). Neither the FlowCAM® nor the FluoroProbe provides a perfect picture of the phytoplankton community, but in combination were capable of characterizing the full phytoplankton community in the Gulf of Mexico (See et al. 2005). For zooplankton, there is no in situ sampling technique for species composition currently available.

The FlowCAM® was evaluated for analysis of phytoplankton and zooplankton species composition in preserved samples for SFE in 2005. The FlowCAM® successfully separated, enumerated and computed the volume of phytoplankton and zooplankton species and was able to separate these organisms from suspended sediment (Poulton and Nelson 2006a; Fig. 2). In a separate study, the FlowCAM® was also able to quantify the large colonies of the toxic cyanobacteria *Microcystis aeruginosa* in preserved samples (Poulton and Nelson 2006b; Fig. 3). The ability of the FlowCAM® to quantify the phytoplankton community in these preserved samples was very good and would be enhanced for in situ sampling where the phytoplankton detection would be based on the chlorophyll fluorescence of each living cell.

Conceptual Model

The conceptual model underlying this study is that the growth of phytoplankton and zooplankton species in the estuary is dependent on the match or mis-match of populations with their food, predator or prey and water quality conditions at high frequency spatial and temporal scales and that knowing how these populations vary at high frequency spatially and temporally and are correlated with high frequency water quality conditions will provide new insights into the magnitude, variability, driving forces and match and miss-match of resource availability at the base of the food web. Further, the FlowCAM® provides the ability to rapidly and inexpensively quantify these high frequency spatial and temporal variations in phytoplankton and zooplankton communities in the field and laboratory and therefore provides management and conservationist and

scientists with a new tool for rapid adaptive management of delta water operations to enhance lower food web resources needed to support fishery production and to identify the introduction and bloom development of harmful algal blooms in the estuary.

Goals

1) Use FlowCAM® technology to determine the high frequency spatial and temporal variation of phytoplankton and zooplankton communities and their association with water quality conditions for critical habitats associated with the development of key pelagic species in the delta and Suisun Bay (e.g., the lower Sacramento River during early spring for Delta smelt).

This information could provide new information about the availability and variability of suitable habitat for phytoplankton and zooplankton species and quantity of food resources available at the base of the food web. Such information could be used to assist data analysis and predictive and mechanistic modeling efforts and provide policy makers with timely information for adaptive management actions that enhance plankton resources needed to support production of pelagic fish.

2) Develop a state of the art monitoring program for phytoplankton and zooplankton species composition for the estuary that is rapid and cost effective. Such a monitoring program will provide a) real-time in situ identification, enumeration and estimation of phytoplankton and zooplankton species; b) accurate and rapid analysis of preserved phytoplankton and zooplankton laboratory samples; 3) provide early warning systems for the presence and development of harmful algal bloom species; 4) provide information on the introduction of exotic zooplankton species.

Accurate and real-time processing of phytoplankton and zooplankton samples in the field and rapid processing of preserved plankton samples in the laboratory will lead to more rapid management response time to changing conditions in the estuary that can be used to enhance lower food web resources and provide early warning systems for new or harmful plankton in the estuary.

Hypotheses

1) Phytoplankton and zooplankton species vary at high frequency spatial scales along the longitudinal axis of the estuary in relation to each other and to water quality variables in the estuary such that they form discrete patches with different abiotic and biotic characteristics.

2) Phytoplankton and zooplankton community composition vary at high frequency time scales (hours to weeks) at fixed locations in the delta in relation to each other and to changes in water quality variables.

3) The FlowCAM® is a more reliable and better indicator of real-time in situ phytoplankton community composition and biomass than the FluoroProbe which measures phytoplankton pigment concentration.

4) The FlowCAM® is an accurate and more rapid method for identification, enumeration and estimation of biomass for in preserved phytoplankton and zooplankton species samples than traditional microscopy.

3) Approach and scope

General Summary - This study will conduct field studies and laboratory tests using the portable FlowCAM® and historical data analyses to 1) characterize the high frequency spatial and temporal variation of phytoplankton and zooplankton communities in the estuary, 2) evaluate state of the art technologies for in situ real-time measurement of phytoplankton community composition and biomass and 3) develop more rapid analysis of phytoplankton and zooplankton identification, enumeration and biomass estimates in preserved samples. Each task in this project will be is independent of the others.

Detailed study description by Task:
Task 2. Quantify the high frequency spatial variation of phytoplankton and zooplankton community composition along longitudinal gradients in the estuary.

Hypothesis - Phytoplankton and zooplankton species vary at high frequency spatial scales along the longitudinal axis of the estuary in relation to each other and to water quality variables in the estuary such that they form discrete patches with different abiotic and biotic characteristics.

Field study - High frequency phytoplankton and zooplankton species composition, density and biomass in conjunction with water quality conditions will be collected along the longitudinal axis of the estuary between Suisun Bay and Rio Vista on the Sacramento River and between Suisun Bay and Stockton on the San Joaquin River. These transects will be conducted each month between spring and fall (March through September) for two years. Transects will include different habitats included flooded islands, shoals and channel habitat. As many samples will be taken along these longitudinal transects as possible in a systematic fashion. Research demonstrated that equally spaced high frequency sampling along a longitudinal transect provided a good estimate of spatial variability for water quality variables and chlorophyll *a* concentration in the estuary (Jassby et al. 1997). During the sampling run, water containing phytoplankton species will be transferred by diaphragm pump from the water column to a container linked to the FlowCAM® on board ship where the species will be identified and counted and the cell dimensions used to estimate biomass in situ. A water sample for phytoplankton species identification and enumeration by microscopy will also be preserved in Lugol's iodine solution (Utermöhl 1958).

Phytoplankton cells in the community will be measured with three objectives 20X (3 to 45 µm diameter cells), 10X (5 to 95 µm diameter cells) and 4X (10 to 250 µm diameter cells) or the most appropriate size range of the three for the sample area based on initial sampling. Zooplankton for species identification and biomass estimates will be collected simultaneously from the water column by diaphragm pump and concentrated on board ship by running the pumped water through a 153 µm mesh zooplankton net fixed in a vertical position. Zooplankton from the cod end of the plankton net will be immediately preserved in Lugol's iodine solution or 10% buffered formalin and then run through the FlowCAM® for real-time digital imaging to determine species composition, animal density and animal biomass once the phytoplankton sampling is completed. Zooplankton will be measured for small (<600-700 µm) and large (>1-3 mm) size categories. A replicate sample will be preserved in 10% buffered formalin for identification and enumeration in the laboratory by dissecting microscope combined with digital imagery processing for comparison.

The FlowCAM® identifies the phytoplankton and zooplankton by taxonomic group or species through libraries developed by the manufacturer and the user from the images obtained by the FlowCAM® at different locations. Once the libraries are created from initial cruise transects, the FlowCAM® software will allow for further analysis and pattern matching of future samples/runs with the FlowCAM®. Sample post-processing and Identifications are relatively fast once the libraries are developed and will not cause significant delay in the use of the system. Identification will be at least to the genus and species level if possible or binned into size classes for biomass estimates. Water quality conditions associated with phytoplankton and zooplankton communities along the longitudinal axis of each river will be obtained using a YSI 6600 (YSI Instruments Inc.) real-time water quality sonde (pH, dissolved oxygen, water temperature, specific conductance, NTU and chlorophyll fluorescence). The concentration of dissolved nitrate and ammonia nitrogen, dissolved soluble and total phosphorus, dissolved silica and chlorophyll *a* and phaeophytin concentration will be measured with selected discrete samples. Water for these samples will be pumped from the water column. Water samples for nitrogen and phosphorus will be filtered through 0.45 µm pore size Millipore HATF04700 nucleopore filters and frozen until analysis by colorimetric technique (US EPA, 1983). Silica concentration will be determined by the molybdate blue method (USGS, 1985). Water samples for chlorophyll *a* and phaeophytin concentration will be filtered through Millipore GF/F glass fiber filters and frozen until analysis. Pigments will be extracted in 90% acetone and analyzed for chlorophyll *a (*corrected for phaeophytin) and phaeophytin using spectrophotometry (method 10200H, APHA *et al*., 1998). Because nutrients are rarely limiting, nutrient measurements will be made to confirm they are in excess. Comparisons of phytoplankton and zooplankton communities in relation to streamflow will be done using streamflow data from DAYFLOW data files (iep.water.ca.gov).

Data analysis - Correlation among phytoplankton and zooplankton community composition and water quality data will be determined statistically using multivariate statistical procedures such as canonical correlation and ARIMA time series analysis. Spectral analysis will be used to characterize the periodicity in the data. Similarity among phytoplankton and/or zooplankton groups will be determined by cluster analysis. The spatial patterns and associations in these data will be compared with the historical data from monthly sampling at fixed stations analyzed in the same fashion as the high frequency data. Analyses will use the SAS statistical package (SAS 2004).

Value - This information will provide valuable information on the location, amplitude, variation and overlap of phytoplankton and zooplankton communities and their association with water quality conditions that may be important for real-time management of fishery resources. This information will also identify habitat needs for phytoplankton and zooplankton species. Such information is needed for long-term data analysis and predictive and mechanistic models. It may also suggest new approaches to field sampling and management of biological resources in the estuary.

Task 3. Quantify the high frequency temporal variation of phytoplankton and zooplankton community composition at fixed stations in the estuary.

Hypothesis - Phytoplankton and zooplankton species composition vary at high frequency temporal scales with regard to each other and to water quality variables.

Field study - The high frequency temporal (hours to weeks) variation of phytoplankton and zooplankton community composition and their association with water quality conditions will be measured at three continuous water quality monitoring stations operated by the Department of Water Resources. These stations routinely measure the water quality variables pH, water temperature, specific conductance, NTU and chlorophyll fluorescence at 15 min intervals using an in situ YSI 6600 water quality sonde. Weather measurements include air temperature, wind speed and direction and solar irradiance. Chlorophyll fluorescence is calibrated to laboratory extracted chlorophyll *a* concentration using techniques described in Hypothesis 1. The FlowCAM® will conduct real-time identification, enumeration and estimation of phytoplankton species composition for at least two weeks in the spring, summer and fall. Sample water will be pumped from 1 m depth in the water column into the station housing and then into a container attached to the FlowCAM®. Screening the pump and input port with a large mesh (>500 µm) will limit fouling of the input port from large particles. In addition, copper tubing will be applied to the intake port of the FlowCAM® to limit biofouling. For phytoplankton sampling a size range will be selected that best represents the community based on test runs. Companion water samples for microscopic analysis of phytoplankton species composition will be collected using an ISCO automatic water sampler. Sampling at the continuous

monitoring station at Antioch will also allow evaluation of the ability of the FlowCAM® to conduct real-time monitoring of the *Microcystis* toxic bluegreen algal bloom. This work will be done in cooperation with a CALFED grant to Dr. Lehman to monitor *Microcystis* biomass in the estuary. Operation of the instrument will be monitoring daily during the sampling period. In a separate study, high frequency zooplankton species identification, enumeration and biomass estimates will be conducted at the same three continuous monitoring stations on concentrated zooplankton samples. The zooplankton will be pumped from the water column, concentrated using a zooplankton net (153 µm mesh) and preserved in 10% buffered formalin or Lugol's iodine solution before processing with the FlowCAM® as described in Hypothesis 1. Zooplankton will initially be preserved as a precaution against large zooplankton swimming against the FlowCAM® inflow current, but preservation will be eliminated if possible. Screening as described in Hypothesis 1 will limit the fouling by large particles on the input port to the FlowCAM®. The sampling will be systematic and include as many samples as possible during a diel period.

Data analysis – Periodicity in the species and water quality data will be quantified using spectral analysis. Correlation between phytoplankton and zooplankton species and water quality conditions will be determined using multivariate analysis such as canonical correlation analysis and ARIMA time series analysis. Similarity of phytoplankton and zooplankton groups will be determined using cluster analysis of nondimensional data. High frequency temporal patterns in phytoplankton biomass will be compared with continuous phytoplankton chlorophyll *a* concentration (YSI 6600 chlorophyll *a* fluorescence calibrated with laboratory extracted chlorophyll *a* concentration as described in Hypotheses 1) measured concurrently at the monitoring station using ARIMA (time series correlation) and spectral analysis (temporal pattern). Periodicity in the high frequency species and biomass data and their correlation with water quality will be compared with historical measurements of chlorophyll *a* concentration (fluorescence) and water quality variables at the continuous monitoring stations using spectral analysis and ARIMA. The influence of high frequency changes in species composition on carbon load compared with monthly data will also be evaluated using ANOVA. Analyses will use the SAS statistical package (SAS 2004).

Value – This information will provide valuable information on the influence of high frequency variation of phytoplankton and zooplankton communities on population trends that will assist development of mechanistic and predictive models and compute more accurate estimates of phytoplankton and zooplankton carbon load and the quality of phytoplankton food available to the estuary. It will also provide valuable information on the covariance of phytoplankton and zooplankton species composition and with high frequency changes in water quality conditions. This information could be used to better design continuous phytoplankton and zooplankton monitoring programs in the estuary for evaluation of fishery resources, impacts of harmful algal blooms and exotic species introductions.

Task 4. Compare the accuracy of FlowCAM® and FluoroProbe instruments for measurement of phytoplankton community composition and biomass.

Hypothesis - The FlowCAM is a more reliable and better indicator of in situ phytoplankton community composition and biomass than the Fluoroprobe which only measures phytoplankton pigment concentration.

Study – Comparison of FlowCAM® and bbe FluoroProbe (http://www.bbe-moldaenke.de and http://www.bbe.us) technologies for characterization of phytoplankton communities and their biomass will be tested for three of the DWR continuous monitoring stations: D10 in Suisun Bay, P8 at Stockton on the San Joaquin River and C3A at Hood on the Sacramento River. These stations were selected for the FluoroProbe in the CALFED grant to Dr. Mueller-Solger. High frequency samples will be collected for at least two weeks in spring, summer and fall with both instruments. Results will be compared between the two machines and with phytoplankton cell counts and biomass estimates from samples preserved with Lugols iodine solution and analyzed by the traditional inverted microscope technique (Utermöhl 1958). Microscopy will count phytoplankton cells to the picoplankton level. Estimates of biomass will also be compared with chlorophyll fluorescence measured continuously by YSI 6600 sonde and calibrated with extracted chlorophyll *a* and phaeophytin pigment concentrations as described in Hypothesis 1 (method 10200H, APHA et al. 1998). The FluoroProbe work will be done in collaboration with Dr. Mueller-Solger who has a CALFED grant to evaluate its use for phytoplankton community sampling in the delta.

Analysis – Differences between the total and group biomass measured by each machine, microscopy and chlorophyll *a* concentration will be analyzed by analysis of variance. Analyses will use the SAS statistical package (SAS 2004).

Task 5. Evaluate the speed and accuracy of the FlowCAM® to identify, enumerate and compute phytoplankton and zooplankton in preserved samples.

Hypothesis - The FlowCAM® is an accurate, reliable and more rapid method for identification, enumeration and estimation of biomass for phytoplankton and zooplankton species than traditional microscopy for preserved samples.

Study – The accuracy and efficiency of analyzing preserved phytoplankton and zooplankton samples in the laboratory with microscopy and FlowCAM® technology will be compared for samples collected at 10 stations for one year at monthly intervals by the EMP monitoring program. For phytoplankton, comparisons will be made of the species composition at least to genera, cell density and biomass values obtained by traditional inverted microscope analysis of samples preserved with Lugol's iodine solution (Utermöhl 1958) enhanced to capture picoplankton and the FlowCAM® run for three objectives: 20X (3 to 45

µm cell diameter), 10X (5 to 95 µm cell diameter) and 4X (10 to 275 µm cell diameter). For zooplankton samples preserved with 10% buffered formalin or ethanol, comparisons will be made between species composition at least to genera, animal density and biomass estimates using the FlowCAM® and standard dissecting microscope techniques (zooplankton metadata, www.iep.water.ca.gov. The FlowCAM® will be run at two magnifications to quantify large (≥1- 3 mm) and small (>600-700 µm) zooplankton in the samples. The time and cost necessary to analyze each sample will be recorded for an efficiency comparison.

Analysis – Comparison of phytoplankton or zooplankton species density and biomass and the sample processing time between the FlowCAM® and microscopy will be compared statistically with ANOVA (t-test). Analyses will use the SAS statistical package (SAS 2004).

Task List

Task 1. Management of contracts, subcontracts, accounting, personnel and reporting. January 2007 – December 2008.
Task 2. Conduct high frequency phytoplankton and zooplankton spatial variation study. June 2007 – September 2008.
Task 3. Conduct high frequency phytoplankton and zooplankton temporal study. June 2007 – September 2008.
Task 4. Compare FlowCAM and Fluoroprobe for estimating phytoplankton community composition and biomass. June 2007 – September 2008.
Task 5. Evaluate the accuracy and efficiency of using the FlowCAM for analyzing phytoplankton and zooplankton species composition compared with microscopy. June 2007 – December 2008.
Task 6. Technical assistance with field sampling, data analysis and journal paper and report writing. January 2007 to December 2008
Task 7. Report preparation including progress reports, final report, presentations at the CALFED Science Conference, at least one national meeting and two peer reviewed journal articles, a manual for FlowCAM application in the delta and a digital imagery species library. January 2007 – December 2008.

Deliverables - Results of these studies will be used to enhance knowledge of the spatial and temporal structure of phytoplankton and zooplankton communities and their association with water quality conditions in critical fish habitats of the estuary and evaluate new technologies for accurate and real-time measurement of phytoplankton and zooplankton community composition in situ and the laboratory needed for timely adaptive management decisions. This information will be distributed through at least two peer reviewed journal articles, three semi-annual reports, a final report to CALFED, a manual on the best use of the FlowCAM® in the delta for phytoplankton and zooplankton sampling, a digital imagery library of phytoplankton and zooplankton for FlowCAM® use and

presentations at the CALFED Science Conference, State of the Estuary Conference, local meetings and at least one national meeting.

Schedule –January 2007 through December 2008.

Cost - $248,349.

4) Feasilibity

The proposed project is feasible and fully implementable within three years and can start as soon as funding is available through contracts and subcontracts. The project will be managed by Dr. P. W. Lehman through a contract between DWR and CALFED and a subcontract between DWR and Bigelow Lab for Ocean Sciences. Dr. Lehman will coordinate management decisions among the collaborators and facilitate the contract management through the contract administrators at DWR.

There are no permits, endangered species issues or other restrictions associated with conducting this work.

The portable FlowCAM® is a relatively new instrument but has been tested in field and laboratory research throughout the country. The ability of the FlowCAM® to quantify phytoplankton and zooplankton species from the SFE was confirmed for preserved field samples containing a mixed assemblage of delta phytoplankton collected by van Dorn water sampler, a mixed assemblage of zooplankton collected by net tows and the wide diameter colonial bluegreen alga *Microcystis aeruginosa* collected in net samples *(*Fig. 3). There was concern that the high turbidity of the delta would clog the input tubing, but the samples were easily read in the laboratory. In the field, clogging of the input port will be controlled by pumping water from the delta to the FlowCAM® on board ship or inside a continuous monitoring station. Large mesh screens (> 500 µm) placed over both the pump and FlowCAM® input port significantly reduces clogging. Copper tubing placed on the input port will also reduce biofouling. Another concern in the use of the FlowCAM® was the time needed to develop a species library, but experience has demonstrated that this develops fairly quickly (N. Poulet, unpublished).

The Fluoroprobe listed in Task 5 is already available as a part of an ongoing CALFED grant to Dr. Mueller-Solger, some phytoplankton and zooplankton samples will be analyzed as part of the Department of Water Resources Estuarine Monitoring Program and CALFED grants to Dr. Mueller-Solger for evaluation of the Fluoroprobe and Dr. Lehman for monitoring of Microcystis. Boats, boat operators and sampling equipment are available through the Department of Water Resources Estuarine Monitoring Program.

5) Relevance to CALFED Science

This proposed work was described in detail in relation to Topic 4: Habitat availability and response to change and was briefly described in relation to Topic 2: Aquatic Invasive Species and Topic 3: Trends and patterns of populations and system response to a changing environment. Many of the descriptions were similar under each Topic.

Topic 4: Habitat availability and response to change

The purpose of this research is to obtain new high frequency spatial and temporal information on the magnitude and variability of phytoplankton and zooplankton community composition and how these correlate with water quality conditions in the upper estuary and then to compare these with historical data to gain a broader understanding of the variability associated with phytoplankton and zooplankton populations in the estuary. Such information will provide direction for development of adaptive management strategies and predictive and mechanistic models needed to address the effects of anticipated changes in environmental conditions in the delta from climate, water management, harmful algal blooms and species invasions in key habitats for fishery production. Information from these studies can also be used to develop state of the art monitoring programs for phytoplankton and zooplankton species at sensitive spatial and temporal time scales needed to manage lower food web resources to support fishery production in habitats such as wetlands.

Questions/Hypotheses: The first part of the research will examine spatial patterns among phytoplankton and zooplankton species composition and water quality conditions and address the following hypotheses 1) Phytoplankton and zooplankton species vary at high frequency spatial scales and are associated with each other and water quality variables in the estuary such that they form patches with different abiotic and biotic characteristics that affect resource availability in the estuary.

Detailed question that will be addressed are: 1) How do phytoplankton and zooplankton species composition vary along high frequency (< 1 km) along longitudinal gradients in the estuary?; 2) How do zooplankton species composition vary with phytoplankton species composition along longitudinal gradients in the estuary; 3) How does high frequency spatial variation of phytoplankton and zooplankton species composition along longitudinal gradients in the estuary vary with water quality conditions such as water temperature?, turbidity, specific conductance, salinity, pH and dissolved oxygen concentration. 4) Do the high frequency spatial patterns describe a more variable phytoplankton and zooplankton community structure in relation to water quality conditions than historical data for similar time periods and similar locations? and 5) Are key water quality or key species good predictors of high frequency spatial change in phytoplankton and zooplankton species composition?

The research will also measure high frequency temporal variation (e.g., hourly to daily) in phytoplankton and zooplankton species composition and their correlation

with water quality conditions to address hypothesis 2 : Phytoplankton and zooplankton community composition vary at high frequency temporal scales in relation to each other and to water quality variables. Specific questions this work will address are: 1) How do phytoplankton and zooplankton species composition vary at high frequency intervals?; 2) Do zooplankton species composition vary directly with phytoplankton species composition at high frequency temporal scales?; 3) Are high frequency temporal variations in phytoplankton and zooplankton species composition correlated with high frequency changes in water quality conditions such as water temperature, turbidity, specific conductance, salinity, pH and dissolved oxygen concentration? 4) Do high frequency temporal patterns describe a more variable phytoplankton and zooplankton community structure in relation to water quality conditions than the historical data for similar time periods and similar locations? and 5) Are key water quality or key species identified in field measurements of phytoplankton and zooplankton species and water quality conditions good predictors of high frequency temporal change in phytoplankton and zooplankton species composition?.

Key components: This research will provide 1) information on the current habitat extent, condition and spatially explicit phytoplankton and zooplankton species composition data and the potential impacts of anticipated stressors associated with water quality conditions; 2) Multivariate predictive models for regions of the data that correlate phytoplankton and zooplankton species composition and water quality conditions; 3) Factors will include the high frequency variation of the abiotic factors (air and water temperature, salinity, streamflow, turbidity (NTU), day length, pH and dissolved oxygen) and the biotic factors (phytoplankton and zooplankton species composition including current and future harmful bluegreen algal species such as *Microcystis aeruginosa* and *Cylindrospermopsis* sp.).

Topics 2 and 3: This proposal addresses Topic 2 because the FlowCAM® will be used to identify the high frequency spatial and temporal distribution of *Microcystis aeruginosa* a newly established harmful algal bloom in the estuary that at high densities and toxic concentrations may threaten the delta food web (Lehman et al. 2005). The FlowCAM® in conjunction with high spatial and temporal water quality monitoring will address the questions of how *Microcystis* varies with water quality conditions and how it may impact phytoplankton and zooplankton species composition. Information on the water quality conditions associated with *Microcystis* and the correlation of bluegreen algae with phytoplankton and zooplankton species will also provide insight into factors that could enhance the development of other bluegreen algae in the future. Key components include using the high frequency data to develop scenarios and multivariate statistical models to predict cell density of the planktonic invader *Microcystis* from water quality conditions and to predict phytoplankton and zooplankton community composition based on the density of *Microcystis*. Coincident high frequency water quality variables will be measured using a YSI 6600 and include water temperature, pH, turbidity, specific conductance and dissolved oxygen

concentration. Daily streamflow will be obtained from the IEP DAYFLOW database.

The proposal also addresses Topic 3: Trends and patterns of populations and system response to a changing environment. This study will measure high frequency spatial and temporal associations of phytoplankton and zooplankton species composition and water quality variables in areas of the delta and time periods thought to be important for key fish species in the delta such as the early spring in the lower Sacramento River for delta smelt. Such information will provide insight into the influence of daily water operations on water quality conditions and the resulting high frequency spatial and temporal impact on the distribution, variability and magnitude of phytoplankton and zooplankton species composition.

Questions / hypotheses include: How does the high frequency spatial variation of phytoplankton and zooplankton species composition affect our estimate of the magnitude of biomass available at the base of the food web to support fishery resources? Does the distribution of zooplankton depend on the distribution of phytoplankton or the reverse at high frequency spatial (<1 km) and temporal (hourly, daily and weekly) time scales? How do the high frequency spatial and temporal patterns of phytoplankton and zooplankton species composition vary with high frequency water quality conditions?

Key components: Phytoplankton and zooplankton species composition are the key species of interest. Phytoplankton and zooplankton are critical components of the delta food web but we know nothing about their high frequency variation and how this may affect the availability of resources at the base of the food web. Phytoplankton carbon provides the primary source of food for zooplankton which feed juvenile fish such as delta smelt, longfin smelt and threadfin shad. The spatial distribution and seasonal timing of these resources can affect the availability of resources for the fishery.

The approach of this work is to use the FlowCAM® and YSI 6600 water quality sonde to quantify the high frequency spatial and temporal variation in phytoplankton and zooplankton species composition and water quality conditions at critical regions during spring, summer and fall. The sampling will cover the delta region and provide a new look at the structure of the plankton communities that may assist protection of critical habitat through water management strategies. The results of the work will be to develop a conceptual model based on quantitative data of how phytoplankton and zooplankton communities interact among themselves and how they correlate with water quality conditions. The high frequency nature of the data will provide a more complete picture of how the plankton communities associate and correlate with water quality conditions.

Other desirable project features

Collaborative effort – This proposal is a collaborative effort between the Department of Water Resources, the Bigelow Laboratory for Ocean Sciences and Fluid Imaging Technologies Inc.. Dr. Poulton will provide the expertise in the operation and interpretation of FlowCAM technology. Graduate student assistants will be provided by Dr. Dahlgren at U. C. Davis.

Cost share – This study provides cost share through its combination of CALFED and IEP programs. FluoroProbe equipment ($31,000) and some phytoplankton species identification ($2000) will be provided through a CALFED grant to Dr. Mueller-Solger for FluoroProbe studies of phytoplankton communities in the delta. Some phytoplankton and zooplankton sampling and microscopic identification and enumeration of preserved field samples will be provided by the Department of Water Resources Estuarine Monitoring Program and CALFED grant # SCI-05-C122 to Dr. Lehman for *Microcystis* studies ($2000). The Estuarine Monitoring Program will also provide one month salary for Dr. Lehman ($15,000). This totals: $50,000.

Other desirable features **-** This proposal will also assist development of methods to assist monitoring needed for adaptive management of phytoplankton communities that cause drinking water problems and affect shallow water habitat restoration. *Microcystis* contains toxins that cause cancer in humans and wildlife and along with other species such as *Aulacoseira granulata* and *Oscillatoria* sp. cause taste and odor problems in drinking water. Phytoplankton blooms can also cause dissolved oxygen problems, an important long-term issue in the deep water channel near Stockton on the San Joaquin River and increase THM formation. Restoration of shallow water habitats is also an important CALFED goal and methods to determine the influence of these habitats on food web production, water quality and drinking water quality are critical to long-term adaptive management.

6) Qualifications

The principal investigator Dr. Lehman is a senior scientist with 20 years experience in plankton and water quality sampling and plankton identification in the delta. She is a member of the Department of Water Resources Estuarine Monitoring Program and has peer reviewed journal articles on phytoplankton, zooplankton and water quality on the San Francisco Estuary. She is also an experienced principal investigator for Interagency Program, CALFED and NOAA funded grants for research in the estuary. She will be responsible for facilitating payments, reporting, accounting and hiring dedicated staff to conduct the field studies. The contracts will be run through DWR contract administrators who are experienced with CALFED grants. Contract administration is included in the overhead for Dr. Lehman.

Dr. Poulton is a scientist with Bigelow Laboratory for Ocean Sciences and a scientific consultant to Fluid Imaging Technologies Inc. which developed and distributes the imaging-in-flow instrument known as FlowCAM®. At Bigelow

Laboratory she is a member of the J. J. MacIssac Aquatic Cytometry facility and has 5 years experience working with the FlowCAM® instrumentation for both laboratory and field studies. She is an experienced with phytoplankton and zooplankton sampling and identification, specifically harmful algal blooms. She will provide expertise in the use of the FlowCAM® technology in field studies, assist with data analysis, interpretation of data, report writing and will guide any discussion with the Bigelow Laboratory and Fluid Imaging Technologies for technical issues regarding operation of the instrument and data analysis.

Dr. Mueller-Solger is a scientist with the Department of Water Resources Estuarine Monitoring Program and is experienced in phytoplankton and zooplankton sampling and identification. She is the principal investigator for the CALFED funded program that will evaluate the Fluoroprobe for characterizing phytoplankton class composition in the delta. She will provide expertise on the use of the Fluoroprobe, field data, Fluoroprobe equipment through her CALFED grant and review of the study comparing the Fluoroprobe and the FlowCAM® for characterizing phytoplankton community composition.

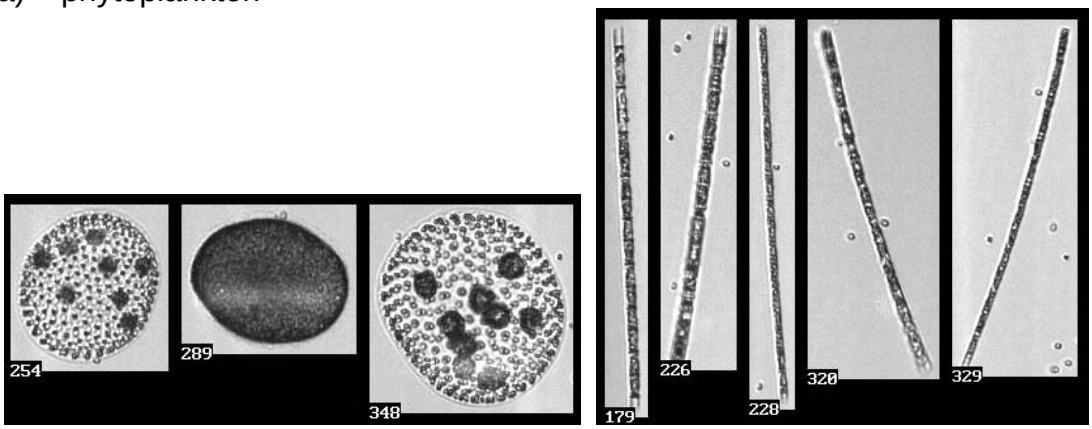
The DWR Estuarine Monitoring Program staff will assist with the deployment and operation of the FlowCAM® and Fluoroprobe and have 20 years of technical expertise in deploying and maintaining automatic sampling systems in the estuary. DWR and EMP Staff also routinely collect phytoplankton, zooplankton and water quality samples in the delta and are qualified to identify phytoplankton and zooplankton.

Budget – equipment justification: The only equipment purchase above $5000 is the FlowCAM® which will cost $81,230.

Figure 1. The portable imaging-in-flow instrument FlowCAM® distributed by Fluid Imaging Technologies, Inc.

Figure 2. Images of a) phytoplankton and b) zooplankton in preserved samples obtained with the FlowCAM® in 2005.

a) phytoplankton



b) zooplankton

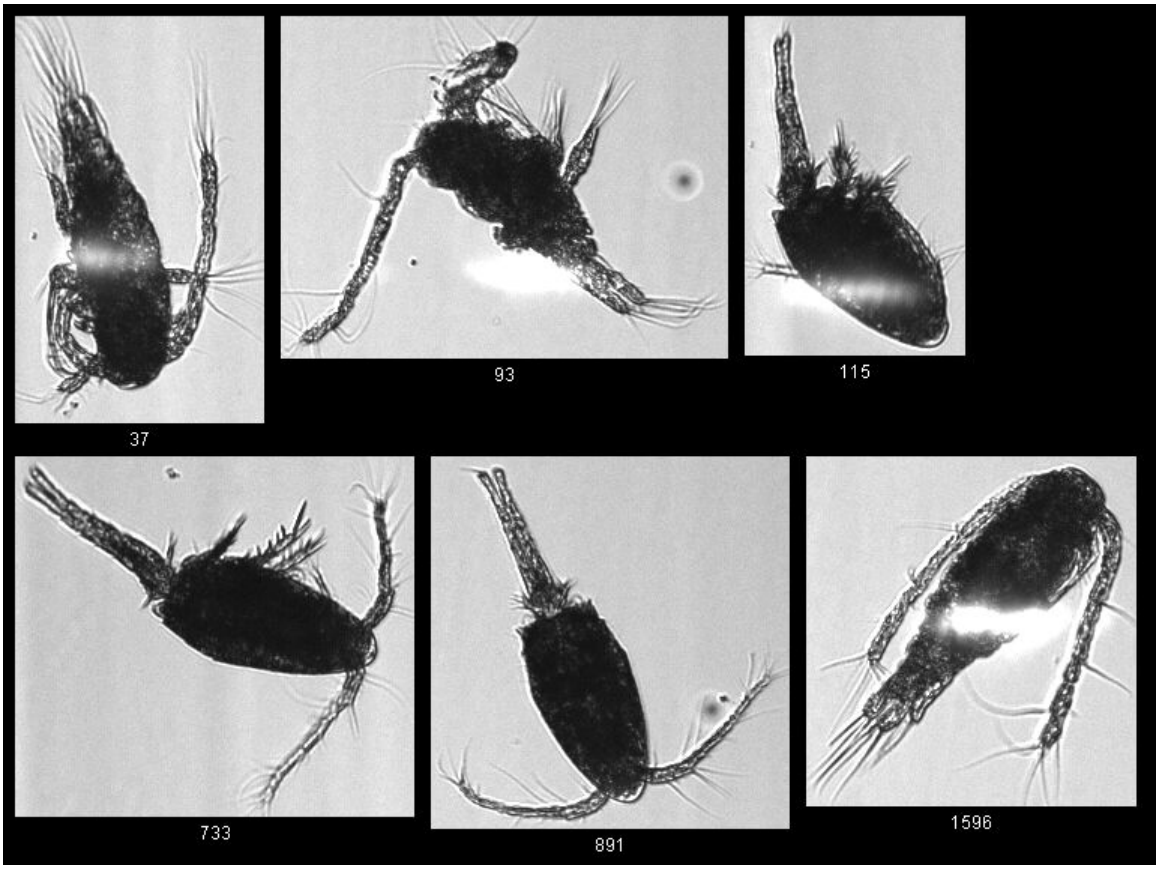
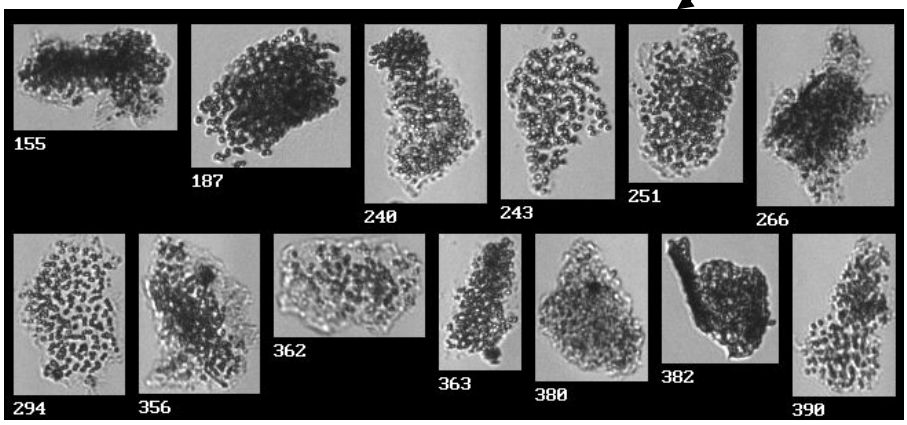


Fig. 3 FlowCAM images of the colonial bluegreen alga *Microcystis aeruginosa* in preserved samples for the delta and the biomass table obtained from the analysis.



To obtain the biovolume estimates data on every particle obtained the data for each run was analyzed using a spreadsheet (generated by the FlowCAM software). For each microcystis colony counted by the instrument the ABD (area based diameter – dark pixels) for each colony was used to calculate the biovolume of the colony/particle. The equation used was as follows – this equation utilized the ABD calculation (area based diameter – based on number of dark pixels obtained from each particle):

$$\textbf{Volume of a particle} = 4/3\ \pi\ (\tfrac{1}{2}\ \textbf{ABD})^3$$

Once the biovolume was calculated for each particle an average was obtained for each size fraction was determined and back calculated to the biovolume per ml of the original net tow sample – based on the dilutions used during sample processing.

Id	Area	ABD Diameter	Biovolume	ESD Diameter	Length	Width
1	650.85	28.79	12488.30199	39.27	45.46	33.44
2	11205.65	119.45	891942.5039	150.54	183.06	116.49
3	1481.72	43.43	42869.44744	62.72	76.17	46.38
4	731.16	30.51	14862.95013	41.43	47.56	34.28
5	639.77	28.54	12165.78968	38.62	44.67	32.26
6	2680.94	58.42	104342.9367	73.57	79.33	63.24
7	645.31	28.66	12319.89357	43.73	54.16	33.28
8	11501.99	121.02	927576.7267	163.83	204.02	121.06
9	5827.16	86.14	334497.5953	160.03	173.08	45.99
*10	34024.06	208.14	4718946.443	272.33	342.94	182.89

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Curriculum Vitae: P. W. Lehman, Ph.D.

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Education: B.S. Renewable Natural Resources (1972), M.S. Ecology (1974), and Ph.D. Ecology (1979) at University of California, Davis, CA

Research Interests: Research interests include studies associated with phytoplankton biomass, growth rate and species composition, water quality and lower food web dynamics relating to the biological impacts of climate change, eutrophication and wetland restoration in the upper San Francisco Bay estuary.

Other qualifications: Principal scientist of $860,000 CALFED ERP 2000-2001 dissolved oxygen study in the San Joaquin River (completed) and $500,000 CALFED Science grant (current); Principal and Senior scientist for CALFED and Sacramento-San Joaquin River Interagency Ecological Program grants of over $1 million to study phytoplankton growth in the San Joaquin River, carbon production and water quality in the Delta, floodplain and tidal wetlands (Liberty Island) and the distribution and toxicity of toxic bluegreen algae in the Delta

Professional Experience:

1986-present: Staff Environmental Specialist
Division of Environmental Services, California Department of Water Resources, Sacramento, CA

1982-1985: Associate Environmental Specialist
California Department of Water Resources, Sacramento, CA

1980-1981: Instructor
Chapman College (ext), Alameda, CA

1978-1980: Postdoctor and Research associate
Land, Air and Water Resources, University of California, Davis, CA

1977-1978: National Research Council Fellowship
Bedford Institute of Oceanography, Nova Scotia, Canada

Selected publications:

Lehman, P. W., T. Sommer and L. Rivard. In review. Phytoplankton primary productivity, respiration, chlorophyll *a* and species composition in the Yolo

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PROFESSIONAL MEMBERSHIPS : American Society of Limnology and Oceanography; Estuarine Research Federation; American Association for the Advancement of Science;

RECENT COLLABORATORS : Greg Boyer, State University of New York, Syracruse; Catherine Hall, CSIRO, Australia; Swee Teh University of California at Davis; Ted Sommer and Randy Mager, CA Department of Water Resources

Total Project Budget Summary by Task and by Fiscal Year

Note: This budget summary **automatically links** to the costs and totals on the **"Budget Detail"** worksheet.
DO NOT CHANGE FORMULAS OR ENTER NUMBERS INTO ANY CELLS EXCEPT THE SHADED CELLS for "Cost Share" and "Other Matching Funds"

BUDGET SUMMARY	Total Amount for Year 1	Total Amount for Year 2	Total Amount for Year 3	Total Amount for All Years
Total Costs for Task One	$ 1,764.00	$ 1,764.00	$ -	$ 3,528.00
Total Costs for Task Two	$ 110,171.40	$ 23,466.00	$ -	$ 133,637.40
Total Costs for Task Three	$ 14,528.00	$ 12,764.00	$ -	$ 27,292.00
Total Costs for Task Four	$ 5,630.00	$ 2,630.00	$ -	$ 8,260.00
Total Costs for Task Five	$ 5,630.00	$ 1,630.00	$ -	$ 7,260.00
Total Costs for Task Six	$ 26,337.99	$ 17,921.72	$ -	$ 44,259.71
Total Costs for Task Seven	$ 17,056.00	$ 7,056.00	$ -	$ 24,112.00
Total Costs for Task Eight	$ -	$ -	$ -	$ -
Total Costs for Task Nine	$ -	$ -	$ -	$ -
Total Costs for Task Ten	$ -	$ -	$ -	$ -
Total Costs for Task Eleven	$ -	$ -	$ -	$ -
Total Costs for Task Twelve	$ -	$ -	$ -	$ -
Total Costs for Task Thirteen	$ -	$ -	$ -	$ -
Total Costs for Task Fourteen	$ -	$ -	$ -	$ -
Total Costs for Task Fifteen	$ -	$ -	$ -	$ -
Total Costs for Project Tasks	$ 181,117.39	$ 67,231.72	$ -	$ 248,349.11
1/Cost Share	$ 35,000.00	$ 15,000.00	$ -	$ 50,000.00
2/ Other Matching Funds	$ -	$ -	$ -	$ -

1/ *Cost share funds* are specifically dedicated to your project and can include private and other State and Federal grants. Any funds listed in this line must be further described in the text of your proposal (see Chapter 3, Section D, of the PSP document)

2/ *Other matching funds* include other funds invested consistent with your project in your project area for which the ERP grant applicant is not eligible. Any funds listed in this line must be further described in the text of your proposal (see Chapter 3, Section D, of the PSP document)

Detailed Budget Breakdown by Task and by Fiscal Year

		Year 1			Year 2			Year 3		
BUDGET FOR TASK ONE (Administrative)	**TOTAL AMOUNT TASK 1 All Years**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 1**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 2**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 3**
Personnel										
Lehman - reporting, accounting, tracking, publication	$ 2,520.00	$ 63.00	20	$ 1,260.00	$ 63.00	20	$ 1,260.00	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
Personnel Subtotal	**$ 2,520.00**			**$ 1,260.00**			**$ 1,260.00**			**$ -**
[1/] Benefits as percent of salary	40%			$504.00			$504.00			$0.00
Personnel Total (salary + benefits)	**$3,528.00**			**$1,764.00**			**$1,764.00**			**$0.00**
Other Costs	**Total All Years**			**Total Year 1**			**Total Year 2**			**Total Year 3**
Operating Expenses: (ex: seed, plant materials, irrigation supplies, software, office supplies, etc)	$ -			$ -			$ -			$ -
2/ Travel and Per Diem	$ -			$ -			$ -			$ -
3/ Equipment	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
Other Costs Subtotal	**$ -**			**$ -**			**$ -**			**$ -**
[5/]Overhead Percentage (Applied to Personnel & Other Costs)				$ -			$ -			$ -
Total Costs for Task One	**$ 3,528.00**			**$ 1,764.00**			**$ 1,764.00**			**$ -**

1/ Indicate your rate, and change formula in column immediately to the right of this cell

2/ Travel expenses and per diem must be at rates specified by the Department of Personnel Administration. The contractor is required to maintain travel receipts and records for auditing purposes. No travel out of the state of California shall be reimbursed unless prior written authorization is obtained from the State.

3/ Please provide a list and cost of major equipment ($5,000 or more) to be purchased, and complete "Equipment Detail" Worksheet

4/ Please list each subcontractor and amounts (if subcontractor not selected yet, use function like "ditch construction subcontractor")

5/ Indicate rate in column immediately to the right of this cell; and provide a description of what expenses are covered by overhead. If overhead is > 15% must provide justification

Proposal Number
Proposal Name

Detailed Budget Breakdown by Task and by Fiscal Year

Applicant Name

BUDGET FOR TASK TWO	TOTAL AMOUNT TASK 2 All Years	Year 1 Amount per hour	Year 1 Number of Hours	Year 1 Total Amount for Year 1	Year 2 Amount per hour	Year 2 Number of Hours	Year 2 Total Amount for Year 2	Year 3 Amount per hour	Year 3 Number of Hours	Year 3 Total Amount for Year 3
Personnel										
Lehman - oversight, field sampling and analysis	$ 5,040.00	$ 63.00	40	$ 2,520.00	$ 63.00	40	$ 2,520.00	$ -		$ -
Dempsey - equipment design	$ 1,386.00	$ 63.00	22	$ 1,386.00	$ 63.00		$ -	$ -		$ -
Santos - boat operation	$ 11,340.00	$ 63.00	90	$ 5,670.00	$ 63.00	90	$ 5,670.00	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
Personnel Subtotal	**$ 17,766.00**			**$ 9,576.00**			**$ 8,190.00**			**$ -**
[1/] Benefits as percent of salary	40%			$3,830.40			$3,276.00			$0.00
Personnel Total (salary + benefits)	**$24,872.40**			**$13,406.40**			**$11,466.00**			**$0.00**
Other Costs	**Total All Years**			**Total Year 1**			**Total Year 2**			**Total Year 3**
Operating Expenses: (ex: seed, plant materials, irrigation supplies, software, office supplies, etc)	$ 2,000.00			$ 1,000.00			$ 1,000.00			$ -
2/ Travel and Per Diem	$ -			$ -			$ -			$ -
Equipment- FlowCAM ($81,230); sample pumps ($2,000)	$ 83,230.00			$ 83,230.00			$ -			$ -
4/ Sub-Contractor - phytoplankton counts	$ 2,000.00			$ 1,000.00			$ 1,000.00			$ -
4/ Sub-Contractor - UC Davis graduate student	$ 21,535.00			$ 11,535.00			$ 10,000.00			$ -
field sampling and analysis of data;	$ -			$ -			$ -			$ -
17.93 per hour year 1 and $18.56 per hour year 2;	$ -			$ -			$ -			$ -
42% benefits; 25% overhead	$ -			$ -			$ -			$ -
Other Costs Subtotal	**$ 108,765.00**			**$ 96,765.00**			**$ 12,000.00**			**$ -**
[5/]Overhead Percentage (Applied to Personnel & Other Costs)				$ -			$ -			$ -
Total Costs for Task Two	**$ 133,637.40**			**$ 110,171.40**			**$ 23,466.00**			**$ -**

1/ Indicate your rate, and change formula in column immediately to the right of this cell

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3/ Please provide a list and cost of major equipment ($5,000 or more) to be purchased, and complete "Equipment Detail" Worksheet

4/ Please list each subcontractor and amounts (if subcontractor not selected yet, use function like "ditch construction subcontractor")

5/ Indicate rate in column immediately to the right of this cell; and provide a description of what expenses are covered by overhead. If overhead is > 15% must provide justification

BUDGET FOR TASK THREE	TOTAL AMOUNT TASK 3 All Years	Year 1 Amount per hour	Year 1 Number of Hours	Year 1 Total Amount for Year 1	Year 2 Amount per hour	Year 2 Number of Hours	Year 2 Total Amount for Year 2	Year 3 Amount per hour	Year 3 Number of Hours	Year 3 Total Amount for Year 3
Personnel										
Lehman - oversight and field sampling	$ 2,520.00	$ 63.00	20	$ 1,260.00	$ 63.00	20	$ 1,260.00	$ -		$ -
Dempsey - equipment design	$ 1,260.00	$ 63.00	20	$ 1,260.00	$ 63.00		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -

	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
Personnel Subtotal	**$ 3,780.00**			**$ 2,520.00**			**$ 1,260.00**			**$ -**
1/ Benefits as percent of salary	40%			$1,008.00			$504.00			$0.00
Personnel Total (salary + benefits)	**$5,292.00**			**$3,528.00**			**$1,764.00**			**$0.00**
Other Costs	**Total All Years**			**Total Year 1**			**Total Year 2**			**Total Year 3**
Operating Expenses: (ex: seed, plant materials, irrigation supplies, software, office supplies, etc)	$ -			$ -			$ -			$ -
2/ Travel and Per Diem	$ -			$ -			$ -			$ -
3/ Equipment	$ -			$ -			$ -			$ -
4/ Sub-Contractor- phytoplankton cell counts	$ 2,000.00			$ 1,000.00			$ 1,000.00			$ -
4/ Sub-Contractor - UC Davis LAWR graduate student	$ 20,000.00			$ 10,000.00			$ 10,000.00			$ -
field sampling and analysis of data;	$ -			$ -			$ -			$ -
17.93 per hour year 1 and $18.56 per hour year 2;	$ -			$ -			$ -			$ -
42% benefits; 25% overhead	$ -			$ -			$ -			$ -
Other Costs Subtotal	**$ 22,000.00**			**$ 11,000.00**			**$ 11,000.00**			**$ -**
5/ Overhead Percentage (Applied to Personnel & Other Costs)				$ -			$ -			$ -
Total Costs for Task Three	**$ 27,292.00**			**$ 14,528.00**			**$ 12,764.00**			**$ -**

1/ Indicate your rate, and change formula in column immediately to the right of this cell

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3/ Please provide a list and cost of major equipment ($5,000 or more) to be purchased, and complete "Equipment Detail" Worksheet

4/ Please list each subcontractor and amounts (if subcontractor not selected yet, use function like "ditch construction subcontractor")

5/ Indicate rate in column immediately to the right of this cell; and provide a description of what expenses are covered by overhead. If overhead is > 15% must provide justification

BUDGET FOR TASK FOUR	**TOTAL AMOUNT TASK 4 All Years**	**Year 1** Amount per hour	**Year 1** Number of Hours	**Year 1** Total Amount for Year 1	**Year 2** Amount per hour	**Year 2** Number of Hours	**Year 2** Total Amount for Year 2	**Year 3** Amount per hour	**Year 3** Number of Hours	**Year 3** Total Amount for Year 3
Personnel										
Lehman - oversight on sampling and data analysis	$ 1,260.00	$ 63.00	10	$ 630.00	$ 63.00	10	$ 630.00			$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -

	$ -	$ -		$ -	$ -		$ -	$ -		$ -
Personnel Subtotal	**$ 1,260.00**			**$ 630.00**			**$ 630.00**			**$ -**
1/ Benefits as percent of salary				$0.00			$0.00			$0.00
Personnel Total (salary + benefits)	**$1,260.00**			**$630.00**			**$630.00**			**$0.00**
Other Costs	**Total All Years**			**Total Year 1**			**Total Year 2**			**Total Year 3**
Operating Expenses: (ex: seed, plant materials, irrigation supplies, software, office supplies, etc)	$ -			$ -			$ -			$ -
2/ Travel and Per Diem	$ -			$ -			$ -			$ -
3/ Equipment	$ -			$ -			$ -			$ -
4/ Sub-Contractor UC Davis LAWR graduate student	$ 7,000.00			$ 5,000.00			$ 2,000.00			$ -
field sampling and analysis of data;	$ -			$ -			$ -			$ -
17.93 per hour year 1 and $18.56 per hour year 2;	$ -			$ -			$ -			$ -
42% benefits; 25% overhead	$ -			$ -			$ -			$ -
	$ -			$ -			$ -			$ -
Other Costs Subtotal	**$ 7,000.00**			**$ 5,000.00**			**$ 2,000.00**			**$ -**
5/ Overhead Percentage (Applied to Personnel & Other Costs)				$ -			$ -			$ -
Total Costs for Task Four	**$ 8,260.00**			**$ 5,630.00**			**$ 2,630.00**			**$ -**

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3/ Please provide a list and cost of major equipment ($5,000 or more) to be purchased, and complete "Equipment Detail" Worksheet

4/ Please list each subcontractor and amounts (if subcontractor not selected yet, use function like "ditch construction subcontractor")

5/ Indicate rate in column immediately to the right of this cell; and provide a description of what expenses are covered by overhead. If overhead is > 15% must provide justification

		Year 1			Year 2			Year 3		
BUDGET FOR TASK FIVE	**TOTAL AMOUNT TASK 5 All Years**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 1**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 2**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 3**
Personnel										
Lehman - oversight on sampling and data analysis	$ 1,260.00	$ 63.00	10	$ 630.00	$ 63.00	10	$ 630.00	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
Personnel Subtotal	**$ 1,260.00**			**$ 630.00**			**$ 630.00**			**$ -**
1/ Benefits as percent of salary				$0.00			$0.00			$0.00
Personnel Total (salary + benefits)	**$1,260.00**			**$630.00**			**$630.00**			**$0.00**

Other Costs	Total All Years			Total Year 1			Total Year 2			Total Year 3
Operating Expenses: (ex: seed, plant materials, irrigation supplies, software, office supplies, etc)	$ -			$ -			$ -			$ -
2/ Travel and Per Diem	$ -			$ -			$ -			$ -
3/ Equipment	$ -			$ -			$ -			$ -
4/ Sub-Contractor - UC Davis LAWR graduate student	$ 6,000.00			$ 5,000.00			$ 1,000.00			$ -
field sampling and analysis of data;	$ -			$ -			$ -			$ -
17.93 per hour year 1 and $18.56 per hour year 2;	$ -			$ -			$ -			$ -
42% benefits; 25% overhead	$ -			$ -			$ -			$ -
	$ -			$ -			$ -			$ -
Other Costs Subtotal	**$ 6,000.00**			**$ 5,000.00**			**$ 1,000.00**			**$ -**
5/ Overhead Percentage (Applied to Personnel & Other Costs)				$ -			$ -			$ -
Total Costs for Task Five	**$ 7,260.00**			**$ 5,630.00**			**$ 1,630.00**			**$ -**

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3/ Please provide a list and cost of major equipment ($5,000 or more) to be purchased, and complete "Equipment Detail" Worksheet

4/ Please list each subcontractor and amounts (if subcontractor not selected yet, use function like "ditch construction subcontractor")

5/ Indicate rate in column immediately to the right of this cell; and provide a description of what expenses are covered by overhead. If overhead is > 15% must provide justification

		Year 1			Year 2			Year 3		
BUDGET FOR TASK SIX	**TOTAL AMOUNT TASK 6 All Years**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 1**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 2**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 3**
Personnel										
Poulton - field sampling; technical assistance; report writing;	$ 13,975.00	$ 21.50	350	$ 7,525.00	$ 21.50	300	$ 6,450.00	$ -		$ -
FlowCAM data analysis	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
Personnel Subtotal	**$ 13,975.00**			**$ 7,525.00**			**$ 6,450.00**			**$ -**
1/ Benefits as percent of salary	50%			$3,762.50			$3,225.00			$0.00
Personnel Total (salary + benefits)	**$20,962.50**			**$11,287.50**			**$9,675.00**			**$0.00**
Other Costs	**Total All Years**			**Total Year 1**			**Total Year 2**			**Total Year 3**
Operating Expenses: (ex: seed, plant materials, irrigation supplies, software, office supplies, etc) - phone $335 + 49% overhead	$ 670.00			$ 335.00			$ 335.00			$ -
2/ Travel and Per Diem - 4 trips at $2018/trip and 49% overhead	$ 8,072.00			$ 6,054.00			$ 2,018.00			$ -
one Trip: per diem rate 162/day for 7 days = $1134;	$ -			$ -			$ -			$ -
average flight cost=$700.;	$ -			$ -			$ -			$ -

rental car= $24/day for 6 days = $144; gas=$40	$ -			$ -			$ -			$ -
	$ -			$ -			$ -			$ -
	$ -			$ -			$ -			$ -
	$ -			$ -			$ -			$ -
Other Costs Subtotal	**$ 8,742.00**			**$ 6,389.00**			**$ 2,353.00**			**$ -**
5/ Overhead Percentage (Applied to Personnel & Other Costs)	49%			$ 8,661.49			$ 5,893.72			$ -
Total Costs for Task Six	**$ 44,259.71**			**$ 26,337.99**			**$ 17,921.72**			**$ -**

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4/ Please list each subcontractor and amounts (if subcontractor not selected yet, use function like "ditch construction subcontractor")

5/ Indicate rate in column immediately to the right of this cell; and provide a description of what expenses are covered by overhead. If overhead is > 15% must provide justification

		Year 1			**Year 2**			**Year 3**		
BUDGET FOR TASK SEVEN	**TOTAL AMOUNT TASK 7 All Years**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 1**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 2**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 3**
Personnel										
Lehman - reporting and data analysis	$ 8,820.00	$ 63.00	70	$ 4,410.00	$ 63.00	70	$ 4,410.00	$ -		$ -
Mueller-Solger - review	$ 1,260.00	$ 63.00	10	$ 630.00	$ 63.00	10	$ 630.00	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
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	$ -	$ -		$ -	$ -		$ -	$ -		$ -
Personnel Subtotal	**$ 10,080.00**			**$ 5,040.00**			**$ 5,040.00**			**$ -**
1/ Benefits as percent of salary	40%			$2,016.00			$2,016.00			$0.00
Personnel Total (salary + benefits)	**$14,112.00**			**$7,056.00**			**$7,056.00**			**$0.00**
Other Costs	**Total All Years**			**Total Year 1**			**Total Year 2**			**Total Year 3**
Operating Expenses: (ex: seed, plant materials, irrigation supplies, software, office supplies, etc)	$ -			$ -			$ -			$ -
2/ Travel and Per Diem	$ -			$ -			$ -			$ -
3/ Equipment	$ -			$ -			$ -			$ -
4/ Sub-Contractor - UC Davis LAWR graduate student	$ 10,000.00			$ 10,000.00						$ -
field sampling and analysis of data;	$ -			$ -			$ -			$ -
17.93 per hour year 1 and $18.56 per hour year 2;	$ -			$ -			$ -			$ -
42% benefits; 25% overhead	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
Other Costs Subtotal	**$ 10,000.00**			**$ 10,000.00**			**$ -**			**$ -**

[5] Overhead Percentage (Applied to Personnel & Other Costs)				$ -			$ -			$ -
Total Costs for Task Seven	**$ 24,112.00**			**$ 17,056.00**			**$ 7,056.00**			**$ -**

1/ Indicate your rate, and change formula in column immediately to the right of this cell

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3/ Please provide a list and cost of major equipment ($5,000 or more) to be purchased, and complete "Equipment Detail" Worksheet

4/ Please list each subcontractor and amounts (if subcontractor not selected yet, use function like "ditch construction subcontractor")

5/ Indicate rate in column immediately to the right of this cell; and provide a description of what expenses are covered by overhead. If overhead is > 15% must provide justification

		Year 1			Year 2			Year 3		
BUDGET FOR TASK EIGHT	**TOTAL AMOUNT TASK 8 All Years**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 1**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 2**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 3**
Personnel										
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
Personnel Subtotal	**$ -**			**$ -**			**$ -**			**$ -**
[1] Benefits as percent of salary				$0.00			$0.00			$0.00
Personnel Total (salary + benefits)	**$0.00**			**$0.00**			**$0.00**			**$0.00**
Other Costs	**Total All Years**			**Total Year 1**			**Total Year 2**			**Total Year 3**
Operating Expenses: (ex: seed, plant materials, irrigation supplies, software, office supplies, etc)	$ -			$ -			$ -			$ -
2/ Travel and Per Diem	$ -			$ -			$ -			$ -
3/ Equipment	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
Other Costs Subtotal	**$ -**			**$ -**			**$ -**			**$ -**
[5] Overhead Percentage (Applied to Personnel & Other Costs)				$ -			$ -			$ -
Total Costs for Task Eight	**$ -**			**$ -**			**$ -**			**$ -**

1/ Indicate your rate, and change formula in column immediately to the right of this cell

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Proposal Number
Proposal Name

Detailed Budget Breakdown by Task and by Fiscal Year

Applicant Name

3/ Please provide a list and cost of major equipment ($5,000 or more) to be purchased, and complete "Equipment Detail" Worksheet
4/ Please list each subcontractor and amounts (if subcontractor not selected yet, use function like "ditch construction subcontractor")
5/ Indicate rate in column immediately to the right of this cell; and provide a description of what expenses are covered by overhead. If overhead is > 15% must provide justification

		Year 1			Year 2			Year 3		
BUDGET FOR TASK NINE	**TOTAL AMOUNT TASK 9 All Years**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 1**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 2**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 3**
Personnel										
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
Personnel Subtotal	**$ -**			**$ -**			**$ -**			**$ -**
1/ Benefits as percent of salary				$0.00			$0.00			$0.00
Personnel Total (salary + benefits)	**$0.00**			**$0.00**			**$0.00**			**$0.00**
Other Costs	**Total All Years**			**Total Year 1**			**Total Year 2**			**Total Year 3**
Operating Expenses: (ex: seed, plant materials, irrigation supplies, software, office supplies, etc)	$ -			$ -			$ -			$ -
2/ Travel and Per Diem	$ -			$ -			$ -			$ -
3/ Equipment	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
Other Costs Subtotal	**$ -**			**$ -**			**$ -**			**$ -**
5/ Overhead Percentage (Applied to Personnel & Other Costs)				$ -			$ -			$ -
Total Costs for Task Nine	**$ -**			**$ -**			**$ -**			**$ -**

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3/ Please provide a list and cost of major equipment ($5,000 or more) to be purchased, and complete "Equipment Detail" Worksheet
4/ Please list each subcontractor and amounts (if subcontractor not selected yet, use function like "ditch construction subcontractor")
5/ Indicate rate in column immediately to the right of this cell; and provide a description of what expenses are covered by overhead. If overhead is > 15% must provide justification

		Year 1			Year 2			Year 3		
BUDGET FOR TASK TEN	**TOTAL AMOUNT TASK 10 All Years**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 1**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 2**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 3**
Personnel										

	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
Personnel Subtotal	**$ -**			**$ -**			**$ -**			**$ -**
1/ Benefits as percent of salary				$0.00			$0.00			$0.00
Personnel Total (salary + benefits)	**$0.00**			**$0.00**			**$0.00**			**$0.00**
Other Costs	**Total All Years**			**Total Year 1**			**Total Year 2**			**Total Year 3**
Operating Expenses: (ex: seed, plant materials, irrigation supplies, software, office supplies, etc)	$ -			$ -			$ -			$ -
2/ Travel and Per Diem	$ -			$ -			$ -			$ -
3/ Equipment	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
Other Costs Subtotal	**$ -**			**$ -**			**$ -**			**$ -**
5/ Overhead Percentage (Applied to Personnel & Other Costs)				$ -			$ -			$ -
Total Costs for Task Ten	**$ -**			**$ -**			**$ -**			**$ -**

1/ Indicate your rate, and change formula in column immediately to the right of this cell

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4/ Please list each subcontractor and amounts (if subcontractor not selected yet, use function like "ditch construction subcontractor")

5/ Indicate rate in column immediately to the right of this cell; and provide a description of what expenses are covered by overhead. If overhead is > 15% must provide justification

		Year 1			Year 2			Year 3		
BUDGET FOR TASK ELEVEN	**TOTAL AMOUNT TASK 11 All Years**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 1**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 2**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 3**
Personnel										
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -

Proposal Number
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Detailed Budget Breakdown by Task and by Fiscal Year

Applicant Name

	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
Personnel Subtotal	**$ -**			**$ -**			**$ -**			**$ -**
[1/] Benefits as percent of salary				$0.00			$0.00			$0.00
Personnel Total (salary + benefits)	**$0.00**			**$0.00**			**$0.00**			**$0.00**
Other Costs	**Total All Years**			**Total Year 1**			**Total Year 2**			**Total Year 3**
Operating Expenses: (ex: seed, plant materials, irrigation supplies, software, office supplies, etc)	$ -			$ -			$ -			$ -
2/ Travel and Per Diem	$ -			$ -			$ -			$ -
3/ Equipment	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
Other Costs Subtotal	**$ -**			**$ -**			**$ -**			**$ -**
[5/]Overhead Percentage (Applied to Personnel & Other Costs)				$ -			$ -			$ -
Total Costs for Task Eleven	**$ -**			**$ -**			**$ -**			**$ -**

1/ Indicate your rate, and change formula in column immediately to the right of this cell

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5/ Indicate rate in column immediately to the right of this cell; and provide a description of what expenses are covered by overhead. If overhead is > 15% must provide justification

		Year 1			**Year 2**			**Year 3**		
BUDGET FOR TASK TWELVE	**TOTAL AMOUNT TASK 12 All Years**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 1**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 2**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 3**
Personnel										
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
Personnel Subtotal	**$ -**			**$ -**			**$ -**			**$ -**
[1/] Benefits as percent of salary				$0.00			$0.00			$0.00

Personnel Total (salary + benefits)	**$0.00**			**$0.00**			**$0.00**			**$0.00**
Other Costs	**Total All Years**			**Total Year 1**			**Total Year 2**			**Total Year 3**
Operating Expenses: (ex: seed, plant materials, irrigation supplies, software, office supplies, etc)	$ -			$ -			$ -			$ -
2/ Travel and Per Diem	$ -			$ -			$ -			$ -
3/ Equipment	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
Other Costs Subtotal	**$ -**			**$ -**			**$ -**			**$ -**
5/ Overhead Percentage (Applied to Personnel & Other Costs)				$ -			$ -			$ -
Total Costs for Task Twelve	**$ -**			**$ -**			**$ -**			**$ -**

1/ Indicate your rate, and change formula in column immediately to the right of this cell

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		Year 1			Year 2			Year 3		
BUDGET FOR TASK THIRTEEN	**TOTAL AMOUNT TASK 13 All Years**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 1**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 2**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 3**
Personnel										
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
Personnel Subtotal	**$ -**			**$ -**			**$ -**			**$ -**
1/ Benefits as percent of salary				$0.00			$0.00			$0.00
Personnel Total (salary + benefits)	**$0.00**			**$0.00**			**$0.00**			**$0.00**
Other Costs	**Total All Years**			**Total Year 1**			**Total Year 2**			**Total Year 3**
Operating Expenses: (ex: seed, plant materials, irrigation supplies, software, office supplies, etc)	$ -			$ -			$ -			$ -

Proposal Number
Proposal Name

Detailed Budget Breakdown by Task and by Fiscal Year

Applicant Name

2/ Travel and Per Diem	$ -			$ -			$ -			$ -
3/ Equipment	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
Other Costs Subtotal	**$ -**			**$ -**			**$ -**			**$ -**
5/ Overhead Percentage (Applied to Personnel & Other Costs)				$ -			$ -			$ -
Total Costs for Task Thirteen	**$ -**			**$ -**			**$ -**			**$ -**

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		Year 1			**Year 2**			**Year 3**		
BUDGET FOR TASK FOURTEEN	**TOTAL AMOUNT TASK 14 All Years**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 1**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 2**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 3**
Personnel										
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
Personnel Subtotal	**$ -**			**$ -**			**$ -**			**$ -**
1/ Benefits as percent of salary				$0.00			$0.00			$0.00
Personnel Total (salary + benefits)	**$0.00**			**$0.00**			**$0.00**			**$0.00**
Other Costs	**Total All Years**			**Total Year 1**			**Total Year 2**			**Total Year 3**
Operating Expenses: (ex: seed, plant materials, irrigation supplies, software, office supplies, etc)	$ -			$ -			$ -			$ -
2/ Travel and Per Diem	$ -			$ -			$ -			$ -
3/ Equipment	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -

Other Costs Subtotal	**$ -**			**$ -**			**$ -**			**$ -**
[5/]Overhead Percentage (Applied to Personnel & Other Costs)				$ -			$ -			$ -
Total Costs for Task Fourteen	**$ -**			**$ -**			**$ -**			**$ -**

1/ Indicate your rate, and change formula in column immediately to the right of this cell

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5/ Indicate rate in column immediately to the right of this cell; and provide a description of what expenses are covered by overhead. If overhead is > 15% must provide justification

		Year 1			**Year 2**			**Year 3**		
BUDGET FOR TASK FIFTEEN	**TOTAL AMOUNT TASK 15 All Years**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 1**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 2**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 3**
Personnel										
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
Personnel Subtotal	**$ -**			**$ -**			**$ -**			**$ -**
[1/] Benefits as percent of salary				$0.00			$0.00			$0.00
Personnel Total (salary + benefits)	**$0.00**			**$0.00**			**$0.00**			**$0.00**
Other Costs	**Total All Years**			**Total Year 1**			**Total Year 2**			**Total Year 3**
Operating Expenses: (ex: seed, plant materials, irrigation supplies, software, office supplies, etc)	$ -			$ -			$ -			$ -
2/ Travel and Per Diem	$ -			$ -			$ -			$ -
3/ Equipment	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
Other Costs Subtotal	**$ -**			**$ -**			**$ -**			**$ -**
[5/]Overhead Percentage (Applied to Personnel & Other Costs)				$ -			$ -			$ -
Total Costs for Task Fifteen	**$ -**			**$ -**			**$ -**			**$ -**

Detailed Budget Breakdown by Task and by Fiscal Year

1/ Indicate your rate, and change formula in column immediately to the right of this cell
2/ Travel expenses and per diem must be at rates specified by the Department of Personnel Administration. The contractor is required to maintain travel receipts and records for auditing purposes. No travel out of the state of California shall be reimbursed unless prior written authorization is obtained from the State.
3/ Please provide a list and cost of major equipment ($5,000 or more) to be purchased, and complete "Equipment Detail" Worksheet
4/ Please list each subcontractor and amounts (if subcontractor not selected yet, use function like "ditch construction subcontractor")
5/ Indicate rate in column immediately to the right of this cell; and provide a description of what expenses are covered by overhead. If overhead is > 15% must provide justification

Budget
Cost Share

Item	source	$ amount
FluoroProbe	Dr. Mueller-Solger CALFED grant - FluoroProbe	31000
phytoplankton species laboratory identification	Dr. Mueller-Solger CALFED grant - FluoroProbe	2000
phytoplankton species laboratory identification	Dr. Lehman CALFED grant - Microcystis	2000
salary Dr. Lehman	Division of Environmental Services	15000
		50000

California Home

Signature

MAX P. Lehman DWR

The applicant for this proposal must submit this form by printing it, signing below, and faxing it to +1 877-408-9310. Send exactly one form per transmission.

Failure to sign and submit this form will result in the application not being considered for funding. The individual submitting this proposal will receive e-mail confirmation as soon as this signature page has been processed.

The individual signing below declares that:

- all representations in this proposal are truthful;
- the individual signing the form is authorized to submit the application on behalf of the applicant (if applicant is an entity or organization);
- the applicant has read and understood the conflict of interest and confidentiality discussion under the Confidentiality and Conflict of Interest Section in the main body of the PSP and waives any and all rights to privacy and confidentiality of the proposal on behalf of the applicant, to the extent provided in this PSP; and
- the applicant has read and understood all attachments of this PSP.

Proposal Title: Using FlowCAM technology to measure high frequency spatial and temporal variation in phytoplankton and zooplankton species composition and develop state-of-the-art plankton monitoring programs

Proposal Number: 2006.01-0056

Applicant Organization: California Department of Water Resources

Applicant Contact: Barbara McDonnell

Using FlowCAM technology to measure high frequency spatial and temporal variation in phytoplankton and zooplankton species composition and develop state-of-the-art plankton monitoring

Applicant Signature Barbara McDonnell **Date** 8/28/06