INTERAGENCY ECOLOGICAL PROGRAM

ENVIRONMENTAL MONITORING PROGRAM
REVIEW AND RECOMMENDATIONS

Final Report

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Summary

Initiated in 1971, the Environmental Monitoring Program (EMP) monitors water quality conditions as well as phytoplankton, zooplankton, and benthos abundance and distribution in the upper San Francisco Estuary. The EMP is carried out under the auspices of the California Interagency Ecological Program (IEP) by the California Department of Water Resources (DWR) and the US Bureau of Reclamation (USBR) with assistance from the California Department of Fish and Game (DFG) and the US Geological Survey (USGS). The EMP is conducted in compliance with the State Water Resources Control Board (SWRCB) water right decision D-1641 permitting DWR and USBR to operate the State Water Project (SWP) and the Central Valley Project (CVP), respectively. Its goals are to ensure compliance with SWRCB water quality objectives and to detect water quality and ecological changes in the upper estuary related to water project operations for more efficient management of the estuary.

In the 21st century, growing water demands, as well as complex ecological issues related to water project operations, habitat restoration, and species introductions present new challenges for resource managers and environmental scientists. These demands and challenges also greatly increase the demand for timely environmental monitoring data and information in the upper San Francisco Estuary. In 2001-2002, the DWR and USBR conducted a programmatic review of the EMP in accordance with D-1641 Condition 11 (e) and IEP guidelines. The intent of this review was to determine how the EMP could better meet current information needs for water resource management and protection. This review also reexamined program aims and the relationship of the EMP to other compliance and baseline aquatic monitoring activities in the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (Bay-Delta). The programmatic review was conducted in two phases. The first phase consisted of an in-depth technical review of the EMP. The second phase consisted of a review by program managers and legal staff from various IEP agencies.

The technical review involved four subject area teams (SAT) consisting of invited technical experts, the IEP Science Advisory Group (SAG), stakeholder representatives and other interested parties participating in public review meetings, and a core team of EMP scientists. This four-tiered technical review was designed to assure broad-based and scientifically sound recommendations. All recommendations for EMP monitoring and special studies met three criteria: 1) continued fulfillment of the program's legal mandate, 2) continuity of long-term data sets, and 3) implementability of proposed monitoring and special studies within a fixed program budget. The management and legal review further assured that the recommendations were consistent with these criteria. This report summarizes the results and recommendations of the 2001-2002 EMP review and proposes program modifications.

Overall, the EMP was found to be a tremendously valuable long-term environmental monitoring program providing essential data and information for resource management and scientific understanding of estuarine processes. After more than three decades of uninterrupted operation, the EMP's greatest asset is its consistent and comprehensive long-term environmental data record. One of the most important program objectives is thus to maintain and continue adding to this data record, prohibiting a complete redesign of the EMP during the 2001-2002 programmatic review.

The review identified the need for improvements in three general program areas: (1) program aims, (2) monitoring data and information products, and (3) program design and implementation. Reviewers recommended that program aims should follow the original EMP mission, guide its design, and focus its products. In response to this recommendation and integrating the "customer needs" identified by the SATs, the review core team formulated a hierarchy of program goals, objectives, and specific questions of increasing specificity.

Following the review recommendations for improved data and information products, EMP staff are working toward improving data and meta-data management and accessibility, conducting and reporting more in-depth data analyses, developing routine web-based analysis and reporting tools, and replacing the annual data report to the

SWRCB with an annual status and trends report. This report will summarize the results of data analyses, identify future study plans, and refer to data and information stored by the EMP on a dedicated server managed by EMP staff and available via the Internet through the IEP and EMP web sites. The new reporting format would be consistent with the intent of D-1641 Condition 11 (c) and would thus not require concurrence of the Executive Director of the State Water Resources Control Board for changes to D-1641. EMP staff are also examining and updating sample analysis procedures to assure the highest data quality and intend to complement the annual status and trends report with technical reports, research articles, and articles published in the IEP newsletter as opportunities allow.

Reviewers made numerous EMP design and implementation recommendations regarding sampling design, monitoring elements, funding, resource allocations, and legal obligations, and the relationship between monitoring and special studies. Implementation of many of these recommendations will be contingent upon the concurrence of the SWRCB Executive Director to modify Table 5 and Figure 4 of D-1641. The proposed changes to D-1641 monitoring consist of (1) establishment of a new multiparameter station and reestablishment of three historical baseline stations, (2) addition of 14 new, reinstallation of 14 previously discontinued, and integration of three existing (but not currently required by D-1641) individual monitoring elements, (3) more accurate description and consolidation of several nearby discrete and continuous stations, (4) change of discrete monitoring frequency from monthly to near-monthly according to the tides, and (5) a temporary (2003-2004) reduction in benthos monitoring frequency to conduct benthos studies. These modifications would allow implementation of a revised monitoring program based on current conceptual models of the relationships among physical, chemical, and biological processes of the Bay-Delta and designed to meet specific program objectives identified during the review. In particular, they would allow for better characterization of the temporal and spatial variability in the system through the increased use of continuous monitoring at strategic locations. Ultimately, this would enable the EMP to better distinguish between the effects of project operations and other factors (e.g., establishment of introduced species or large-scale restoration projects).

Where flow data are available, the proposed design would also allow for calculation and reporting of constituent fluxes across regions of the Bay-Delta.

Program reviewers also recommended continued monitoring at four non-mandated EMP stations and the consolidation, establishment or expansion of additional stations to complete the recommended EMP station network and improve monitoring efficiency and products. We propose to maintain, establish, or expand the recommended stations as non-mandated IEP program elements, funding permitting. We would also study data comparability of ten additional continuous-discrete station pairs and redundancies with other monitoring programs to determine the potential for further station consolidations and discontinuations. Final recommendations about these stations would be included in the next triennial SWRCB review report in 2005.

The proposed program also contains a prioritized series of recommended special studies to be conducted in parallel with, and in some cases prior to, the proposed monitoring activities. These special studies are intended to address unresolved questions about appropriate spatial and temporal sampling design, field and laboratory procedures, and long-term patterns and trends in all measured variables. As pointed out by many reviewers, such studies are essential for maintaining the vitality and gaining the maximum benefit from a long-term monitoring program. These studies would, however, not be part of the D-1641 mandated monitoring program and could be funded and carried out independently and in collaboration with non-EMP researchers. In many cases, funding would have to be obtained through competitive proposal processes.

For more information about the EMP and the 2001-2002 review and additional background materials, please contact Anke Mueller-Solger, Department of Water Resources, 3251 S Street, Sacramento, CA 95816-7017, Office: (916) 227-2194, Fax: (916) 227-7554, amueller@water.ca.gov, or visit the EMP website at http://iep.water.ca.gov/emp/. The authors of this report wish to thank Jon Burau, Erwin VanNieuwenhuyse, Ken Lentz, Wim Kimmerer, Ted Sommer, Steve Ford, Phil Wendt, and Barbara McDonnell for helpful discussions and comments on four draft reports. We are also grateful to all review participants listed in Appendix 1 of this report for their insightful comments and support throughout this two-year review process.

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Also available:

1. EMP Review Subject Area Team Reports (November 2001)
2. IEP Science Advisory Group Review of the EMP (May 2002)
3. EMP Review Core Team Response to the IEP Science Advisory Group (March 2003)
4. IEP Management Team Comments Concerning the EMP Review (December 2002)
5. EMP Review Core Team Response to the IEP Management Team (March 2003)
6. Background Information for the 2001-2002 Review of the IEP Environmental Monitoring Program (January 2001, includes program history)

To obtain these documents and other information about the EMP and about the 2001-2002 EMP review, please contact

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I. Introduction

The Sacramento and San Joaquin River watersheds provide much of California's developed fresh water supplies. The primary rivers of these watersheds converge in the Sacramento-San Joaquin Delta (the Delta), the eastern portion of the San Francisco Estuary (Figure 1). Historically, Delta waters flowed westward toward the Pacific Ocean passing through Suisun, San Pablo, and San Francisco bays. Today, a large proportion of Delta water is pumped to various locations in southern California and the San Francisco Bay area. Delta water is also used within the Delta and throughout much of the associated watersheds for a variety of "beneficial uses," including agricultural, municipal, and industrial applications, recreation, and fish and wildlife protection and enhancement.

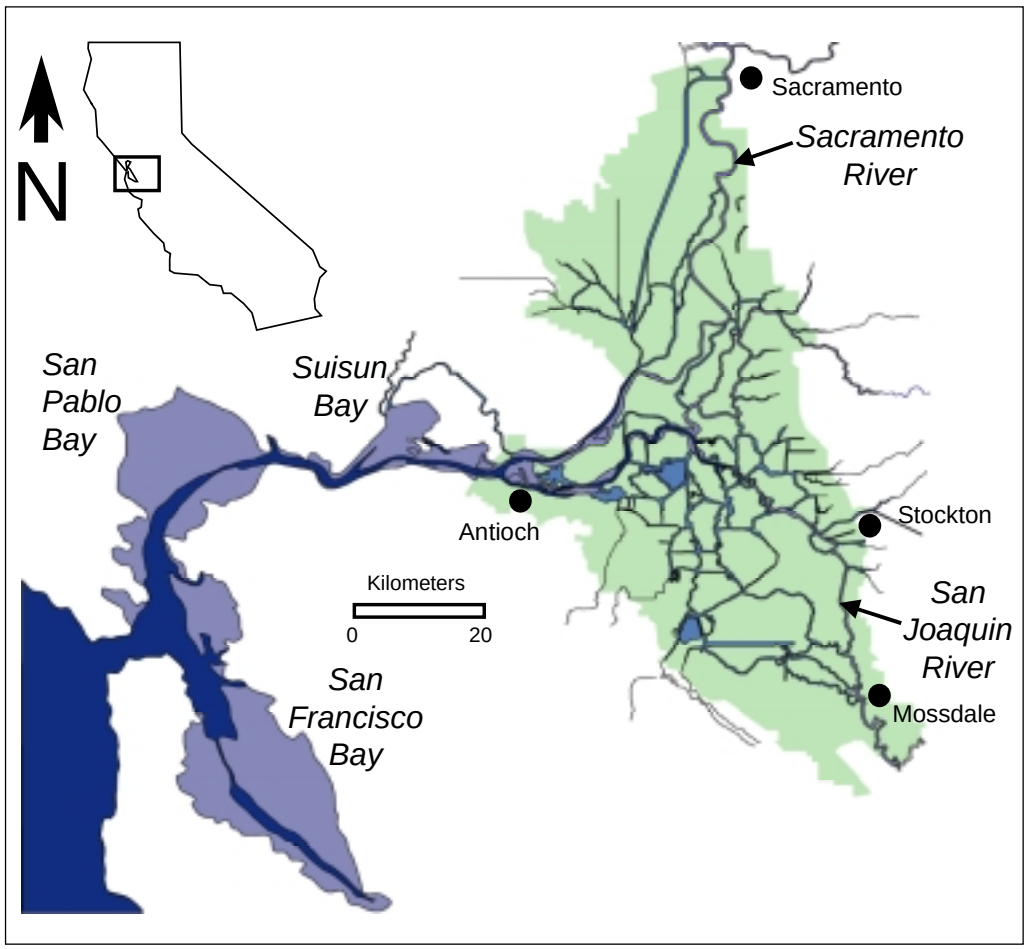


Figure 1: San Francisco Estuary. The Delta (green shading) includes the waterways and land area between Antioch, Sacramento, Stockton, and Mossdale.

Historically, Delta waters flowed westward toward the Pacific Ocean passing through Suisun, San Pablo, and San Francisco bays. Today, a large proportion of Delta water is pumped to various locations in southern California and the San Francisco Bay area. Delta water is also used within the Delta and throughout much of the associated watersheds for a variety of "beneficial uses," including agricultural, municipal, and industrial applications, recreation, and fish and wildlife protection and enhancement.

While seasonal and interannual climatic variations continue to affect Delta hydrology, flow patterns in the Delta have been increasingly altered throughout the 20th century by implementation of water storage and conveyance projects. These projects are intended to provide and protect beneficial uses within the Delta and provide high-quality water throughout much of the State. The two agencies charged with managing California's water supply are the United States Bureau of Reclamation (USBR) and the California Department of Water Resources (DWR). These agencies operate the California Central Valley Project (CVP) and the State Water Project (SWP), respectively, in accordance with water right permit conditions set forth by the State Water Resources Control Board (SWRCB). Permit conditions include mandatory environmental monitoring in the Delta and Suisun and San Pablo bays to determine the impact of flow alterations on water quality and living resources.

The Environmental Monitoring Program (EMP) for the Delta, Suisun Bay, and San Pablo Bay (the upper estuary) is conducted under the auspices of the California Interagency Ecological Program (IEP). The EMP was initiated in 1971 in compliance with SWRCB Water Right Decision 1379 and continued under D-1485 and D-1641[1]. Its goal is to "*ensure compliance with the water quality objectives, to identify meaningful changes in any significant water quality parameters potentially related to operation of the SWP or the CVP, and to reveal trends in ecological changes potentially related to project operations* […]" (D-1641, p.149).

The EMP is funded and carried out jointly by the two water right permittees, USBR and DWR, via the IEP (Figure 2). In the 2002 IEP work plan, DWR provided 54% and the

[1] California State Water Resources Control Board, Water Right Decision 1641, Revised March 15, 2000.

USBR provided 46% of the annual EMP budget of $2,107,000. Most of the EMP staff is supplied by DWR, thus DWR received 71% of the 2002 EMP funding, while the USBR received 10%. DWR and USBR also fund technical involvement in the EMP by the California Department of Fish and Game (DFG – 9% of 2002 funding) and the United States Geological Survey (USGS – 4% of 2002 funding). In 2002, the EMP budget provided full or partial salaries for about 30 agency employees and a benthos taxonomist under contract to DWR, the maintenance and operation of two research vessels and seven continuous shore stations, monitoring equipment and supplies, laboratory analyses, and information technology.

2002 EMP Funding

Source	Amount	Recipient	Amount
USBR	$956,000 (45%)	USBR	$203,000 (10%)
DWR	$1,151,000 (55%)	DWR (DES)	$1,503,000 (71%)
		DWR (CD)	$127,000 (6%)
Total	**$2,107,000**	DFG	$184,000 (9%)
		USGS	$90,000 (4%)

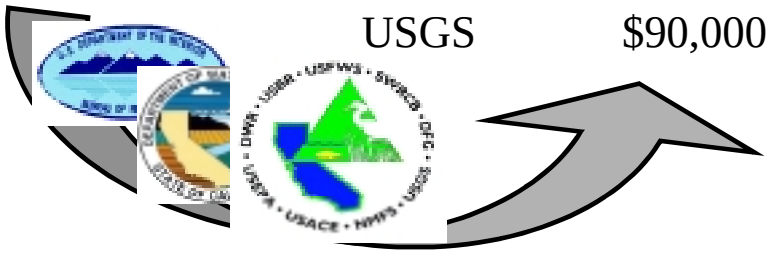


Figure 2: 2002 EMP funding sources and recipients. DES: DWR Division of Environmental Services; CD: DWR Central District.

The EMP provides data and information used, in part, to determine CVP and SWP compliance with Delta water quality objectives for salinity/chloride and dissolved oxygen levels at specific locations. These water quality objectives are specified in the SWRCB regional *Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary* (1995 “Bay-Delta Plan,” 95-1WR) and in the Central Valley Regional Water

Quality Control Board's Central Valley Region Basin Plan for the Sacramento and San Joaquin River Basins (4th edition, 1998). In addition, the EMP monitors a wide range of other chemical, physical, and biological baseline variables to provide vital environmental information for the protection of beneficial uses, to reveal trends in ecological changes, and for forecasting impacts of future water project operations.

The EMP is part of a growing network of monitoring programs in the San Francisco Estuary (Figure 3) and its tributaries. Planned or envisioned programs include a new National Estuarine Research Reserve (NERR, s. http://www.ocrm.nos.noaa.gov/nerr/) monitoring program through San Francisco State University (SFSU) and various IEP and California Bay-Delta Authority (hereafter referred to as "CALFED") programs.

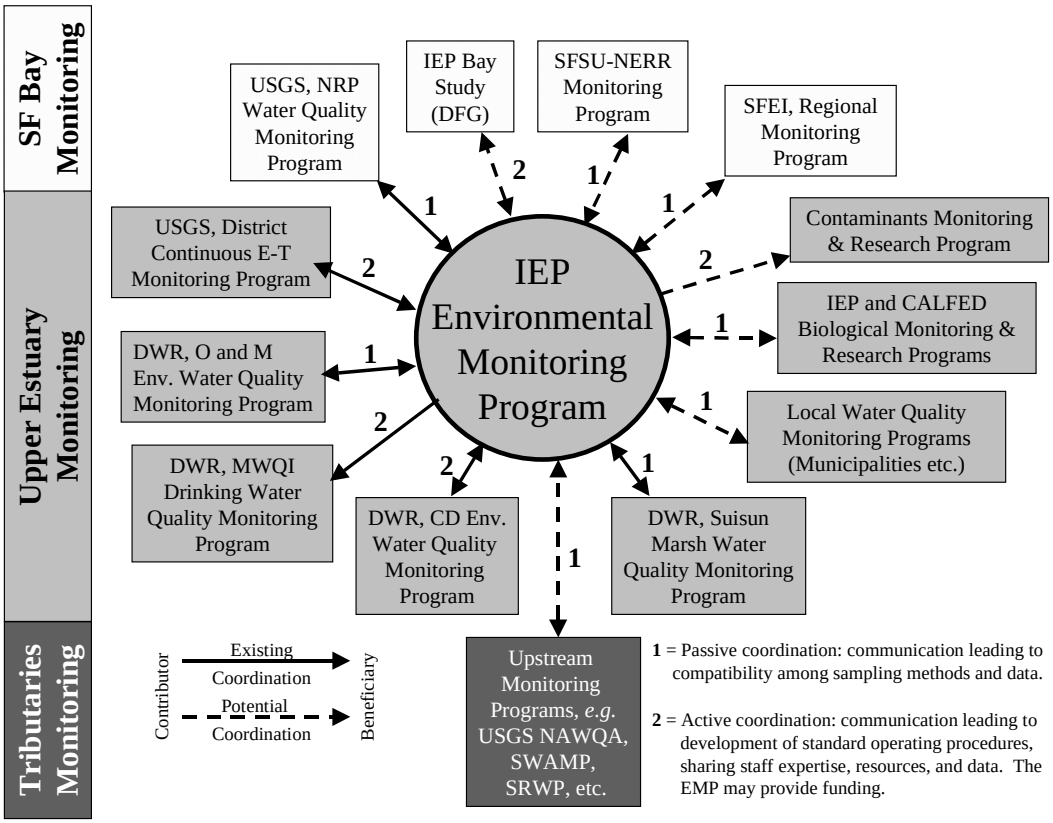


Figure 3: EMP interactions with existing and potential monitoring programs[2].

[2] Acronyms not defined elsewhere in the text: SFEI: San Francisco Estuary Institute; MWQI: DWR Municipal Water Quality Investigations Program; NAWQA: USGS National Water-Quality Assessment; SWAMP: SWRCB and Regional Water Quality Control Boards Surface Water Ambient Monitoring Program; SRWP: Sacramento River Watershed Program; CD: DWR Central District; O and M: DWR Division of Operations and Maintenance.

Currently, all existing monitoring programs in the San Francisco Estuary complement each other by monitoring different variables or monitoring at different locations or times, although redundancies as well as gaps exist. The diversity and large number of monitoring programs presents a formidable challenge for full integration, but also many opportunities for communication, coordination and collaboration among programs. Much coordination and collaboration can occur within the existing IEP and CALFED framework, and in many cases such efforts are already under way[3]. The active participation of representatives from several other monitoring programs in the EMP review is a good example of fruitful interaction. Another example is the IEP Bay-Delta Tributaries Data Base (B-DAT) under development by the DWR Interagency Information System Services Section[4]. This comprehensive database is intended to give public access to IEP and other Bay-Delta monitoring data via one single user interface ("one-stop shopping").

The EMP and several other San Francisco Estuary monitoring programs are conducted in compliance with legal obligations ensuring their long-term continuation. Some monitoring in the San Francisco Estuary such as the Menlo Park-based USGS National Research Program (NRP) water quality monitoring are not required by legal obligations and may be at greater risk of discontinuation with the potential of creating large gaps in the monitoring network. On the other hand, these types of programs have more operational latitude than their legally mandated counterparts.

D-1641 requires a review of the EMP every three years "to ensure that the goals of the monitoring program are attained" (D-1641 Condition 11 (e), p. 149). IEP guidelines call for regular program reviews every five years. This report is a result of the 2001-2002 programmatic review of the EMP. It contains the monitoring rationale, review highlights, and recommended program plans for a revised monitoring program and associated special studies. This report is based on detailed reviews conducted by four technical subject area teams (SATs) evaluating the water quality, phytoplankton, benthos, and zooplankton components of the EMP, an independent review by the IEP Science

[3] See Water Quality SAT report at http://iep.water.ca.gov/emp/SAT%20reports.html
[4] B-DAT is available over the internet at http://sarabande.water.ca.gov:8000/~bdtdb/

Advisory Group (SAG), and comments received during meetings with stakeholder representatives, agency managers, and other interested parties. The review schedule, meeting notes and SAT and SAG reports as well as earlier drafts of this report and more general information about the EMP are available at or via the EMP home page, http://iep.water.ca.gov/emp/. For access to password-protected documents, please contact Anke Mueller-Solger, amueller@water.ca.gov).

II. EMP Monitoring Rationale[5]

Environmental monitoring provides scientific information necessary to make resource management decisions that allow for both continued economic growth and preservation of our natural resources. Lauded by the IEP Science Advisory Group (SAG) for its uninterrupted operation spanning more than three decades, the EMP is one of the nation's oldest and most comprehensive aquatic monitoring programs. The EMP's long-term consistency and comprehensiveness have made it possible to distinguish effects of flow regulation from other effects such as species invasions and climate change. The program has also consistently contributed to maintaining compliance with water quality objectives. The program has thus been able to fulfill its legal mandate. Its results provide the basis for successful management strategies for the ecologically, economically, and culturally complex San Francisco Estuary. This type of information will only become more important as California's growing human population and other living species continue to compete for limited freshwater resources.

In the 21st century, innovative approaches are necessary to balance the tension between the growing water need of humans and all other water needs. Since its inception in 1994, CALFED has tackled this task with several groundbreaking efforts. In January 2002, CALFED gained State agency status as the "California Bay-Delta Authority." To measure the success of its current projects and guide future projects, CALFED urgently needs reliable system-wide and project-specific baseline monitoring data. While not formally a CALFED program, the EMP delivers much relevant data on the aquatic environment and can serve as an important pillar of a larger CALFED monitoring and assessment effort.

In addition to its role in monitoring and forecasting the effects of water project operations and CALFED projects, EMP data has also been used extensively by the scientific community to gain new insights into the ecology of the San Francisco Estuary

[5] Please see SAT reports for references. They are available at http://iep.water.ca.gov/emp/SAT%20reports.html. Here, we cite only a minimum number of publications, namely the most comprehensive publications, and the most recent publications with which many readers may not yet be familiar.

and estuarine environments in general (e.g., Jassby et al. 2002, Jassby and Cloern 2000, Hollibaugh 1996, Jassby et al. 1995[6]). These insights are fundamental to the development of innovative and sustainable management practices.

The EMP monitors four important system components affected by flow alterations: environmental water quality, phytoplankton, zooplankton, and the benthos. Water quality monitoring provides data for compliance with salinity and dissolved oxygen standards and to ensure the availability of "good quality water" for beneficial uses. Synthesized information on all monitored water quality variables provides a comprehensive picture of environmental water quality patterns and trends in the upper estuary and helps separate the effects of flow alterations from other resource uses and natural impacts.

The abundance and distribution of living organisms are a function of environmental conditions. These organisms are often sensitive indicators of environmental conditions and changes in response to anthropogenic impacts such as flow alterations. Moreover, they are a visible, living part of healthy ecosystems, and the protection of native communities is an important beneficial use. Biological monitoring thus serves as an important tool for ecosystem health assessments and to warn of the deterioration of native communities. Together with water quality monitoring, biological monitoring may also lead to insights about causal mechanisms responsible for the observed patterns.

Phytoplankton monitoring has been an essential component of the EMP from its inception because of the importance of algae as a food resource in aquatic ecosystems and their potential for forming nuisance blooms. Directly or indirectly, algae constitute the food resource base for most aquatic consumers. They also affect water quality in many ways. Phytoplankton is thus an important link between physical and chemical water quality and the biology of the system, particularly higher trophic levels (e.g., fish). Moreover, under certain conditions, some algal species form nuisance blooms and can

[6] Jassby A. D., W. J Kimmerer., S.G. Monismith., C. Armor, J.E. Cloern, T. M. Powell, J. R. Schubel, and T. J. Vendlinski. 1995. Isohaline position as a habitat indicator for estuarine populations. Ecological Applications. 5: 272-289.
Jassby, A. D., and J. E. Cloern. 2000. Organic matter sources and rehabilitation of the Sacramento-San Joaquin Delta (California, USA). Aquatic Conservation 10:323-352.
Jassby, A. D., J. E. Cloern, and B. E. Cole. 2002. Annual primary production: patterns and mechanisms of change in a nutrient-rich tidal ecosystem. Limnology and Oceanography 47: 698-712.
Hollibaugh, J. T., ed. 1996. San Francisco Bay: The Ecosystem. Pacific Division of the American Association for the Advancement of Science, San Francisco, California

endanger beneficial uses through screen clogging and toxin or taste and odor compound production. In the turbid upper San Francisco Estuary, algae are generally light, not nutrient, limited. Due to its turbidity, the San Francisco Estuary is among the least productive large estuaries in the world (Jassby et al. 2002[6]). Currently, there may often not be enough algae to sustain desirable densities of higher trophic level organisms. However, as the estuary becomes less turbid due to sediment retention behind dams and channel armoring, phytoplankton productivity may increase and eventually result in eutrophication with its adverse effects on water quality.

The EMP also monitors zooplankton and the benthos. Zooplankton and benthic invertebrates play an important part in estuarine food webs by converting organic matter to biomass available to fish, birds, mammals, and other animals. Zooplankton, in particular, provides a critical food web link between phytoplankton and early life stages of many fish species. There is growing evidence that various fish species are food-limited early in life (Hollibaugh 1996[6]). Alarmingly, EMP zooplankton monitoring has revealed declining zooplankton densities over the last two decades in much of the upper estuary. On the other hand, nonnative zooplankton and benthic species have become established in the San Francisco estuary in ever-increasing numbers (Cohen and Carlton 1998[7]) and in some cases have had severe effects on water quality and native species. One of the more well-documented cases is that of the invasive, aggressively filter-feeding clam *Potamocorbula amurensis*. As revealed by EMP monitoring, this clam has virtually eliminated seasonal phytoplankton blooms from Suisun Bay and substantially altered benthos community composition after its introduction in the 1980s (Alpine and Cloern 1992, Peterson 2002[8]). *Potamocorbula* also accumulates toxic elements such as selenium providing a direct pathway into the food chain of bottom-feeding fish and ducks. In similar aquatic systems in other parts of the world, the invasive zebra mussel (*Dreissenia polymorpha*) has likewise altered water quality due to its efficient filtration abilities, and has remobilized toxic DDT into the water column. In the upper San Francisco Estuary, zooplankton and benthos monitoring has been essential for detecting

[7] Cohen, A. N. and J. T. Carlton. 1998. Accelerating invasion rate in a highly invaded estuary." Science 279(5350): 555-558.

[8] Alpine, A. E. and J. E. Cloern. 1992. Trophic Interactions and Direct Physical Effects Control Phytoplankton Biomass and Production in an Estuary. Limnology and Oceanography 37(5): 946-955.
Peterson, H. 2002. Long-term benthic community change in a highly invaded estuary. M.S. Thesis, San Francisco State University

ecological changes due to such species introductions (*e.g.,* the apparent negative effect of *Potamocorbula* on several invertebrate and fish species) and for distinguishing these effects from those of water project operations.

Monitoring zooplankton and benthic invertebrates in coordination with monitoring of water quality and phytoplankton permits integrated bioassessments of physical, chemical, and biological environmental conditions, provides information about food resources and the potential for contaminant mobilization, and allows for early detection of invasive nuisance species such as the zebra mussel. Monitoring benthic organisms in particular can help track environmental conditions in specific locations. These conditions include those influenced by flow alterations: due to their generally sessile and stationary existence, benthic invertebrates continuously integrate water, sediment, and food conditions, collecting evidence throughout their lives of environmental quality factors such as salinity, dissolved oxygen, temperature, turbidity, and pollutant loads in their specific geographic location.

In spite of its comprehensive nature, there are several ecologically important system components not monitored by the EMP. These include producers other than planktonic algae (e.g. macrophytes), fishes, and contaminants. Many of these components are monitored by other programs in all or part of the estuary (Figure 2). There are, however, several gaps in the current monitoring network, including consistent long-term monitoring of non-algal producers and microbial organisms, larval fishes, and contaminants in the Delta. Closing these gaps represents a challenge for the entire monitoring community working in the San Francisco Estuary.

While generally agreeing with the monitoring rationale for the EMP described here, the IEP Science Advisory Group (SAG) recommended the formulation of more specific “aims” for the four EMP elements and the program as a whole. In response to this recommendation, the EMP review core team prepared a hierarchy of program goals, objectives, and specific questions consistent with the monitoring rationale, program mission and “customer needs” identified prior to the SAG review. These program aims are described in detail in the next section of this report (section III d (2)).

III. The 2001-2002 programmatic review of the EMP: Process and Results

a. Review process

This document is the result of a comprehensive technical review of the IEP EMP followed by an agency manager review. The stated goal of the technical review was to recommend a balanced, scientifically sound, implementable environmental monitoring program design to fulfill water right permit conditions and address the needs of current and potential users identified during this review. The technical review was led by an EMP review core team consisting of six senior EMP scientists and program managers from DWR, USBR, and the USGS. The review included input and evaluations by four subject area teams (SATs) of invited technical experts, the IEP Science Advisory Group (SAG), EMP staff, and participants in three EMP review meetings (Figure 4).

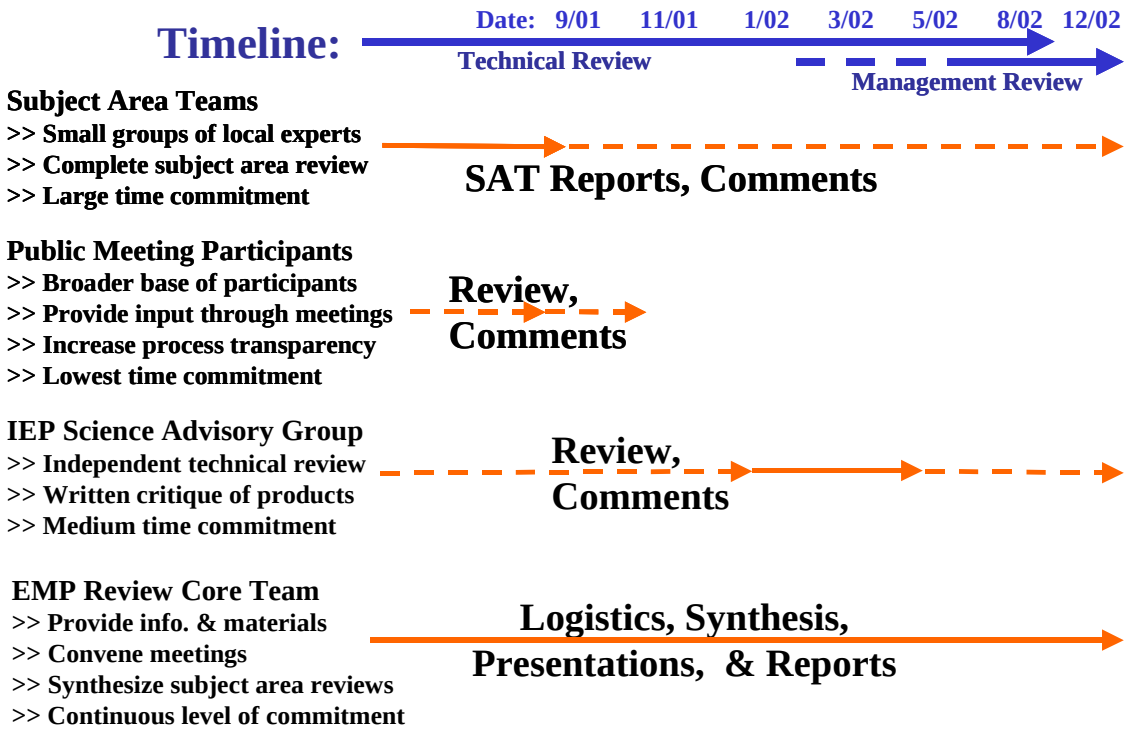


Figure 4: 2001-2002 EMP review timeline and multi-tiered technical review process. Solid arrows: intense direct review activity and products; broken arrows: receive review information and provide oral comments.

The four SATs reviewed the water quality, zooplankton, phytoplankton, and benthos monitoring elements of the EMP. Their work resulted in oral presentations to a diverse group of agency staff and stakeholder representatives at a public meeting on July 30th, 2001, and in written SAT reports. Synthesis of SAT results was achieved through a meeting on August 22, 2001, attended by all SAT leaders and the EMP review core team, and continued informal communications among SATs and core team members. Also, feedback by EMP staff was invited during a special IEP Water Quality Project Work Team Meeting on September 25, 2001 and informally throughout the entire review process. These efforts resulted in a report entitled "EMP Review and Recommendations Report, Draft I, November 2001."

All review participants including agency staff and stakeholder representatives were invited to comment on the first draft report during a public meeting on November 14, 2001. The report was then revised based on the many constructive comments received at this meeting resulting in Draft II (December 2001).

Next, review core team members discussed the EMP and the proposed revisions with staff from other DWR water quality monitoring programs at an in-depth briefing meeting on January 22, 2002, and with the IEP community during a special session (session 4) at the annual IEP workshop in Asilomar, CA, in February 2002. After a meeting with the EMP Review core team on April 4, 2002, the IEP Science Advisory Group (SAG) conducted an in-depth independent review of the EMP and the program review materials provided by the review core team. The SAG submitted its written EMP review report to the IEP on May 22, 2002. The EMP review core team discussed the issues raised by the SAG internally and through a presentation and subsequent discussion at and following the IEP Monitoring Forum on June 19, 2002. The results from these discussions were summarized in a draft response to the SAG and incorporated into Draft III of the "EMP Review and Recommendations" report (October 2002).[9] This concluded the technical review phase.

[9] All Draft EMP Review and Recommendations Reports are available over a password-protected Internet website. For access information, please contact Anke Mueller-Solger, amueller@water.ca.gov, (916)227-2194.

To initiate the management review phase, Draft III of the "EMP Review and Recommendations" report was distributed to staff and managers from various IEP agencies as well as to water project contractors, and comments were invited. Review core team members gave briefing presentations to EMP staff, representatives from the Central Valley Regional Water Quality Control Board, the State Water Resources Control Board, State Water Project Contractors, and DWR and USBR upper level managers and lawyers including the DWR "Bay-Delta Hearings Committee" about review results and recommendations. Changes resulting from the management review are included in this final report, The following three sections provide more specifics on the substantive recommendations arising from the SAT, SAG and management reviews of the EMP.[10]

b. SAT recommendations

All four SATs recognized the importance of maintaining the long-term consistency of the EMP and consequently proposed adjustments rather than a complete redesign of the program. All SATs were also asked to identify current and potential "customers" for EMP data and information and to assess their needs and levels of satisfaction with the existing program. Reviews of the four program elements were then completed relative to these needs. Needs common to all four program elements consisted of (1) compliance with D-1641 conditions and objectives, (2) documentation and interpretation of long-term variability in physical and chemical constituents and lower trophic levels, (3) collection of continuous data for water project operation and for model development and calibration, and (4) closing monitoring gaps (e.g. an expansion of zooplankton monitoring into San Francisco Bay). Identified customers included agency and academic scientists, resource managers, and water project operators in all IEP agencies, as well as water districts, water users, environmental stakeholders, and the general public. To improve customer satisfaction, the four SATs recommended a multitude of procedural changes and special studies. The SATs also identified the overarching importance of improved data and information management, analysis, and dissemination in satisfying customer needs.

[10] For more information about the review process, individual review meetings, and all resulting documents, see Appendix 1 and the EMP web site, http://iep.water.ca.gov/emp/.

All four SAT reports contain proposed plans for monitoring and special studies with five-year implementation time lines starting in 2003. Five years is the recommended period for reviews of IEP programs. The ongoing nature of the recommended program evaluations and implementations will also satisfy the SWRCB triennial review requirement. Funding is addressed by the SAT plans as well: while some recommended changes can be implemented with existing EMP funding and personnel, others would require additional IEP or CALFED funding, or should be carried out in collaboration with other agencies or research institutions. These funding augmentations are generally needed for one-time costs of new equipment and for special studies. Overall monitoring program costs are expected to remain level.

There were also several general differences between the four SAT reports. While the water quality and zooplankton SAT reviews yielded proposals for immediate, substantive changes, the phytoplankton and benthos SATs recommended more intensive analyses of existing data and additional special studies prior to program revisions. These recommendations are briefly outlined below.

The main recommendation of the Water Quality SAT is to replace discrete monthly water quality monitoring of electrical conductivity (EC) and water temperature with continuous monitoring using robust “twin sensor” technology and to conduct discrete sampling for all other constituents during alternating spring and neap tides. The Water Quality SAT also recommended consolidating discrete and continuous water quality stations to allow integration of the data streams and improve collection efficiency. Eventually, continuous sensors for other constituents might be added resulting in an overall shift of program emphasis from discrete to continuous monitoring. Finally, the Water Quality SAT recommended a revised spatial design based on hydrodynamic conceptual models. The objective of this substantial revision of the current monitoring design is to better monitor and understand the highly dynamic salt and temperature fields in the upper estuary. Both salinity and water temperature are intricately linked with beneficial uses and water project operations. Additional funding from IEP, CALFED, or other sources would be needed for one-time costs of new equipment and station establishment in order to implement these changes.

Based on previous SAG recommendations and on a 1997-1999 pilot study[11], the zooplankton SAT recommended expansion of EMP zooplankton monitoring into the San Francisco Bay in coordination with the DFG "Bay Study." Specifically, the zooplankton SAT recommended two channel and two shoal stations per basin (South, Central, and San Pablo Bays). Zooplankton is the only major system component not currently monitored by any Bay programs. The zooplankton SAT also recommended or supported reinstating zooplankton monitoring at the northern and possibly southern Delta boundaries. At these stations, zooplankton could be sampled with a pump alleviating the need for boat-based sampling at these remote sites. In addition, the zooplankton SAT recommended changes in sampling and analytical techniques after careful comparison of existing and proposed procedures and an evaluation of erroneous aliasing of tidal signals in the historical zooplankton data.

The phytoplankton and benthos SATs both determined that more in-depth analyses of existing data and accompanying special studies were needed prior to making any decisions about major program revisions. Specifically, in-depth analyses of existing data should be performed to assess phytoplankton and benthos variability at various spatial and temporal scales in order to evaluate the suitability of the current spatial and temporal monitoring design. Accompanying special studies would provide additional necessary data, examine methods, and explore the need for and feasibility or suitability of monitoring additional related variables and habitat types. The phytoplankton SAT report also discusses monitoring of producer groups such as attached benthic and epiphytic algae, macrophytes, and microorganisms. The EMP does not currently monitor these groups. Finally, the benthos SAT recommended forming an IEP Benthos Estuarine Ecology Team (BEET) to guide benthos monitoring and special studies.

[11] Kimmerer, W. and C. Peñalva. 2001. Zooplankton of the Lower San Francisco Estuary. Draft report of a Pilot Study, 1997-1999. Interagency Ecological Program.

c. SAG recommendations

The IEP Science Advisory Group (SAG) met in April 2002 to conduct an independent review of all materials provided by the SATs and the EMP review core team through presentations by core team members and written reports. Several SAG members also participated in the 2001 public EMP review meetings. This group of seven independent scientists from across the United States provided a written review on May 22, 2002.[12]

Overall, the SAG applauded the EMP for its consistent and comprehensive long-term monitoring efforts spanning more than three decades. SAG members also endorsed and supported the scope and design of the 2001-2002 programmatic review and agreed with the main recommendation in the "EMP Review and Recommendations report, Draft II," namely the shift in program emphasis from discrete to continuous monitoring.

As its "primary recommendation," the SAG called for a greater focus on rapidly turning data into useful information products by increasing the EMP's "human intellectual investment" and working with outside researchers. More fundamental criticisms concerned the lack of well-defined program aims and specific questions "germane to the initial reasons for initiating the program" and guiding its design, and a lack of synthesis among program elements.

The SAG also found that two EMP elements, phytoplankton and benthos monitoring, lack program direction and convincing procedures. Finally, individual SAG members made numerous valuable recommendations for program improvement including sampling and data analysis procedures, spatial and temporal program design, and goals of the program and individual program elements.

[12] The full SAG report is available at http://iep.water.ca.gov/emp/pdfFiles/SAGEMPReviewMay02.pdf. For a list of SAG members participating in this review, see part 2 of Appendix I.

d. Management Review

The management review phase involved staff and program managers from the IEP, the Central Valley Regional Water Quality Control Board, the State Water Resources Control Board, State Water Project Contractors, and DWR and USBR upper-level managers and lawyers including the DWR "Bay-Delta Hearings Committee."

Overall, participants in the management review phase were quite satisfied with the EMP and the 2001-2002 review results and recommendations. However, throughout the management review phase it became increasingly obvious that recommendations for modification of D-1641-mandated monitoring needed to be clearly distinguished from recommendations for consideration as non-mandated IEP program elements. Moreover, in the face of the worsening State and federal budget crisis and the ongoing State hiring freeze (expected to last through 2004), managers cautioned against overly ambitious commitments. In consequence, only the proposed reestablishment of three D-1485 stations, two station consolidations, the addition of a new table with geographic coordinates for all stations, and changes to individual monitoring elements at existing EMP stations emerged as recommendations for D-1641 modifications. Managers supported EMP the recommendation to investigate and where appropriate minimize station redundancies and maximize station consolidations over the next five years. Based on manager recommendations, establishment of additional stations, proposed EMP-related special studies, and the expansion of zooplankton monitoring into the San Francisco Bay were classified as recommendations for consideration as non-mandated IEP program elements subject to review and approval by the IEP Management Team and Coordinators. Additional stations are needed to close gaps in the current station network as discussed in the next section, but due to the current budget crisis funding for establishment of these stations may not be available. The original proposal to include San Francisco Bay zooplankton monitoring in the SWRCB Water Right Decision met with strong resistance by State Water Contractor representatives because of the tenuous connections between zooplankton dynamics in the San Francisco Bay (especially in South Bay) and water project operations. Modifying D-1641 to include EMP-related special studies in addition to monitoring would require new language in D-1641, which

would adversely impact implementation of monitoring recommendations. Moreover, including special studies in regulatory permits is inconsistent with established IEP procedures for consideration and funding of IEP special studies.

e. Review synthesis

During the synthesis phase of the 2001-2002 EMP review conducted by the EMP review core team in communication with other review participants, the following three general areas for program improvement emerged as a result of the technical and management program reviews: (1) EMP aims, (2) EMP data and information products, and (3) EMP design and implementation. Reviewers made numerous EMP design and implementation recommendations regarding (a) sampling design, (b) monitoring elements, (c) funding, resource allocations, and legal obligations, and (d) the relationship between monitoring and special studies. Each of these issues is discussed in detail below. Specific recommendations for monitoring and special studies resulting from these considerations are summarized in section IV.

(1) EMP aims

According to the SAG review, the EMP would greatly benefit from more specific “aims” for the four program elements and the whole program. These aims should follow the original EMP mission, guide its design, and focus its products. In response to this recommendation and integrating the “needs” identified by the SATs, the review core team formulated a hierarchy of program ***goals***, ***objectives***, and ***specific questions*** of increasing specificity. They are listed and briefly discussed below. Additional discussions can be found in the "EMP Review Core Team Response to the IEP Science Advisory Group"[13].

a) The current and original overall ***goals*** of the EMP are given in D-1641, Condition 11. According to D-1641, the EMP is legally obliged *(1) to ensure compliance with Bay-*

[13] The EMP Review Core Team's written response to the IEP SAG contains additional technical considerations and rationale. It is available at http://iep.water.ca.gov/emp/ or upon request from Anke Mueller-Solger.

Delta water quality objectives; (2) to identify meaningful changes in any significant water quality parameters potentially related to operation of the State Water Project (SWP) or the Central Valley Project (CVP); and (3) to reveal trends in ecological changes potentially related to SWP/CVP operations. To fulfill these goals, it is necessary to capture changes in environmental variables related to a variety of likely natural and anthropogenic influences and separate the longer-term trends of interest (monthly, seasonal, etc.) from the shorter-term “noise” signals (e.g. tidal fluctuations), and the impact of project operations from all other influences (e.g. the impact of species introductions). This is a broad goal, and thus calls for the most comprehensive program design and data analyses feasible within the existing resources. At the same time, it allows for maximum flexibility regarding reporting of results and neither greatly guides nor very narrowly constrains monitoring and accompanying special studies. An even broader goal is prescribed for the EMP and other IEP programs by the IEP mission to "*provide information on the factors that affect ecological resources in the Sacramento - San Joaquin Estuary that allows for more efficient management of the estuary*."

b) Consistent with the above program goals, we formulated the following seven more specific ***objectives*** for EMP monitoring of water quality, phytoplankton, zooplankton, and benthos in the upper San Francisco estuary. The proposed EMP design described in section III. E. (3) follows these objectives.

1. *On an ongoing, long-term basis, collect and analyze environmental data to characterize spatial and temporal variability of ambient concentrations and fluxes of physicochemical and biological constituents at appropriate spatial (local, regional and system-wide) and temporal (high-frequency “noise” versus longer-term “signal”) scales. Particular attention should be given to constituents for which water quality objectives exist.*

This objective is aimed at collecting appropriate baseline and compliance data and information for fulfilling the D-1641 mandated program goals. To address this objective, we propose a revised EMP sampling design that will provide suitable data to determine how physicochemical and biological constituents are spatially distributed, and how their distribution changes through time at various spatial (local, regional, system-wide) and

temporal scales (primarily: time scales greater than weeks). We also propose that EMP staff and/or outside experts develop strategies for the most useful and effective routine data analyses to detect ecologically meaningful patterns and longer-term trends in the long-term EMP data record, see section III e. (2). At the core of the proposed spatial design are “ambient stations” and “flux stations.” Monitoring at ambient stations is intended to capture prevailing conditions in specific regions. Flux stations are associated with tidal flow stations (operated with or by the USGS or DWR-Central District) and used to calculate water, salt, sediment, nutrient, chlorophyll and other mass fluxes (loads) across regions at key locations along major flow paths in the upper estuary. Ultimately, all stations should be located within one tidal excursion range of each other to facilitate estimation of spatial structure based on knowledge of tidal transport of water parcels. This also necessitates a shift in program emphasis from discrete to continuous monitoring. For further design details and underlying concepts, see section II. e. (3), below.

2. *On an ongoing, long-term basis, characterize spatial and temporal variability of physicochemical and biological constituents in a variety of important "habitat types” over time.*

This and the following objectives are intended to yield more informative monitoring products and address current information needs identified during the EMP review, thus fulfilling the IEP goal to "provide information on the factors that affect ecological resources in the Sacramento - San Joaquin Estuary that allows for more efficient management of the estuary." Different habitat types support different species and ecological processes, and several habitat types in the San Francisco estuary are thought to be of critical importance for the preservation and propagation of native species, including several endangered species. To satisfy objective 2, we thus propose to monitor and better define eight habitat types in the San Francisco estuary distinguished based on ecologically important physical and chemical features. These habitat types include shallow subtidal wetlands and flood plain habitat, two important habitat types currently not monitored by the EMP.

3. *Detect and monitor the establishment, distribution, and temporal trends of non-native phytoplankton, zooplankton, and benthic invertebrate populations.*

The San Francisco Estuary is a highly invaded estuary[7]. Invading species have the potential to substantially affect water quality and native species assemblages. These effects may alter or mask the effects of water project operations and contribute to the observed status and trends of water quality and biological constituents monitored by the EMP. Objective 3 seeks to assess the distribution and temporal trends of non-native species already present in the system and detect future invasions.

4. *Through synthesis of EMP and other data sets, develop hypotheses about ecological processes and underlying mechanisms (including water project operations) for further consideration in special studies.*

Monitoring and analyses conducted to satisfy objectives 1 - 3 should yield observations that could lead to the formulation of hypotheses about ecological processes and underlying mechanisms and possibly evaluations of “ecosystem health.” These hypotheses should be addressed by EMP staff and/or external scientists in separately funded special studies. Ultimately, EMP data and analyses should thus contribute to a better understanding of the causal relationships between environmental factors (including SWP and CVP operations and climate fluctuations) and hydrodynamic and ecological patterns and processes in the upper estuary.

5. *Provide appropriate data for modeling (model boundary conditions), especially for compliance constituents (e.g., temperature and electrical conductivity) at compliance sites.*

EMP data is also useful for numerical modeling applications such as water project operations forecasting and planning studies that to that are principally aimed at predicting changes in salt field dynamics due to large civil engineering projects or habitat restoration projects. To provide appropriate data for modeling, we propose to continuously monitor EC and temperature and in some cases additional variables (e.g. chlorophyll a fluorescence and turbidity) at “flux” stations already or potentially determining model boundary conditions, or natural boundaries between regions with priority given to designated D-1641 compliance monitoring stations.

6. *Maintain and continue adding to the EMP's valuable long-term data record, especially at the most long-term stations, and ensure long-term data compatibility.*
7. *In a timely manner, provide EMP data and associated meta-data in a relational, web-accessible database. Provide results of routine analyses in a similar way.*

Finally, it is evident that a long-term environmental data record such as the EMP data set has great intrinsic value for basic and applied scientific explorations and becomes increasingly more valuable with continued monitoring as long as program consistency is maintained. Objectives 6 and 7 seek to ensure data continuity and improve accessibility and usefulness. To this end, EMP staff has identified the stations with the longest intact and uninterrupted data records. We propose to maintain these stations with comparable monitoring procedures in the future. The EMP shall implement procedural changes only after results produced simultaneously with the historical method and the potential new method have been thoroughly evaluated to ensure method comparability. EMP staff is also in the process of addressing objective 7 as outlined in the next section and under objective 1, above.

c) Specific ***questions*** that should be answered through EMP monitoring and special studies on an ongoing basis relate back to the program goals and objectives and address specific areas important for D-1641 compliance or to resolve critical uncertainties related to ecosystem management decisions and scientific understanding. Some questions are fairly basic and the intent is to routinely provide answers with automated, web-based analysis and reporting tools and a summary in the annual status and trends report, while others require more complex analyses and would yield technical reports and peer-reviewed publications. The questions also identify how to better integrate data among monitoring elements and programs to further our understanding of environmental conditions within the estuary. The sampling design determined by the program objectives, above, and described in more detail below would control the data stream available to answer each question (*e.g.*, discrete or continuous sampling, replicates among regions, etc.). The answers to these questions would be provided in specific program products released in a timely manner using traditional (*e.g*., reports, newsletter contributions, journal publications of staff analyses as opportunities allow) as

well as more innovative reporting tools (*e.g.*, interactive web sites with data base access and custom web tools). A list of questions identified during this review is given in section IV a. Not all possible questions are listed, and the questions are expected to change with changing management priorities and new physical and ecological insights. New questions will need to be continuously solicited from managers and scientists.

(2) EMP data and information products

All review participants and the IEP SAG agreed that the EMP needs to dedicate more effort to its products. This includes improved data and information management, analysis, synthesis, and timely dissemination of data and information. If done in coordination with all other monitoring programs in the San Francisco Estuary, this could lead to more comparable data and better data accessibility to all monitoring data via one single user interface ("one-stop shopping"), as well as more useful and timely information for all "customers." The IEP SAG strongly recommended that the EMP increase its "human intellectual investment" to achieve this goal. Recognizing this need, the EMP succeeded in hiring four additional Ph.D.-level scientists[14] since September 2000 and increased the intellectual involvement of all program staff by encouraging regular active participation in IEP Water Quality Project Work Team meetings; see its web site at http://iep.water.ca.gov/emp/IEP%20WQ%20PWT.html. Also, the EMP now has its own server managed by EMP staff and is working to streamline data flow and quality control procedures and include better and more easily accessible meta-data files. For example, EMP staff have recently assembled geographical coordinates for all D-1641 in a "shapefile" (.shp) spatial data format appropriate for Geographic Information System (GIS) applications.

Longer-term objectives for improved data and information products include the development of web-based analysis and reporting tools and replacement of the annual data report with a more informative and concise annual status and trends report. This report would summarize the results of data analyses, identify future study plans, and refer to data and information stored on the EMP server and available via the Internet

[14] Marc Vayssieres, Phil Giovannini, and Anke Mueller-Solger, DWR, and Erwin VanNieuwenhuyse, USBR.

through the new IEP "BDAT" user interface via the IEP and EMP web sites. The new reporting format would be consistent with the intent of D-1641 Condition 11 (c). In addition, EMP staff would be encouraged to use EMP data to produce newsletter articles, technical reports, and peer-reviewed publications as opportunities allow. Overall, the proposed program would emphasize greater collaboration and coordination with other programs, agencies, and universities for improved monitoring efficiency and products. This shift in program orientation has already been set in motion, as evidenced for example by the recent increase in IEP proposals for collaborative special studies submitted by EMP staff.

(3) EMP design and implementation

The present EMP design has produced a large amount of valuable data. To preserve data continuity, EMP reviewers thus worked to carefully adjust the existing EMP design to better fit the current program aims rather than making wholesale revisions. Specifically, reviewers proposed an updated conceptual basis for the EMP sampling design and investigated monitoring elements and their integration as well as funding, resource allocations, and legal obligations, and the relationship between monitoring and special studies. EMP reviewers sought to address these program design issues within the redesign constraints set by the need for maintaining D-1641 compliance, long-term program continuity, and a fixed program budget. These constraints represented a considerable challenge for program design optimization.

a) Sampling design

The newly formulated EMP goals and objectives, above, are primarily aimed at capturing longer-term trends (seasonal, annual, or longer) resulting from natural and anthropogenic influences. However, over the last three decades it has become increasingly clear that in the highly dynamic upper San Francisco Estuary, only very strong long-term trends (signals) can be ascertained from monthly discrete samples because of the prevalence of pronounced high frequency variations (noise). To better separate long-term signals from high frequency noise, the EMP thus needs to be better able to recognize and characterize high frequency variations. In the proposed revised

EMP, this would be accomplished through a shift in program emphasis from discrete to continuous sampling. The ultimate goal would be to create a network of continuous monitoring stations within a tidal excursion of neighboring stations throughout the upper estuary. This would facilitate data analysis at the prevailing transport (tidal) time scales and higher-resolution assessments of spatial variability. Priority would be given to continuous monitoring of electrical conductivity (EC) and water temperature, two key water quality constituents in the estuary for which robust sensor technology is available. In addition to EC and water temperature sensors, some EMP stations would also include continuous monitoring sensors for other important variables such as turbidity, pH, dissolved oxygen, and chlorophyll *a*. Discrete sampling for the remaining EMP water quality variables and phytoplankton would largely be carried out during routine maintenance of the continuous monitoring stations at alternating spring and neap tides to avoid tidal aliasing effects. Due to the need for a winch and nets, most zooplankton and benthos monitoring would continue to be vessel-based and would also be carried out at alternating spring and neap tides.

In the proposed adjusted EMP, stations would be distributed throughout the estuary according to a stratified sampling design with the strata based on physical and ecological conceptual models of the estuary and stations within strata located at distances of no more than one tidal excursion range from the nearest neighboring station (Figure 5). Physically, we separate the Bays and Delta into strata based on geometry, on the influence of regional scale hydrodynamic transport processes, and on hydrologic influences (which in this context include river inputs, pumping, gate operations and barrier manipulations) (Figures 5-8). In San Pablo and Suisun Bays, stations are located at important bathymetric features: “sills” and deeper areas associated with gravitational circulation “cells” (Figures 6 and 8). In the Delta, station categorization according to the physically determined strata (Figures 7 and 8) is quite similar to regional categorization determined statistically from the long-term EMP data set (Figure 9). Ecologically, we distinguish eight habitat types, including two in the lower estuary (Figure 10). These habitat types are distinguished based on ecologically important physical and chemical features such as depth, turbidity, tidal energy, residence time, connectivity to surrounding water bodies, wet period, etc.

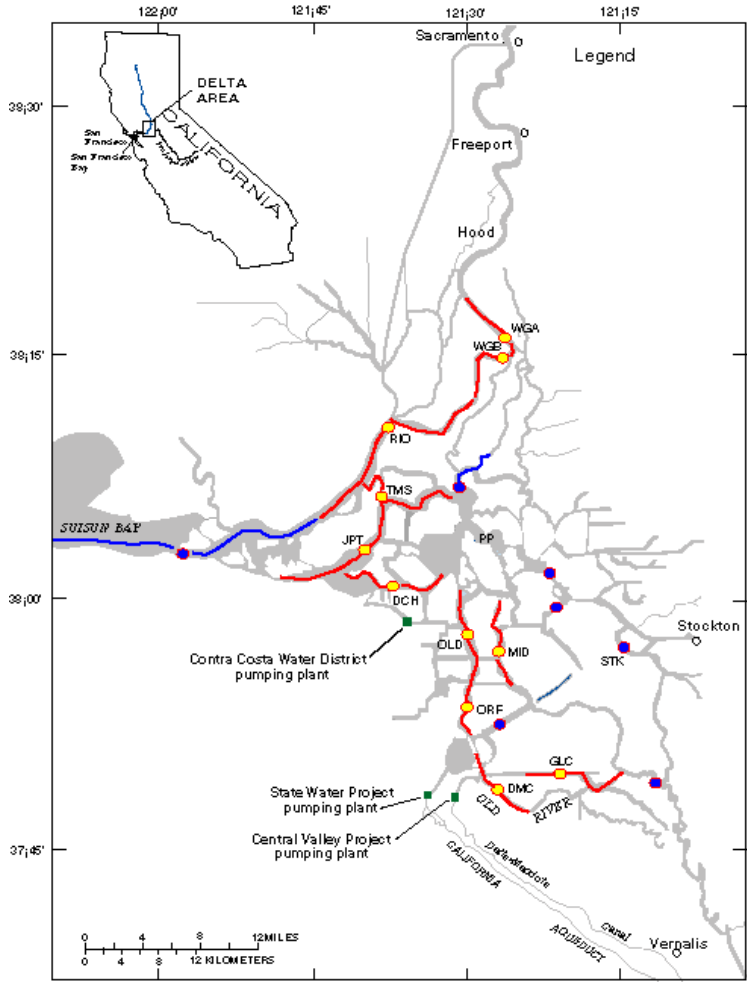


Figure 5: "Slack water plot:" Preliminary estimates of tidal excursions at fixed USGS flow stations (red lines emanating from yellow dots) and special studies stations (blue lines emanating from blue dots). Data and graphics: J. Burau, USGS.

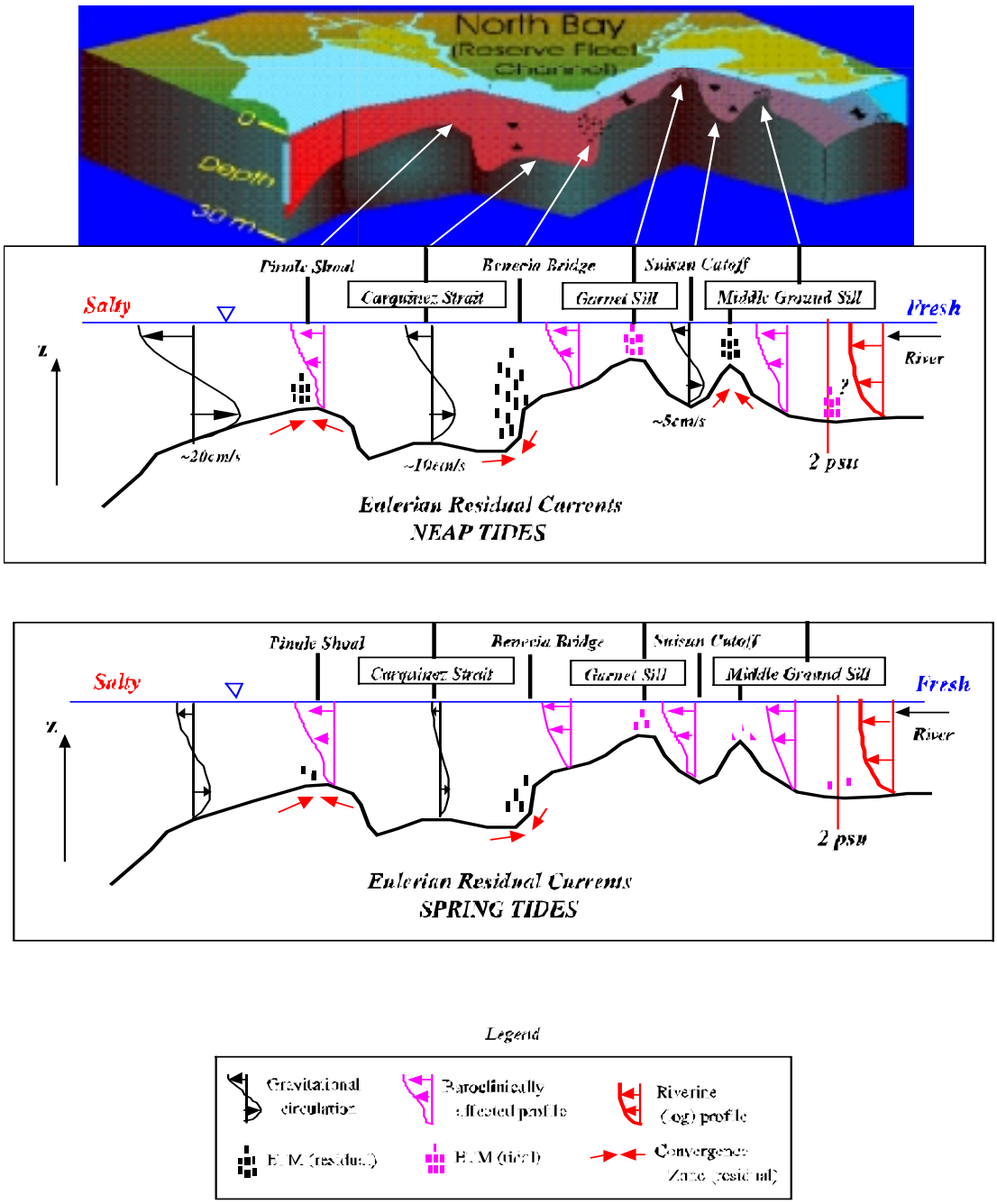


Figure 6: Conceptual model of Eulerian residual circulation for San Pablo and Suisun bays and Carquinez Strait. This model emphasizes the importance of bottom topography (bathymetry) and the difference between conditions that occur during neap and spring tides and provides the basis for EMP continuous station placement in these areas. (Data and graphics: J. Burau, USGS)

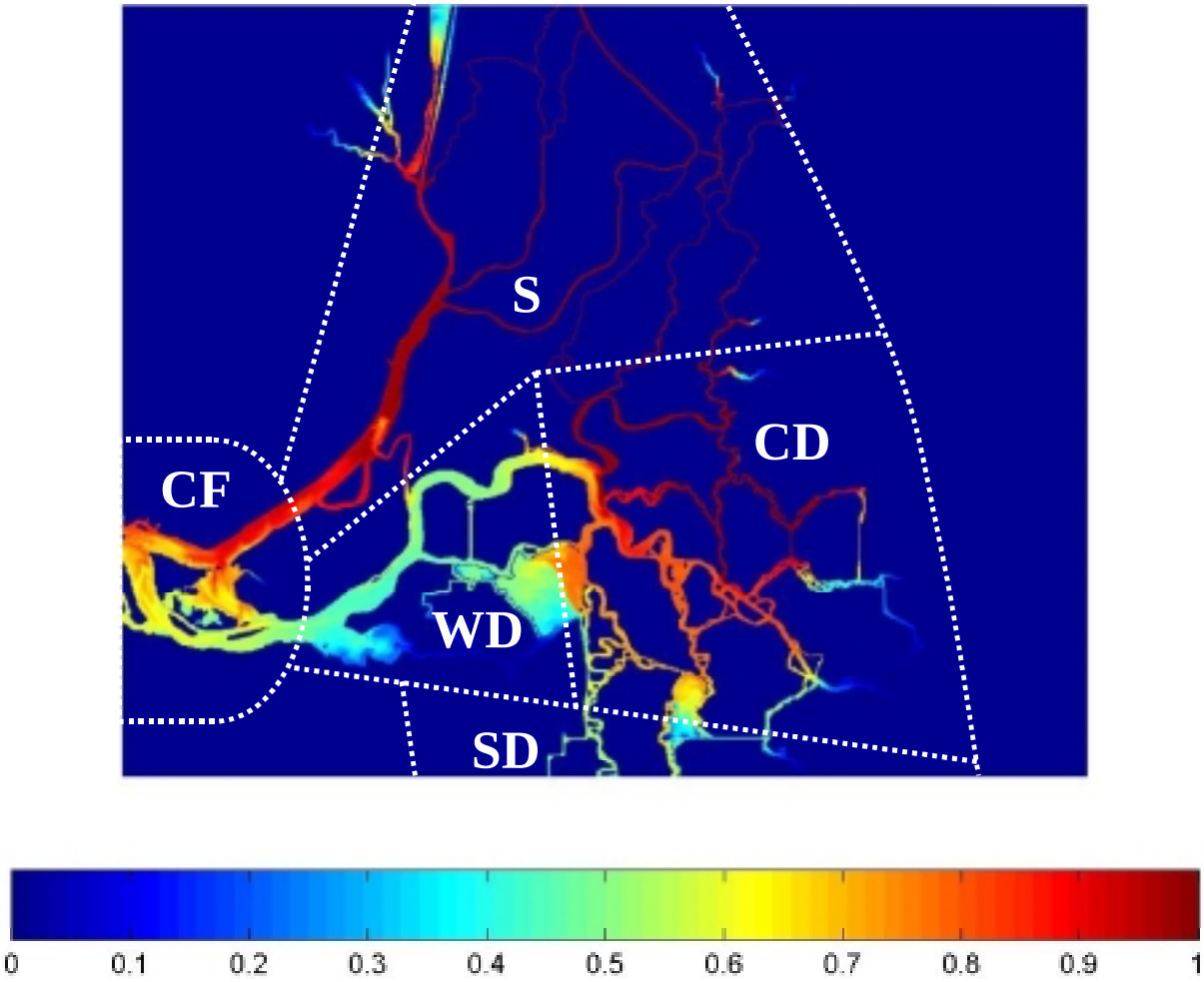


Figure 7: Numerical simulation of the Sacramento River influence on the Delta. This image was generated by introducing Sacramento River water into the simulation with concentrations of one (red) over a simulation of 35 days. Sacramento River water was allowed to move throughout the Delta under the prevailing hydrologic conditions in August-September 2001. The concentrations throughout the Delta were initially set to zero (blue). This simulation emphasizes the importance of physical processes in determining Delta regions and the high degree of spatial variability among regions and between and within similar habitat types. Modified from simulation and graphics by N. Monsen, USGS Menlo Park. (Broken white lines: boundaries between physically defined Delta regions; S: Sacramento River; CF: Confluence region, WD: Western Delta; CD: Central Delta; SD: South Delta)

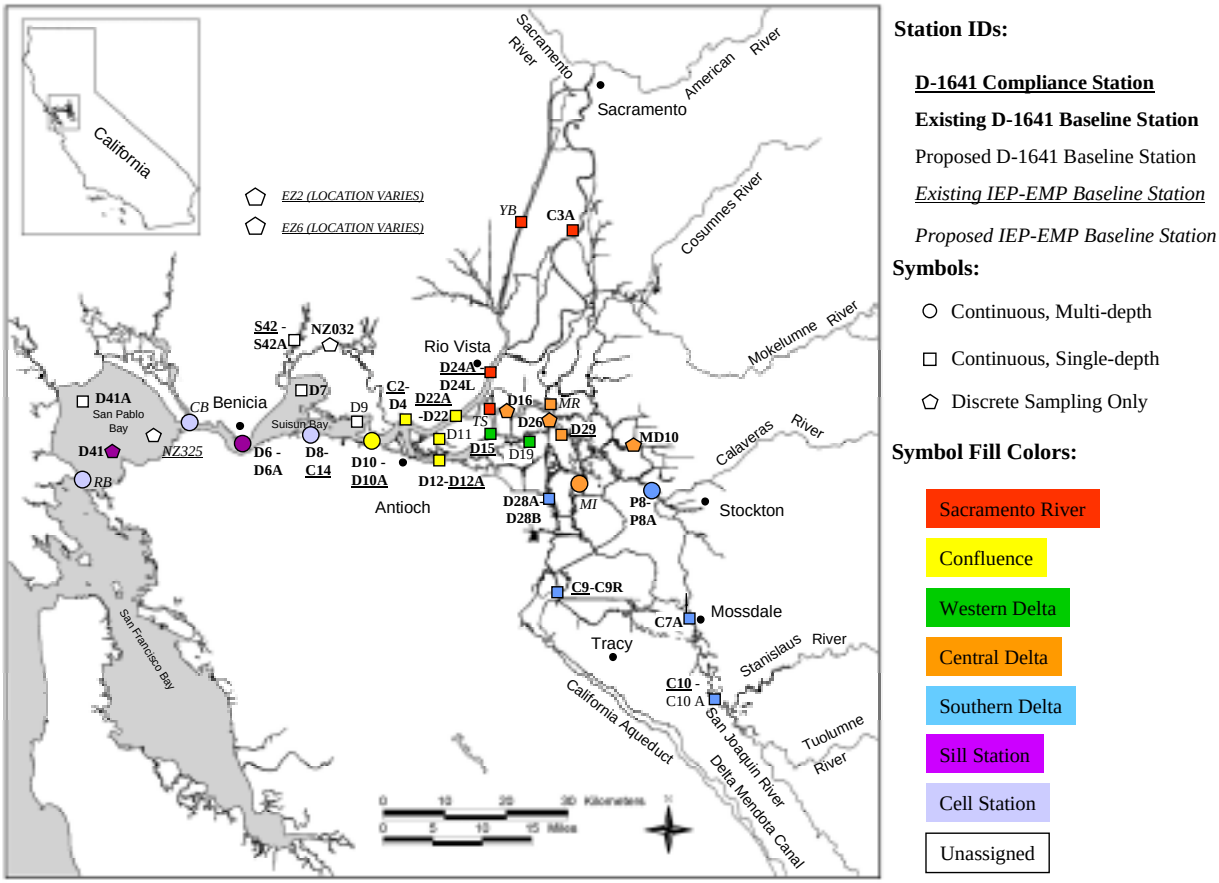


Figure 8: Recommended EMP stations with their associated bathymetric features in Suisun Bay and San Pablo Bay and physically defined Delta regions. (Bathymetric features: shallow “sills” and deeper gravitational circulation “cells”, s. Figure 6; Delta regions: based on geometry, regional scale hydrodynamic transport processes, and on hydrologic influences, s. Figure 7. For details about Station IDs and Symbols, s. Figure 12).

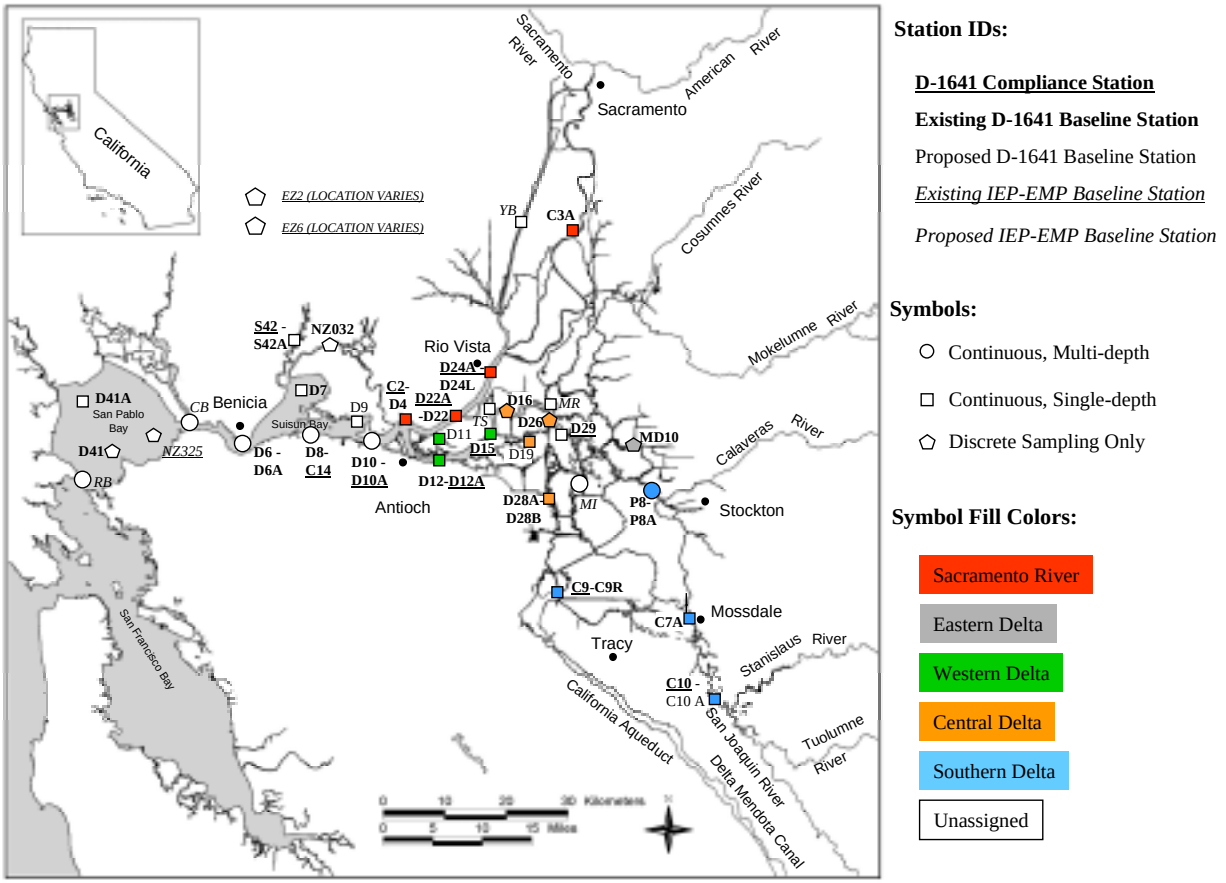


Figure 9: Stations associated with Delta regions determined statistically from EMP water quality data (based on Lehman 1996 and Jassby & Cloern 2000[15], see Table E. For details about Station IDs and Symbols, s. Figure 12).

[15] Jassby, A. D., and J. E. Cloern. 2000. Organic matter sources and rehabilitation of the Sacramento-San Joaquin Delta (California, USA). Aquatic Conservation 10:323-352.
Lehman, P. W. 1996. Changes in chlorophyll a concentration and phytoplankton community composition with water-year type in the upper San Francisco Bay Estuary, p. 351-374. In J. T. Hollibaugh [ed.], San Francisco Bay : The ecosystem. Pacific Division of the American Association for the Advancement of Science.

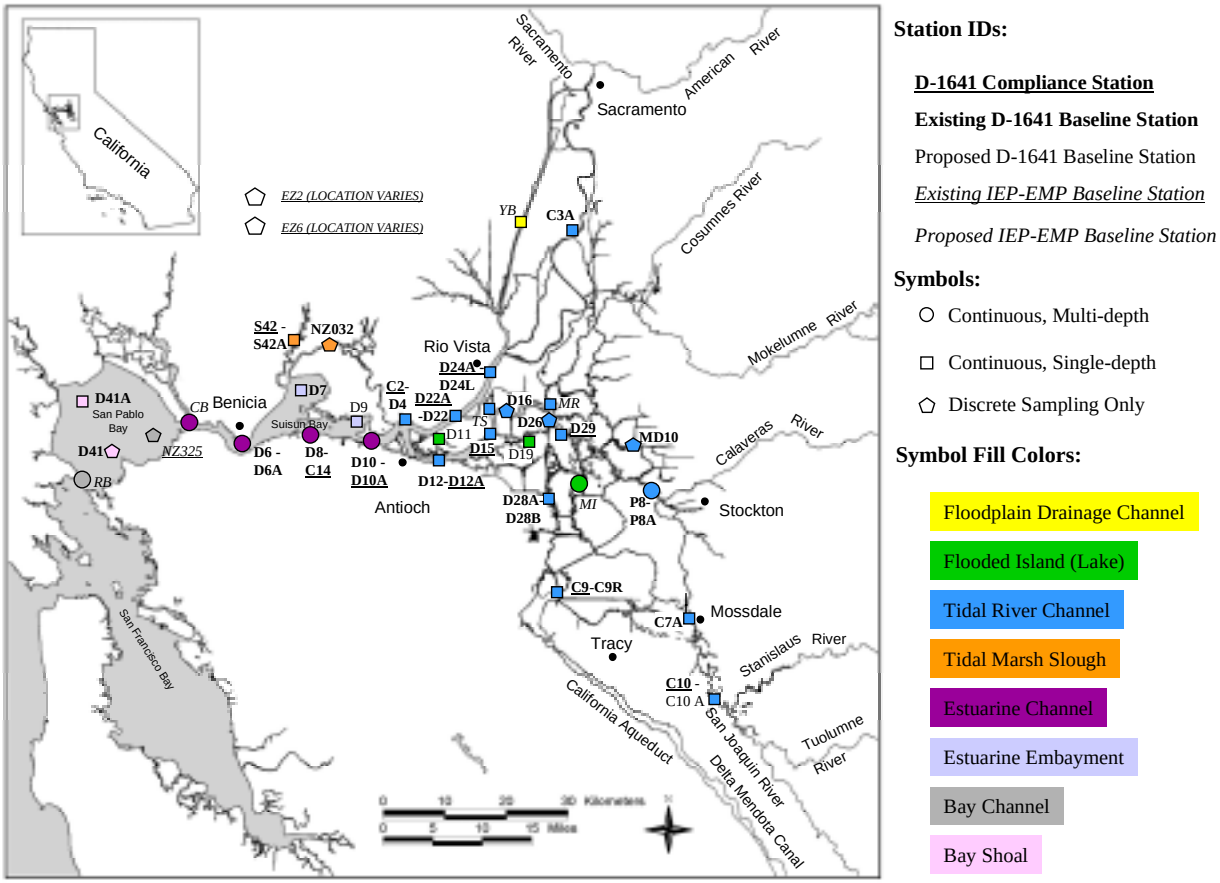


Figure 10: Habitat types represented by the proposed EMP stations. (For details about Station IDs and Symbols, s. Figure 12.)

Based on the monitoring objectives and questions listed above, the EMP should be designed to determine temporal variability within the physical and ecological regions represented by the stations shown in Figures 8, 9, and 10, and the exchanges between them and across the entire upper estuary. Accordingly, sampling stations are divided into two distinct categories depending on whether a sampling station's primary aim is to estimate mass flux across regions (a flux station) or temporal variations within a region (an ambient station). As mentioned above, flux stations would yield appropriate data for calculating water, salt, sediment, nutrient, chlorophyll and other mass fluxes (loads) across regions at key locations along major flow paths in the upper estuary (Figure 11). At flux stations, flow (not traditionally measured by the EMP) should be measured concurrently with EMP constituents by or in collaboration with the USGS or DWR-Central District. The remaining proposed stations are ambient stations. These stations would be distributed throughout the upper estuary (and possibly in the lower estuary for zooplankton monitoring by the IEP Bay Study) to capture prevailing environmental conditions in specific regions and habitat types.

To preserve monitoring continuity (objective 6, above), station locations identified according to these conceptual models would be matched to the greatest possible degree with historical EMP stations, especially those with consistent data streams spanning three or more decades and existing D-1641 compliance stations. To clarify station identities, EMP staff have assembled geographical coordinates for all existing EMP stations (Table E) and propose to list stations at which discrete and continuous monitoring is carried out at nearby (located within two miles or less) rather than identical locations as separate stations within "station pairs." "A" or "B" would be added to the station identification number of one of the two stations in each station pair (generally to the more recently established station). Benthos monitoring has historically been conducted along cross-channel transects with stations identified by the addition of "-L" (for locations near the left channel bank) or "-R" (for right channel bank). These historical station identifiers would be used for two baseline stations where only benthos monitoring is conducted (D24-L, C9-R). The separated stations would be identified as compliance,

baseline, or compliance and baseline monitoring stations depending on the type of monitoring performed.

For greater monitoring efficiency and improved information products, we propose analytical integration and ultimately consolidation of twelve discrete-continuous monitoring station pairs, provided there is good agreement between data recorded at these neighboring stations. Special studies would be conducted to assess longitudinal and lateral constituent variability to ascertain data comparability and to ensure the data obtained are most representative of local conditions. Over the next three years, we would conduct studies at ten station pairs to determine if their data are sufficiently comparable to allow consolidation of discrete and continuous monitoring stations. Final recommendations for these station consolidations would be included in the next triennial SWRCB-mandated program review in 2005. At this time, we propose to consolidate two station pairs, C3/C3A and C10/C10A. Available data from the continuous baseline monitoring stations on the Sacramento River at Green's Landing (C3) and Hood (C3A), located two miles apart from each other, shows that data comparability between these two locations is sufficient[16] to allow consolidation without compromising the long-term continuity of discrete data collected from C3. We would move discrete sampling from C3 to C3A and conduct comprehensive side-by-side sampling for one year to document discrete and continuous data comparability for all measured variables. The new continuous baseline monitoring station on the San Joaquin River near Vernalis (C10A) will be located immediately (0.2 miles) downstream of discrete baseline monitoring at the current station C10. Due to the very short distance between C10 and C10A, water quality is not expected to be different between these two locations. We would thus conduct side-by-side baseline monitoring for a year followed by the consolidation of all baseline monitoring at the new baseline monitoring station C10A. Compliance "continuous recorder" monitoring at C10 would be continued at its current location. For more details about specific proposed EMP stations, station rationale, and important special studies see the Tables in section IV.

[16] See EMP Water Quality Subject Area Team review reports for details. These reports are available upon request and over the Internet at http://iep.water.ca.gov/emp/SAT%20reports.html.

In addition to measurements at fixed stations, vessel-based, fixed depth flow-through measurements of EC, turbidity, dissolved oxygen, and chlorophyll *a* fluorescence between fixed stations would continue to provide high spatial resolution for these variables during the zooplankton-benthos monitoring cruises. Eventually (after exploring its utility and applicability in the Delta through special studies), we may also propose analysis of routinely acquired remote sensing images for high spatial resolution monitoring of some constituents.

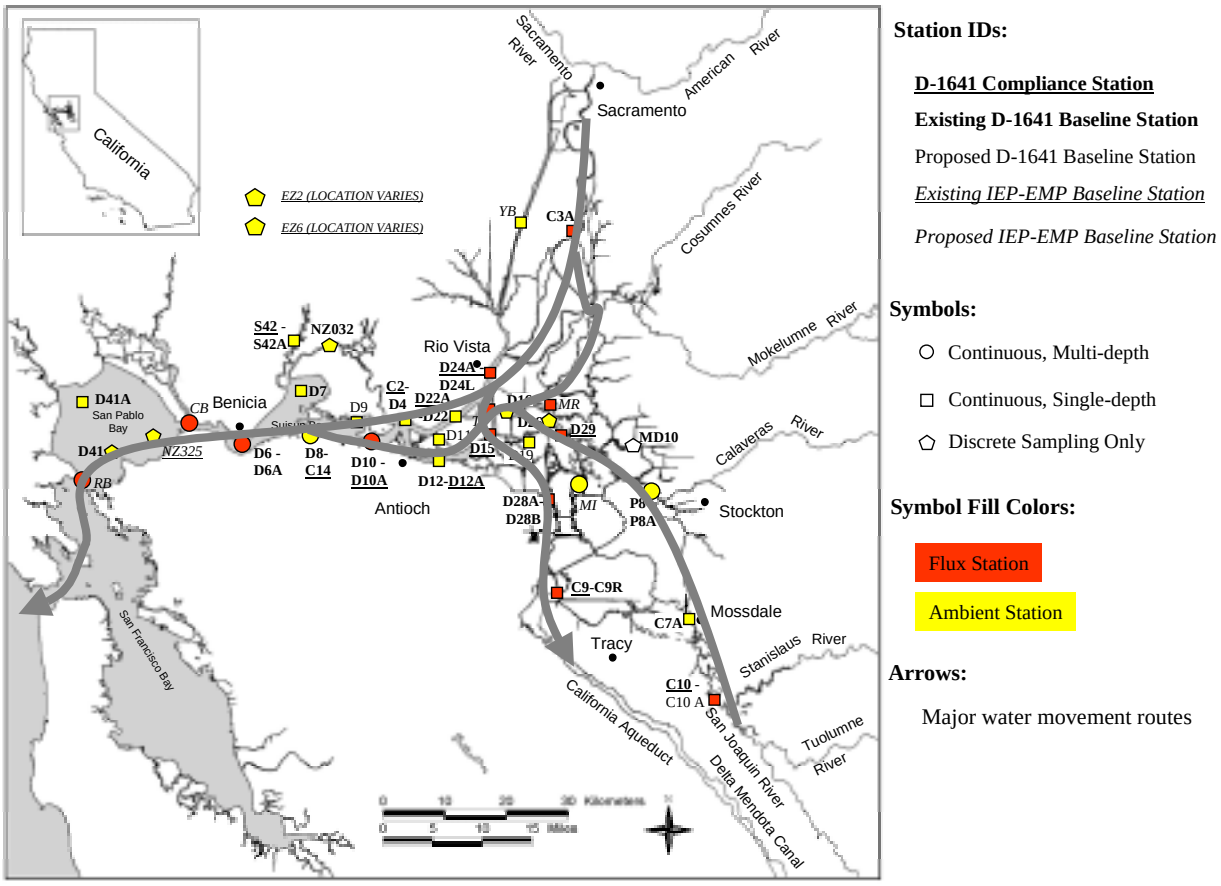


Figure 11: Proposed ambient and flux stations. (For Details about Station IDs and Symbols, s. Figure 12.)

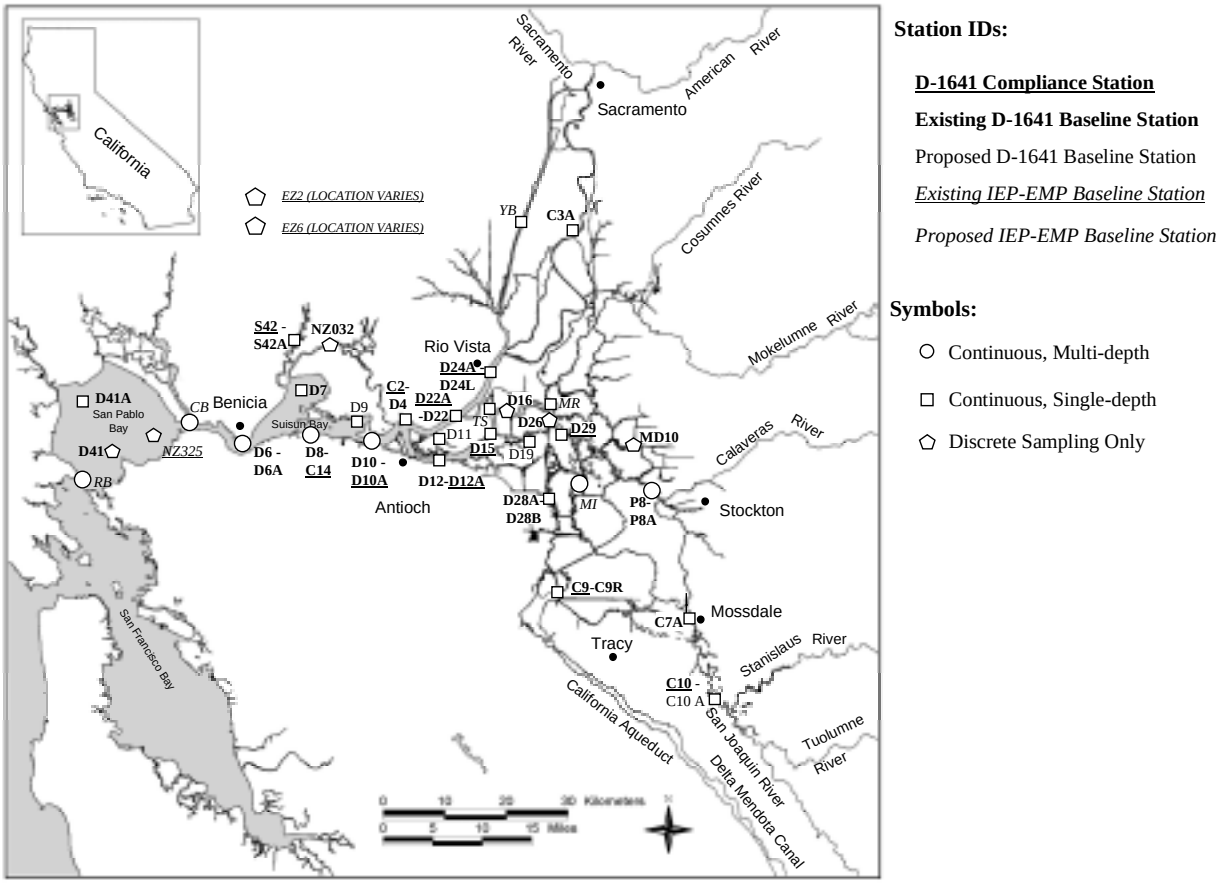


Figure 12: Existing and proposed EMP stations. (D-1641 Stations: Existing D-1641 mandated EMP compliance stations and existing and proposed D-1641 mandated EMP baseline monitoring stations. IEP-EMP Stations: Additional existing or proposed EMP stations for non-mandated environmental baseline monitoring intended to address IEP goals. Station pairs (e.g. D10-D10A): Neighboring stations located at a distance of no more than 2 miles from each other and proposed for consolidation or analytical integration. Continuous Stations: Continuous measurement of important variables complemented in most cases by discrete monitoring of additional variables. Multi-Depth: Vertical arrays of continuously recording probes at two or more depths. Single-Depth: Continuously recording probes at 1-m depth below the water surface. Discrete Sampling Only: Stations without continuous recording instrumentation. For more station details, see tables in part IV, below.)

b) Monitoring elements

Overall, the proposed revised EMP design attempts to increase efficiency, integration, consistency, and compatibility of the continuous and discrete EMP monitoring elements by increasing the number of variables monitored concomitantly at or in close proximity to continuous monitoring stations. Redundancies with monitoring conducted by other programs will be further investigated and, wherever possible, eliminated. EMP staff are also examining and updating sampling and sample analysis procedures as recommended by program reviewers to document and assure the highest data quality for all measured variables. Data continuity is maintained through extensive comparisons of historical and modern methods.

The network of strategically located continuous monitoring stations described above would allow more comprehensive analyses at appropriate (including tidal) time scales and spatial scales to detect patterns and trends in water quality and phytoplankton, zooplankton, and benthos abundance and distribution in the upper the San Francisco Estuary. For constituents monitored at fixed stations, we would attempt to deduce their day-to-day spatial structure based on knowledge of tidal excursion ranges and local processes. This knowledge would enable spatially intense data analysis of multiple EMP variables and better assessments of anthropogenic impacts such as project operations as well as natural phenomena such as climate change. It would also allow for more statistical analyses of regional and system-wide long-term trends as described in objective 1, above, although in some cases these analyses may require data from additional stations. Vessel-based, fixed depth flow-through measurements between fixed stations and, if special studies prove its feasibility, remote sensing might serve to test the accuracy of spatial extrapolations of fixed station data.

Currently, several system components are not sufficiently monitored in the San Francisco Estuary. It is unclear what role, if any, the EMP should play in filling these gaps in the existing estuarine monitoring network. As mentioned in section II, these system components include non-algal producers and microbial organisms, larval fishes, and contaminants in the Delta. It appears that many of these system components have historically “fallen through the cracks” of agency monitoring because of uncertain

responsibilities, lack of jurisdictional pressures and funding, or insufficient recognition of their importance. While larval fish monitoring was historically conducted by DFG, it has been halted in recent years because of uncertainty about appropriate program design for this difficult and expensive type of monitoring and about the utility of the resulting data. An important first step for integrating these “missing links” into the current monitoring network would be a SWRCB and CALFED supported investigation of agency responsibilities for monitoring these components and potential funding sources. Also, the most effective monitoring variables (indicators) for detecting patterns and trends in these system elements would have to be identified. The proposed EMP special studies plan includes such an investigation for non-algal producers including microbes and macrophytes. Investigations into the importance and logistics of monitoring other system elements may be carried out by agency programs historically more concerned about these components such as DFG for larval fishes and Regional Water Quality Control Boards for contaminants. Also, several planned and ongoing short-term, non-EMP research studies should deliver some of the necessary insights.

While the EMP never monitored non-algal producers, microbes, or larval fishes, it historically included a contaminants monitoring element: pesticide and heavy metal concentrations were assessed twice per year. This sampling effort was discontinued in 1995 because it was not producing meaningful results due to the regular sampling strategy employed and analytical method limitations. Contaminants monitoring should vary in intensity and location throughout the year based on events related to land use and runoff patterns. This would greatly increase the complexity and cost of the EMP. Since water project operations do not directly contribute contaminants to the system, DWR and USBR cannot justify the high cost associated with implementation of appropriate contaminants monitoring, at least in the context of the EMP. However, project operations contribute to contaminant effects through transport processes. Yet, development and implementation of contaminants monitoring may be most appropriately addressed through the planned CALFED drinking water quality monitoring program and within a basin planning framework set by the SWRCB and RWQCB’s. Any contaminants monitoring in the Delta should be closely coordinated with the ongoing Regional Monitoring Program (RMP) contaminants monitoring in the lower Estuary conducted by

the San Francisco Estuary Institute (SFEI). The EMP could play a role in coordinated contaminants monitoring and research (Figure 3).

c) Funding, resource allocations, and legal obligations

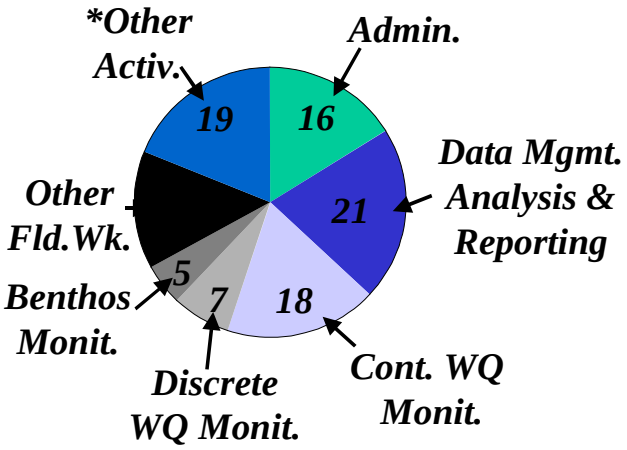
DWR and the USBR are legally obligated to conduct environmental monitoring and comply with water quality standards in return for obtaining the right to export water through the SWP and CVP. The jurisdictional obligation under D-1641 dictates an appropriate program design and ensures continued minimum program funding by DWR and the USBR for the EMP and its D-1641 sister programs (monitoring mainly by DWR Central District, DWR Operations and Maintenance, and USBR Central Valley Operations). Proposals for program design improvements can be submitted every three years and are subject to SWRCB approval and open to scrutiny by water contractors, agencies, stakeholders, and the public. The mandated nature of the program restricts operational flexibility and holds the two agencies responsible for carrying out the monitoring program specified in the Water Right Condition under all circumstances.

As mentioned above, the EMP is currently funded jointly by USBR and DWR, with DWR providing 54% of the annual EMP budget of $2,100,000 as well as most of its staff. The premise of this review is that this level of funding will remain constant in the future. The current uncertain financial climate makes it unlikely that more funding will become available for the EMP in the foreseeable future. Moreover, hiring to replace or add EMP staff is greatly impeded by the ongoing State hiring freeze, now expected to last through 2004. The EMP was fortunately able to hire a senior Environmental Scientist dedicated to data analysis and reporting through the CALFED Science Program in 2001 and replace another staff member in 2002. However, the current budget and hiring situation implies that implementation of the activities recommended in this review will need to rely on existing resources and staff time. A seven-month study to assess EMP staff effort allocation has been completed. The study results will be used as a basis for reallocation and optimization of EMP resources, with redirection of EMP staff time mostly from “other activities” and “other fieldwork” (Figure 13) to EMP activities. Furthermore, several proposed activities such as station consolidations are aimed at increasing program

efficiency. Additional funding sources and collaborators will have to be sought for a number of special studies and for one-time equipment costs. While EMP staff is dedicated to overcoming funding limitations, realistically, funding may prove to be the greatest hurdle to full and timely implementation of all recommended activities.

Due to the poor financial climate, the ongoing State hiring freeze, recommendations by agency managers, and objections to EMP San Francisco Bay zooplankton monitoring by State Water Contractor representatives, we recommend limiting D-1641-mandated monitoring (1) establishment of a new multiparameter station and reestablishment of three historical baseline stations, (2) addition of 14 new, reinstallation of 14 previously discontinued, and integration of three existing (but not currently required by D-1641) individual monitoring elements, (3) more accurate description and consolidation of nearby discrete and continuous stations, (4) change of discrete monitoring frequency from monthly to near-monthly according to the tides, and (5) a temporary (2003-2004) reduction in benthos monitoring frequency to conduct benthos studies (see section IV and associated Tables for details). This would begin the process of improving the EMP monitoring network to better meet program objectives while not overcommitting the program in the face of the current poor funding situation. Program reviewers also recommended the addition of several new stations in the upper estuary, additional station consolidations, and the expansion of zooplankton monitoring into the San Francisco Bay as important for achieving the program’s goals. Because of the constraints and reactions described above, the review core team recommends that the IEP Management Team and Coordinators consider these recommendations for further study and/or implementation as non-mandated IEP program elements, funding permitting. The review core team further recommends implementation of zooplankton monitoring in the San Francisco Bay as part of the IEP "Bay Study" rather than the EMP. Final recommendations for additional station consolidations, additions, and discontinuations, and a revised benthos monitoring design will be included in the next SWRCB-required triennial program review in 2005.

DWR-DES:



* 2% Prepare/review proposals and plans
1% Procedure development & Equipment Selection
10% Working/staff meetings
3% Response to requests from Manager
3% Training

DFG:

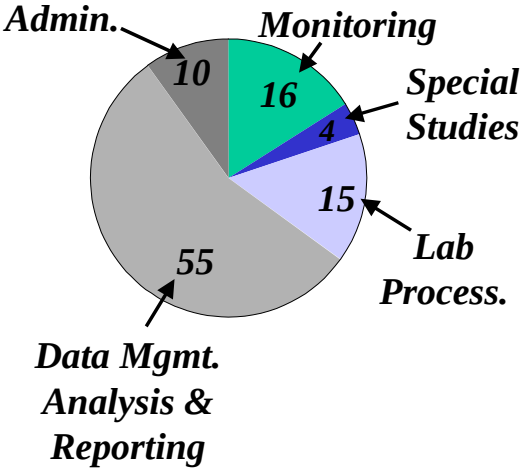


Figure 13: Allocation of EMP staff effort (%) based on a seven-month survey of EMP staff activities. (DWR-DES: Continuous and discrete water quality, phytoplankton, and benthos monitoring; DFG: Zooplankton monitoring.)

d) Relationship between monitoring and special studies

Consistent with the IEP mission to “provide information on the factors that affect ecological resources,” EMP researchers have over the years conducted numerous special studies in addition to monitoring. Many EMP special studies have complemented monitoring activities to help answer questions about appropriate spatial and temporal sampling design, field and laboratory procedures, and long-term patterns and trends in measured or related variables. They have also contributed to fulfilling the EMP goals given by the IEP and D-1641 by providing "information on the factors that affect ecological resources.” While monitoring activities have been specified in monitoring plans throughout the EMP’s existence, there has never been a similar plan for EMP special studies. Also, procedures for proposing EMP special studies and dissemination of study products as well as the relationship between special studies and monitoring activities were never formally specified.

As evidenced by the numerous special studies recommended by the SATs and by the prevalence of special studies in the past, there is clearly an urgent need for special studies that are designed to provide information for optimizing the EMP and its products. The EMP review core team therefore believes it is essential that a monitoring program of this size and scope have a clearly articulated research component as part of its core program. To assure their quality, timely implementation, and recognition, monitoring-related special studies thus need to become a more formal and prominent part of the EMP. EMP reviewers recommended that these studies should complement and be closely integrated with the monitoring program. Due to the financial and legal considerations discussed above, these studies should not be part of the mandated monitoring program and could be funded and carried out independently. Reviewers also felt, however, that only guaranteed funding for special studies and administration by the scientists carrying out these studies can ensure a substantially improved monitoring design for all EMP elements by the beginning of the next IEP review cycle (2007). The review core team thus recommends the IEP Management Team and Coordinators consider prioritizing or even setting aside funds specifically for monitoring-related special studies recommended in formal IEP monitoring program reviews such as the 2001-2002

EMP review. Proposals for these studies would be submitted to the IEP for consideration during the annual IEP study selection process and should fulfill all standard IEP study criteria.

EMP reviewers further recommended identifying priorities for special studies during regular EMP reviews, and including an implementation plan for special studies in the resulting program plans. EMP staff would be responsible for study implementation. Collaborations with non-EMP scientists would be encouraged. For more substantial studies, additional funding (IEP, CALFED, etc.) might be necessary and these studies would have to be designed and proposed according to guidelines put forth by the funding entities. Less substantial studies such as tests of new instrumentation or quality assurance studies are an integral part of monitoring operations, and the existing EMP budget should allow for completing most of these studies. To ensure proper study design, EMP staff are encouraged to develop study proposals according to IEP and EMP special studies guidelines (Appendix 2) and present study proposals and results to the IEP Water Quality Project Work Team, the IEP Estuarine Ecology Team, the new IEP Benthic Estuarine Ecology Team (BEET), IEP forum participants, interested IEP SAG members, and others as appropriate before submitting the proposals for more substantial studies to the IEP Management Team.

The EMP review found that the phytoplankton and benthos monitoring elements are particularly in need of fundamental and comprehensive consideration through intense special studies and study design examination. The shortcomings of phytoplankton monitoring (methods and design) are already being addressed by ongoing methods evaluations conducted by EMP staff and a new CALFED-funded research project headed by Dr. Alan Jassby, UCD. In response to review findings about EMP benthos monitoring and discussions at the first BEET meeting on October 3, 2002, EMP staff and collaborators have submitted three proposals for studies designed to address benthos data and information needs to the IEP. To provide appropriate data for the spatial redesign of the EMP benthos monitoring element, we propose to conduct more spatially intense sampling in 2003-2004, while at the same time reducing routine benthos monitoring at the current ten benthos sites from monthly to quarterly (every three

months). The temporary reduction in sampling frequency would free up EMP resources to conduct the more spatially intense sampling without requiring additional (competitive) IEP funding. More frequent routine sampling would resume thereafter, and a proposal for a redesigned EMP benthos element based on spatially intense monitoring and study findings would be submitted to the SWRCB as part of the next triennial review report due in December 2005. If needed, EMP staff would continue to apply for additional funding for benthos studies through the competitive proposal processes of IEP and CALFED. The benthos studies and the ensuing EMP-benthos redesign would be conducted by EMP staff and outside collaborators under the oversight of the newly formed IEP Benthos Estuarine Ecology Team (BEET), IEP forum participants, and in consultation with the IEP Management Team, Coordinators, and SAG, where appropriate.

IV. EMP monitoring and special studies plans

The following summarizes proposed plans for monitoring and special studies resulting from the 2001-2002 comprehensive evaluation of the IEP EMP described in sections I - III of this report. The monitoring and special studies plans are based on review recommendations for improving EMP data and information products as well as program design and implementation. Details about the proposed prioritized monitoring activities and special studies, individual proposed monitoring stations, and proposed monitoring elements are given in tables. Implementation of the proposed monitoring and special studies plans would enable the EMP to better address the goals, objectives, and specific questions identified during the 2001-2002 review. Overall, the proposed program emphasizes more informative monitoring products, better characterization of the high temporal and spatial variability in system components monitored by the EMP, and improved collaboration and coordination with other programs, agencies, and universities.

a. EMP data and information products

We propose to improve EMP data and information products through the following monitoring and special studies activities. Unless they require program design adjustments (see IV. b.), these activities can be carried out under the existing D-1641.

- Regular examination and updates of EMP sampling and sample analysis procedures to assure and control data quality (see also question 13, below). Priority will be given to several procedures identified by reviewers during the 2001-2002 review, see Tables A and B. In all cases, current and proposed methods would first be tested for comparability of results and all tests and method changes would be documented in meta-data files accompanying the EMP data in the EMP and IEP BDAT databases.
- Maintenance of EMP data and associated information including improved meta-data files and results of routine data analyses on the new EMP server located at DWR-DES in Sacramento with archive copies on CD-ROMs stored at DWR and the USBR. This server is managed by EMP staff in cooperation with the DWR-based Interagency Information Systems Services. EMP data will be stored in in a Microsoft Access™

data base. Geographical information will be maintained in a "shapefile" (.shp) spatial data format appropriate for Geographic Information System (GIS) applications.

- Ensuring timely availability and accessibility of EMP data and associated information through the IEP and EMP web sites and using the new IEP B-DAT user interface for data queries.
- Development of web-based analysis and reporting tools for routinely investigated questions such as questions 1-10, below.
- More in-depth data analyses to address more complex questions such as questions 11 and 12, below. Together with the more routine analyses, this should lead to a better characterization of the temporal and spatial variability in and relationships between system components monitored by the EMP to distinguish between the effects of project operations and other factors. This may also to refinement of the questions listed below, and to additional questions.
- Replacement of the annual data report to the SWRCB with a more informative and concise annual status and trends report. This report would summarize the results of data analyses, identify future study plans, and refer to data and information stored by the EMP on a dedicated server managed by EMP staff and available via the Internet through the IEP and EMP web sites. The new reporting format would be consistent with the intent of D-1641 Condition 11 (c). It is our understanding that this new reporting format would thus not require concurrence of the Executive Director of the State Water Resources Control Board for changes to D-1641.
- Greater encouragement of EMP staff to publish EMP data analysis results in newsletter articles, technical reports, and peer-reviewed publications as opportunities allow. In cases where additional special studies sampling is required to complete analyses, EMP staff should develop and submit study proposals according to guidelines put forth by the EMP (Appendix 2) and by funding entities such as IEP and CALFED, and seek mentoring relationships and collaborations with non-EMP scientists where appropriate. Study proposals and data analysis results should be presented to the IEP Water Quality Project Work Team, the IEP Estuarine Ecology Team, the new IEP Benthic Estuarine Ecology Team (BEET), IEP forum participants, interested IEP SAG members, and at regional and national conferences, as

appropriate. In this way, the EMP intends to increase its “human intellectual investment,” as strongly recommended by the IEP SAG.

- Increased collaboration and coordination with other programs, agencies, and universities and reduction of monitoring redundancies to improve monitoring efficiency and products.
- Regular assessment of "customer needs," program evaluation, and refinement of program aims, procedures, and products.

The following list of questions was identified during the 2001-2002 review based on program goals and objectives, see section III e. (1). They address specific areas important for D-1641 compliance or to resolve critical uncertainties related to ecosystem management decisions and scientific understanding. These questions should be answered through EMP monitoring and special studies on an ongoing basis and yield specific data and information products. Not all possible questions are listed here, and the questions are expected to change with changing management priorities and new physical and ecological insights. New questions will need to be continuously solicited from managers and scientists.

1. *How does EC vary in space and time at different scales? What does this tell us about salinity intrusion (e.g., what was the maximum salinity intrusion for a given year, relative to the water year, and what was the intrusion during certain key times (e.g., before the VAMP, after the VAMP, etc.)? Were the standards in D-1641 met? (Web-based reporting tools and staff analysis summarized in annual report).*
2. *What is the spatial variability of individual constituents during specific (short-term) periods of interest? Using high resolution monitoring (i.e., measured continuously and in some cases via remote sensing) and hydrodynamic modeling, what is the spatial variability of essential constituents such as EC, water temperature, dissolved oxygen, turbidity, and chlorophyll a at high spatial resolution, and how does it change over time? (Web-based reporting tools (maps) and summary in annual report).*
3. *What is the long-term trend in individual constituents at individual stations? How do data collected over the last year compare to the long-term trend? (Web-based reporting tools and summary in annual report).*

4. *What are the long-term regional averages in various constituents, and exchanges between regions? How do data collected over the last year compare to the long-term regional averages? (Web-based reporting tools and staff analysis summarized in annual report). Examples of important management uncertainties targeted by this question and ecologically relevant follow-up questions include the next five questions (questions 5. -10.).*
5. *What is the long-term trend in X2? How do data collected over the last year compare to the long-term trend? Is there a relationship between X2 and the abundance and survival of living resources?*
6. *What is the long-term trend in water temperature? How do data collected over the last year compare to the long-term trend? Is there a relationship between water temperature patterns in various regions and the abundance or distribution of resident fishes?*
7. *What is the long-term trend in dissolved oxygen concentrations in the Stockton Deepwater Ship Channel? How do data collected over the last year compare to the long-term trend? Were the standards in D-1641 met?*
8. *What is the long-term trend in regional water clarity? How do data collected over the last year compare to the long-term trend?*
9. *What are the long-term trends in various constituents among habitat types? How do data collected over the last year compare to the long-term trend?*
10. *What are the patterns in fluxes of salt, turbidity, and chlorophyll at the major input and exit points in the delta? (Web-based reporting tools and staff analysis summarized in annual report; requires collocation of EMP continuous monitoring stations with flow measurement stations ("flux stations")).*
11. *Are seasonal, climatic (e.g., drought and flood) or other signals evident in the EMP data collected over the last year? How does this compare to previous years and long-term trends? (Staff analysis completed and reported each year).*
12. *What relationships exist between regional water quality, hydrological, and meteorological patterns and the abundance or distribution of phytoplankton, zooplankton or benthos? Do they point to specific causal mechanisms? (Staff analysis completed and reported at reasonable intervals (every 1 - 5 years)).*

13. *How can EMP procedures (field, laboratory, data handling and analysis, reporting, etc.) be optimized to best fulfill program goals and objectives? (Ongoing EMP staff efforts and regular internal and external program reviews; findings and decisions reported on EMP web site, in presentations to IEP management and project work teams, agency managers, water project contractors, SWRCB, etc.)*

b. EMP design and implementation

EMP sampling is currently conducted at 22 of the 42 stations listed in D-1641, Table 5 and at four additional non-mandated stations as part of IEP baseline monitoring. The 22 D-1641 mandated EMP stations include 14 of the 18 designated "baseline" monitoring stations, seven of the eight "compliance and baseline" monitoring stations (stations C9, C10, D10, D12, D22, D24, and S42) and one of the 16 "compliance" monitoring stations (D29) listed in D-1641, Table 5. Thus, while one of the EMP's goals is to ensure compliance with SWRCB water quality objectives, it is primarily tasked with comprehensive baseline monitoring in order to achieve its other stated goals -- the identification of meaningful changes in any significant water quality parameters potentially related to operation of the SWP or the CVP, the identification of trends in ecological changes potentially related to SWP/CVP operations, and the gathering of information on the factors that affect ecological resources in the upper San Francisco Estuary that allows for more efficient management of the estuary. To fulfill these goals and address the more specific program objectives and related questions identified during the 2001-2002 EMP review, we propose to implement the revised EMP monitoring design outlined below and described in more detail in Figure A and Tables A - G.

As in the past, EMP staff from DWR, USBR, DFG, and USGS would carry out monitoring and related special studies. Funding for monitoring would continue to be provided by DWR and USBR through the IEP at levels similar to the 2002 EMP budget (approximately $2.1 million - currently the EMP budget provides full or partial salaries for about 30 agency employees and a benthos taxonomist under contract to DWR, as well as for the maintenance and operation of two research vessels, seven shore stations,

laboratory analyses, etc.). Additional funding would be sought from IEP, CALFED, and other sources for special one-time expenditures such as expensive new instrumentation or costly special studies (see Tables A and B).

To facilitate data analysis at the prevailing transport (tidal) time scales, higher-resolution assessments of spatial variability, and calculation of constituent fluxes across regions of the Bay-Delta, we propose to shift program emphasis from discrete to continuous monitoring of essential variables. We would use data from 14 existing continuous recorder and continuous multiparameter stations (C2, C3, C9, C7, C14, D6, D10, D12, D22, D24, D28A, D29, P8, and S42 in the current D-1641 Table 5) and from several additional stations proposed below. We also propose to change the frequency of discrete monitoring of additional variables from monthly to near-monthly according to the tides and to increase monitoring element consistency among stations. The proposed sampling design is based on current conceptual models of physical, chemical, and biological properties of the upper San Francisco Estuary. The proposed EMP station network (Figure 4) combines stratification according to these conceptual models with historical station locations to maintain data continuity. Ultimately, this modified design would enable the EMP to better distinguish between the effects of SWP and CVP operations and other factors (e.g., establishment of introduced species or large-scale restoration projects).

Specifically, we propose the following modifications to D-1641-mandated monitoring. These modifications require concurrence by the SWRCB Executive Director before implementation can begin. Details about the proposed modifications can be found in Tables C-G.

- Establishment of a new multiparameter station (C10A) and establishment of continuous and discrete monitoring at three historical baseline stations discontinued in 1995 (D9, D11, and D19; see Tables C, E, and F). C10A is an important flux site (San Joaquin imports). It would be established in close cooperation with the DWR Municipal Water Quality Investigations (MWQI) monitoring program, and funding has already been secured. Monitoring at the three reestablished sites is needed to better

understand baseline conditions and processes in ecologically important shallow-water habitats.

- Consolidation of two nearby discrete and continuous stations (C3/C3A and C10/C10A) for improved monitoring efficiency and products after comprehensive side-by-side sampling for one year to document discrete and continuous data comparability for all measured variables (Tables C, E, and F). Compliance "continuous recorder" monitoring at C10 conducted by the USBR would be continued at its current location.
- Addition of 14 new, reinstallation of 14 previously discontinued, and integration of three existing (but not currently required by D-1641) individual monitoring elements[17] to increase monitoring element consistency among stations and enable more comprehensive, integrative data analyses. This includes four new "continuous recorder" elements for electrical conductivity (EC) and water temperature at shallow-water monitoring stations (D7, D9, D11, and D19) (Tables C, E, and F).
- Change of discrete physical/chemical water quality, phytoplankton, and zooplankton monitoring frequency from monthly to near-monthly alternating between spring and neap tides to reduce tidal biases (Table C, Footnotes).
- A temporary (2003-2004) reduction in benthos monitoring frequency from monthly to quarterly (Table A) to allow reallocation of staff and equipment to in-depth studies necessary to redesign this program element (Table B). More frequent benthos sampling would resume in 2005 (Table C, Footnotes). Recommendations for benthos monitoring based on study results would be included in the next triennial program review for potential implementation starting in 2006 (Table A).
- More accurate station identification (explained below) and a new D-1641 Table 6 with geographical coordinates for all D-1641 stations (Table G). This information would also be incorporated into the EMP meta-data files and provided in a "shapefile" (.shp) spatial data format appropriate for Geographic Information System (GIS) applications to facilitate integrative data analyses and station consolidations.

[17] Monitoring elements are represented by columns 4 - 9 in Table C (i.e. "Continuous Recorder" monitoring, "Continuous Multiparameter" monitoring, "Discrete Physical/Chemical" monitoring, "Discrete Phytoplankton" monitoring, "Discrete Zooplankton" monitoring, and "Discrete Benthos" monitoring) and further described in the footnotes to Table C.

- A modified D-1641, Figure 4, based on geographical information in the proposed D-1641, Table 6. (Separate JPEG file (1.6 MB); for a very low-quality version, see Figure B).

In the current D-1641, Table 5, discrete and continuous monitoring at 11 stations is carried out at nearby rather than identical locations (C3, C7, C9, D6, D10, D12, D22, D24, D28A, P8, and S42). In the proposed modified Table 5, we would list these sites as separate stations within "station pairs." We would add "A" or "B" to the station identification number of one of the two stations in each station pair (generally to the more recently established station). Benthos monitoring has historically been conducted along cross-channel transects with stations identified by the addition of "-L" (for locations near the left channel bank) or "-R" (for right channel bank). We would use these historical station identifiers for two baseline stations where only benthos monitoring is conducted (D24-L, C9-R). The separated stations would be identified as compliance, baseline, or compliance and baseline monitoring stations depending on the type of monitoring performed. The modification of station designations would not affect compliance monitoring, but would clarify station identity. We also propose the addition of a Table 6 to provide the geographical coordinates of each station and a modified Figure 4 to more accurately show station locations based on these coordinates.

If approved and successfully implemented, these modifications would begin the process of improving the EMP monitoring network to better meet program goals and objectives while not overcommitting the program in the face of the current poor funding situation and the ongoing State hiring freeze. The proposed station consolidations are intended to improve monitoring element consistency among stations and optimize monitoring efficiency, thus helping to balance the costs of the additional monitoring efforts described above. Based on data analyses and considerations described in section III, consolidation of station pairs C3/C3A and C10/C10A can proceed without compromising long-term data continuity. To evaluate the potential for consolidation of ten additional continuous and discrete station pairs (Figure A and Tables C, E, and F), we propose to conduct data comparability studies at these locations (Table B) over the next three years. If these studies show that stations can be consolidated, discrete water

quality, phytoplankton, and, at the most upstream stations, zooplankton samples (using a pump) could eventually be taken during routine continuous instrumentation maintenance. This would decrease vessel use and lower costs associated with boat operations. The USBR is currently retrofitting a new research vessel with two davits, which will allow combining benthos and zooplankton sampling runs to further reduce boat operations costs. We also intend to further explore and ultimately reduce redundancies with other monitoring programs for additional cost savings. Final recommendations about additional D-1641 station consolidations and potential discontinuations would be included in the next triennial SWRCB review report due in 2005. This report would also contain final recommendations for modifications of individual monitoring elements based on the results of studies carried out in 2003 and 2004 (Table B). If approved by the SWRCB, these recommended changes could then be implemented in years 4 (2006) and 5 (2007) of the 2003-2007 IEP review cycle (Table A).

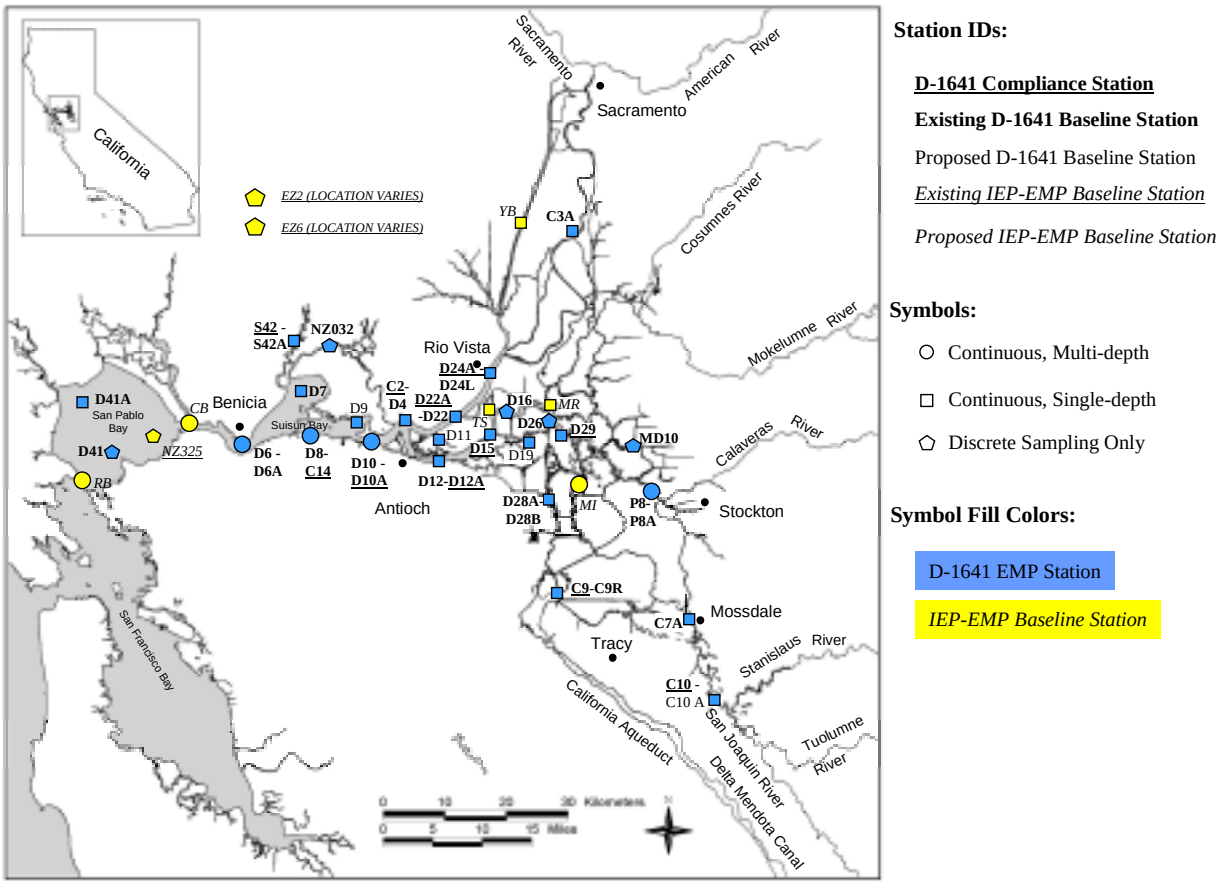
Program reviewers recommended continued monitoring at the four non-mandated EMP stations and the incorporation of five additional stations (Tables D - F: MI, TS, MR, CB, RB) with a total of 10 monitoring elements to complete the recommended EMP station network (Figure A) of "flux" and "ambient" stations (see Section III, Figure 11). Because of the prevailing financial constraints, we propose to maintain or establish these stations as non-mandated IEP program elements, funding permitting. In addition we propose to evaluate a recommended shift of continuous monitoring at "Suisun Bay @ Martinez" (D6A) to a center channel location (Benicia Bridge) to avoid known shore biases at this location. Funding and instrumentation for a vertical, center channel "continuous recorder" array has already been secured. We also intend to explore expansion of the current "continuous recorder" compliance monitoring station D29 to a central Delta multi-parameter compliance and baseline monitoring station. Incorporation of the recommended monitoring at these stations into D-1641-mandated monitoring would be reconsidered during the next triennial SWRCB review in 2005.

The proposed program also contains a prioritized series of recommended special studies to be conducted in parallel with, and in some cases prior to, the proposed monitoring activities (Table B). These special studies are intended to address unresolved questions about appropriate spatial and temporal sampling design, field and laboratory

procedures, and long-term patterns and trends in all measured variables. Due to financial and legal considerations, these studies would not be part of the D-1641 mandated monitoring program and could be funded and carried out independently. Smaller special studies such as equipment tests and quality assurance studies would be carried out with EMP funding and according to the EMP guidelines for special studies in Appendix 2. More substantial special studies may require additional funding which would be obtained through competitive proposal processes.

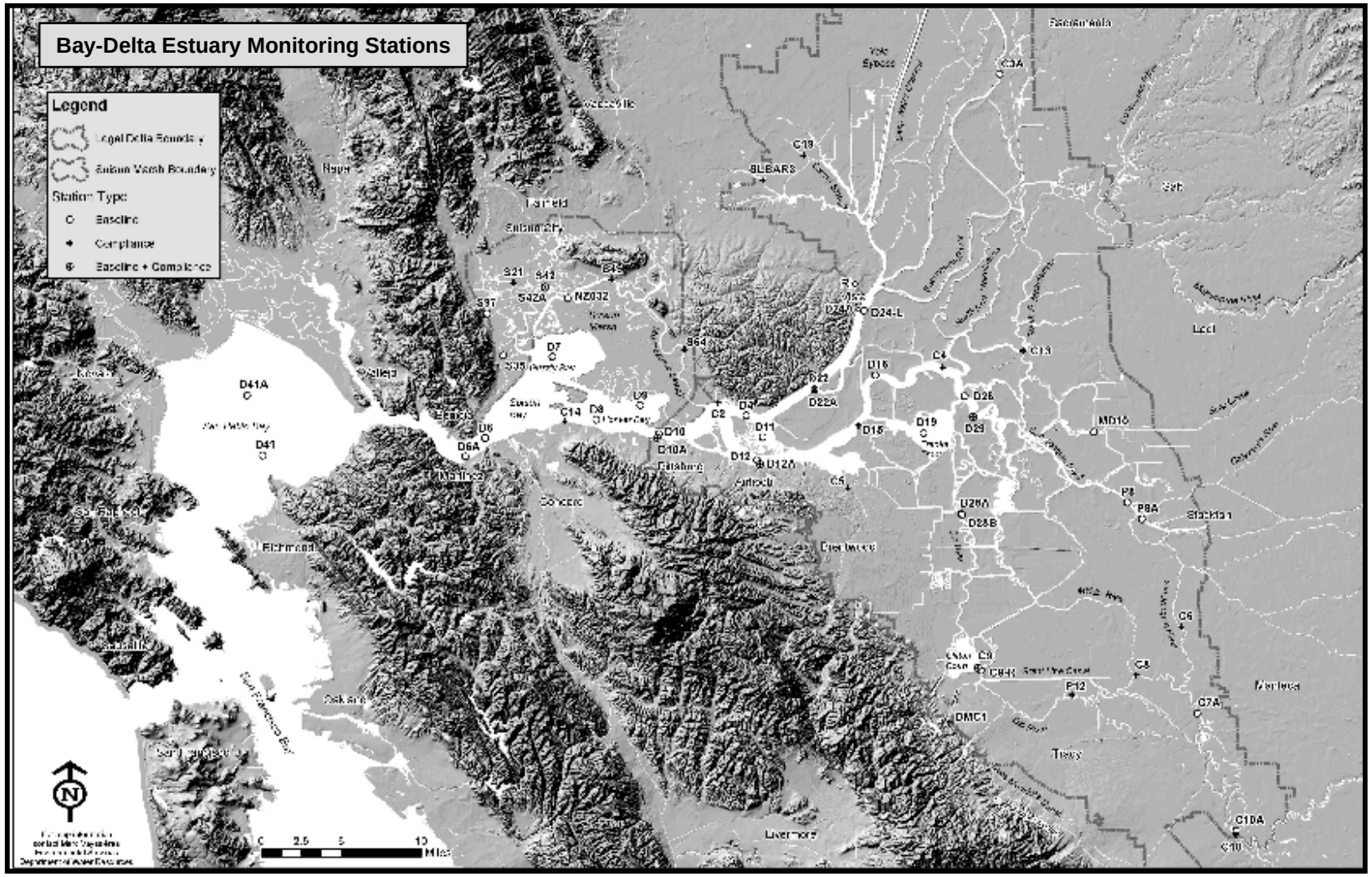
EMP staff would document all implementation efforts and regularly update all interested parties about implementation progress and challenges through its web site (http://iep.water.ca.gov/emp/), in its annual status and trends summary report to the SWRCB, via the IEP newsletter, and at IEP PWT meetings, IEP forum meetings, and the annual IEP meeting in Asilomar, as appropriate. In particular, EMP staff would communicate regularly with the IEP SAG and Management Team. Recommended activities not implemented after five years would be reconsidered for the next IEP and SWRCB review cycles.

Figure A. Proposed EMP station network.



D1641 EMP Stations (blue symbol fill color): EMP compliance and baseline stations in the proposed modified D-1641 Table 5 (see Table A). IEP-EMP Baseline Stations (yellow symbol fill color): Proposed EMP baseline stations not mandated in D-1641 (see Table B). Station pairs (e.g. D10-D10A): Neighboring stations located at a distance of no more than 2 miles from each other and proposed for consolidation or analytical integration. Continuous Stations: Continuous measurement of important variables complemented in most cases by discrete monitoring of additional variables. Multi-Depth: Vertical arrays of continuously recording probes at two or more depths. Single-Depth: Continuously recording probes at 1-m depth below the water surface. Discrete Sampling Only: Stations without continuous recording instrumentation. Please note that Tables A-D also list D-1641 stations that are not part of the proposed EMP station network. These stations are operated by other agency groups as indicated in Table C.

Figure B. Proposed revised Figure 4 (D-1641, p.194)



Please note: This is a very low-resolution representation of the proposed Figure 4 prepared by EMP staff based on the geographical station coordinates in Table G. A higher quality image is provided as a separate JPEG file (1.6 MB).

Table A: Prioritized Monitoring Activities during the 2003-2005 SWRCB and 2003-2007 IEP Review Cycles (Priority level resets each year)

Priority level	Monitoring Activity	Justification	Staff Need	Other Resource Needs	Implementation start date (year) or period
N/A in progress	Improved EMP data and information management and reporting	Fulfills program objectives 6 and 7, and provides the basis for fulfilling all other program objectives	30% of one ES IV, 50% of one ES III, 15% of one WREA and two ES I	Dedicated server, consultant time for software development and web based reporting tools, GIS and spatial analysis software	Started 2001, ongoing task
N/A in progress	Initiate establishment of Conductivity-Temperature (CT) twin sensors at proposed new Continuous Recorder Stations and the center-channel Benicia Bridge location, and work with USBR, DWR-CD, DWR-SMP, and USGS on joint station collaboration and coordination	The increased emphasis on continuous monitoring better accounts for temporal and spatial variability in salinity and water temperature at all time scales.	100% of two CST I/II and 50% of one boat operator during station installation (six months) 25% of one CST I/II and one boat operator for stations maintenance	CT sampling equipment and associated hardware (already purchased). Dedicated boat, foul weather gear (CT sensors for vertical array at D6/40A (Benicia Bridge) have already been purchased.)	Started in 2002 (continue in Years 1 - 2)
1	Replace annual data report with web-based reporting tools and "status and trends" summary report to SWRCB & in IEP newsletter. For 2002, submit reports in both old and new formats to ease transition and test new format.	Value of the monitoring program is greatly increased if timely information is made available to the broadest audience	50% of one ES III, 25% of three ES I/II year-around	Consultant time for software development and web based reporting tools, GIS and spatial analysis software	Year one (2003) (continue indefinitely as routine part of EMP)
2	Begin discrete sampling on alternating spring/neap tides	Reduces biases associated with variability arising from the spring-neap cycle	No additional staff is needed, but field work may be increased by an undetermined amount due to some loss in sampling flexibility	None	Year one (2003) (continue indefinitely as routine part of EMP)
3	Implement quarterly instead of monthly benthos sampling during two-year study period; Dedicate section staff to benthic ecology research and reporting; keep more informative field notebook Return to more frequent sampling in year 3.	Frees up staff and resources for urgently needed benthos special studies; generates greater staff expertise; suitability of current design unclear due to lack of appropriate data (esp. need higher spatial resolution data!)	None	None	Years one and two (2003-2004)
4	Initiate station consolidation at C3/C3A and (as soon as C10A has been built) at C10/C10A according to Table F. Ensure data continuity for all variables through side-by-side discrete sampling for one year, then discontinue sampling at historical discrete stations C3 and C10. Reinstate historical zooplankton sampling at C3A (pump).	The continuous data stream is considered superior to discrete monitoring of basic water quality conditions, and concomitant discrete sampling of additional variables would be beneficial. Staff and resource savings from combining discrete and continuous sites will be applied to other areas within the program.	No additional staff needed. Some training of CST I/II staff maintaining continuous sites to ensure proper collection and storage of discrete samples.	Zooplankton pump sampling equipment.	Years one and 2 (2003-2004)
5	Initiate year-round operation of station D29 (instead of seasonal). Procure funding for expansion to central Delta multi-parameter station, and implement as soon as possible. Initiate discrete WQ, phyto-, and zooplankton sampling. Compare data with data from D26 and D16.	Important central Delta location. Year-around operation of this station could also obviate the need for discrete monitoring stations D26 and D16 if data comparability is sufficient, allowing reallocation of staff and resources to other efforts.	Somewhat expanded continuous station maintenance effort for year-round CR operation. 20% of Sr. CSE for planning and permitting associated with establishment of a new multiparameter station house.	Multiparameter station: Depending on siting of new station house $50,000 - $75,000 may be required for construction of a new station.	Year one (2003); expand station in year 3-5 if funding is available
1	Initiate modification of discrete monitoring elements according to Table F. Add a near-bottom dissolved oxygen and temperature sensor at station P8.	Better spatial coverage and sampling of under-represented habitat types, better integration of monitoring components, quality control for continuously monitored constituents	Depending on exact implementation, we expect a 30% increase in staff field time. Assuming two staff, this would equate to 6 staff days per month.	Some sample storage or collection equipment may be required to deal with sample collection and transit.	Year two (2004) (continue in Years 3 and 4)

(continued)

Table A, continued

Priority level	Monitoring Activity	Justification	Staff Need	Other Resource Needs	Implementation start date (year) or period
2	Start reporting constituent fluxes at flux stations with available flow data, and phytoplankton primary productivity estimates (using K_d/TSS/turbidity and chl. *a*).	Informative data used for food web and hydrodynamic modeling, productivity budgets, etc.	No additional staff needed.	None	Year two (2004) (continue indefinitely as routine part of EMP)
3	Start changing sampling and analytical procedures based on outcomes of special studies	Methods may have to be adjusted to include state-of-the-art procedures and instrumentation to assure highest-quality data and information	Depends on outcome of special studies	Possibly new instrumentation	Year two (2004) (continue in Years 3 - 5)
1	Evaluate EMP revisions and consider adjustments to revisions and implementation schedule in triennial SWRCB review report due December 2005	First formal reality check - Implementation of numerous changes to a multifaceted program is difficult. Adjustments will need to occur along the way. Triennial review is required in D-1641, Condition 11 e.	No additional staff needed.	None.	Year three (2005)
2	Reconsider benthos monitoring design based on insights from year 1 – 2 special studies, reinstate more frequent benthos monitoring. Start routinely measuring benthos biomass according to outcome of special study.	Benthos monitoring reduced in Yeasr 1 & 2, needs to be reestablished. Propose modified design in 2005 triennial review report to SWRCB	10% time of two ES and two supervisors for over one year.	None	Year three (2005) and following years.
3	Increase focus on adding to and updating EMP Metadata files (including "BioGuide" files, if special study to initiate this effort is funded)	Reference information, QA/QC	30% ESI or II, with help from SciAide	None	Year three (2005) (continue indefinitely as routine part of EMP)
4	With funding in place, modify continuous monitoring station D29 from seasonal to year-around operation	s. year 1	20% of Sr. CSE for establishing new station. 5% of CST I/II year-around for station maintenance	s. year 1	Year three (2005)
1	Continue ongoing monitoring efforts from Years 1-3, and evaluate allocation of staff effort to revised EMP and consider adjustments to implementation schedule to ensure a balance between field work, data management, and data analysis and reporting	Continued implementation with ongoing reality check.	20% time of two ES and two supervisors for over one year.	None	Year four (2006) (continue in Year 5)
2	Start implementing monitoring activities recommended in 2005 triennial review report to the SWRCB, if approved. They may include additional station consolidations, additions, and discontinuations.	Further program improvements based on monitoring and special studies results from Years 1-3.	To be determined.	To be determined.	Year four (2006) (continue in Year 5)
1	Initiate next IEP EMP review cycle	Compliance with regular IEP review cycles.	20% time of two ES and two supervisors for over one year.	None	Year five (2007)

Table B: Prioritized Special Studies during the 2003-2007 IEP Review Cycle (Priority level resets each year)

Priority level	Special Study	Justification	Staff Need	Other Resource Needs	Implementation start date (year) or period
N/A in progress	Phytoplankton monitoring procedures	Long-term continuity and QA/QC of monitoring data (discrete and continuous chlorophyll *a*, phytoplankton composition & abundance), concerns about current methods, QA/QC, interest in related measures (primary productivity, C:Chl. *a* ratios, etc.)	Two ES 15%, one ESA, 15%, one SciAide, 30%, 3 years	Historical data, contract with USGS phytoplankton consultant (in place), access to lab, instruments, boat, some supplies (filters, etc.)	Started in 2001, ongoing through 2004
N/A in progress	Zooplankton monitoring procedures	Ongoing study to assure efficient and safe coordination with Bay study and overall sampling improvements	One ES 30%, 1 year (funded by IEP, extension pending)	Boat access, nets, etc.	Started in 2002, IEP funding, ongoing through 2004
1	Spatial and temporal design of EMP phytoplankton monitoring	Need a representative, efficient monitoring design for a highly complex system - Based on historical data and considering current station placement, what is the most appropriate spatial and temporal design for EMP phytoplankton monitoring?	One Staff ES 30%, 3 years	Collaboration with UCD; Advanced statistical skills & computer software (A. Jassby lead, approved CALFED funding)	Year one (likely start June 2003) (continue in Years two and three)
2	Spatially intensive benthos sampling in the Delta	Need higher resolution information about benthos variability across the Delta to better design benthos monitoring. Joint ("piggy-back") study with ongoing Calfed study by Jan Thompson, USGS.	2 ES, 20% for one year. Will use EMP funding freed up by reducing benthos monitoring from monthly to quarterly.	Collaboration with USGS; Glass storage vials, modification to benthic taxonomy contract	Year one (2003), Continue with more focussed studies, see below
3	Initiate a series of studies to determine the lateral or longitudinal variability of affected constituents in areas where station shifts and consolidations at continuous monitoring sites are proposed. Start with existing data and with shifts at Martinez (D6 and D6A versus center channel location), see Table F.	Before moving stations, comparability between the two sites needs to be established to ensure continuity of the valuable long-term data record. Predetermined standards to assess how well continuity can be assumed will be developed.	Two ES 15% per year and two Sci aids 100% time per year	CT sampling equipment and associated hardware for comparisons involving new continuous recorder stations. Dedicated boat, foul weather gear.	Year one (2003) (continue in Years two and three)
4	Initiate studies to test conceptual model for predicting spatial water quality patterns with data from the network of continuous monitoring sites located within tidal excursion ranges of each other	Need to find out more about the potential homogenizing influence of (large) tidal excursions on water quality, and the influence of "local" processes. Will use horizontal profiling with continuous instrumentation and discrete sampling along transect, possibly remote sensing	Two ES III or IV 15% per year and one Sci aid 100% time per year, collaboration with USGS	Access to boat, continuous recording instruments, lab, possibly remote sensing images	Year one (2003) (continue in Years two and three)
5	Initiate a series of special studies to evaluate procedural improvements following recommendations by the SATs and SAG during the EMP review	Methods may have to be adjusted to include state-of-the-art procedures to assure highest-quality data and information	Various field, lab and office staff	Filed and lab gear, possibly new instrumentation, collaboration with DWR Bryte lab	Year one (2003) (continue in Years two to four)
1	Benthos studies: Benthos Bio Guide (species descriptions), Benthos Biomass, and comprehensive long-term data analyses at long-term sites	Species descriptions and biomass are needed for comprehensive, process-oriented analyses. Comprehensive analysis and synthesis of existing data will provide information necessary to develop a more effective monitoring design	Several ES and collaborators, variable time. Additional study funding for 2004 requested from IEP.	Collaboration with experts; Glass storage vials, modification to benthic taxonomy contract	Year two (2004) (possibly apply for funding to continue these studies in Years two and three; or if funding rejected, apply again/elsewhere)

(continued)

Table B, continued

Priority level	Special Study	Justification	Staff Need	Other Resource Needs	Implementation start date (year) or period
2	Utility of Remote Sensing	Readily affordable and available satellite imagery could provide high-resolution spatial variability data for several constituents (temperature, suspended solids, phytoplankton (blooms), etc.) for a system wide (or synoptic) view of Bay-Delta water quality	Two ES and UCSC collaborator (Prof. Raphael Kudela). Vessel crew time. Total funding requested from IEP: $29,200.-:	Landsat TM scenes at $600 per scene, vessel access, software	Year two (2004) (possibly apply for funding to continue in Years two and three; or if funding rejected, apply again/elsewhere)
3	Initiate interagency (DWR, USBR, and USGS) review of upper estuary continuous monitoring network	Reduction of continuous monitoring network redundancy could generate substantial efficiencies among agency programs. Network integration could also result in more straightforward data reporting. Standard operating procedures will provide more comparable data.	One EPM I 10% and one Sr. CSE 20% for one year. Time for USBR and USGS staff is also needed.	None	Year two (2004)
4	Development of an analytical water clarity model linking water quality to remote sensing in the Bay-Delta	Light limits algal growth in the upper estuary and is a major cause for phytoplankton variability. This study investigates how to best monitor light and primary productivity related variables. Superficially addressed by remote sensing study, above, but more substantial study preferred: CALFED postdoctoral fellowship application by T. Swift, UCD, rejected - will be resubmitted for CALFED ERP funding.	Postdoc with expertise in physical limnology/oceanography; one ESIII, 20% (or GS12), one Sci Aid, full-time, plus field assistance, 3 years	Access to various radiometers, turbidimeters, particle (size) counter, electron microscope, etc., - may be done in collaboration with university researchers, CALFED funding	Year two (2004) (continue in Years three and four)
1	Focussed studies of benthic variability in various habitats and along spatial gradients.	Overlooking non-channel habitats and cross- or along-channel variability has been recognized as a shortcoming of the program; study results will contribute to improved benthos monitoring design and data analyses	ESIII lead staff to coordinate study, 30% time, and field crew, boat staff (10%), 3 years	Non-standard sampling gear, identification and enumeration of sample fauna, boat time for survey and sampling; possibly graduate student or postdoc	Year three (2005) (continue in Year four)
2	Special study to evaluate sampling bias associated with tidal phase aliasing – the “slow boat” effect	Sampling over changing tidal phases introduces a form of aliasing into the discrete data that should be accounted for. It may be that no boat is able to reach sampling stations in the delta at the same point on the tide due limitations in operating a vessel in public waters. However, a quantitative evaluation will at least allow documentation of the issue & help interpret historical EMP data.	Two boat operators and four ES for two field days each season over one year. 20% time of one ES to manage and analyze the resulting data.	Requires two existing boats and associated discrete sampling equipment.	Year three (2005)
3	Two-year, pilot monitoring of BOD, size-fractionated chlorophyll a, and continuous flow and in vivo chlorophyll a fluorescence, at stations C3 and C10.	Monitoring these constituents in a coordinated way may provide information that can improve our understanding of delta food web dynamics and how the foundation of the food web changes over time.	30% of two USGS techs. for 3 months to establish ADCP equipment at station 22. 20% of one CST I/II for two weeks to establish a fluorometer at station 9. 5% more staff time during discrete sample collection and for analysis.	Fluorometer, ADCP, maybe some additional lab costs for BOD sample analysis	Year three (2005) (continue in Year four, evaluate in year five)
1	Evaluate need for monitoring of non-algal aquatic producers through a comprehensive customer and monitoring program survey	Relevance of monitoring; Other groups could all be important producers, affected by flow, important resource effects (e.g. macrophytes as "ecosystem engineers"), hardly anything known about them in the Delta	ESIII, 10%, SciAide, 40%		Year four (2006)

Table C: Proposed modifications to EMP monitoring in D-1641, Table 5 (p. 192) with highlighted changes. Also indicated: Operators for D-1641 stations not operated by the IEP EMP.

Station ID[1]	Station Type[2]	Station Description[3]	Cont.Rec.[4]	Cont. Multi-para-meter[5]	Discrete Physical/ Chemical[6]	Discr. Phyto-plank-ton[7]	Discr. Zoo-plank-ton[8]	Dis-crete Ben-thos[9]
C2	C	Sacramento River @ Collinsville	USBR-CVO					
C3	B	Sacarmento River @ Greens Landing	USBR-CVO		(-)	(-)		
C3A	B	Sacramento River @ Hood		*	**X**	**X**	**X**	
C4	C	San Joaquin River @ San Andreas Landing	USBR-CVO					
C5	C	Contra Costa Canal @ Pumping Plant #1	USBR-CVO					
C6	C	San Joaquin River @ Brandt Bridge site	DWR-CD					
C7A	B	San Joaquin River @ Mossdale Bridge (near C7)		*				
C8	C	Old River near Middle River	USBR-CVO					
C9	**C&B**	Clifton Court Forebay Radial Gates		DWR-O&M	**X**	DWR-O&M	**X**	
C9-R	**B**	West Canal @ Mouth of CC Forebay Intake						*
C10	**C**	San Joaquin River near Vernalis	USBR-CVO		(-)	(-)		
C10A	**B**	**San Joaquin River near Vernalis @ San Joaquin River Club**		**X**	**X**	**X**	**X**	
C13	C	Mokelumne River @ Terminous	USBR-CVO					
C14	C	Sacramento River @ Port Chicago	USBR-CVO					
C19	C	Cache Slough @ City of Vallejo Intake	USBR-CVO					
D4	B	Sacramento River above Point Sacramento			*	*	*	*
D6	B	Suisun Bay @ Bull's Head Pt. near Martinez			*	*	*	*
D6A	B	Suisun Bay @ Martinez		*				
D7	B	Grizzly Bay @ Dolphin near Suisun Slough	**X**		*	*	*	*
D8	B	Suisun Bay off Middle Point near Nichols			*	*	*	
D9	**B**	**Honker Bay near Wheeler Point**	**X**		**X**	**X**		
D10	**B**	Sacramento River @ Chipps Island					*	
D10A	**C&B**	Sacramento River @ Mallard Island		*	**X**			
D11	**B**	**Sherman Lake near Antioch**	**X**		**X**	**X**		
D12	**B**	San Joaquin River @ Antioch Ship Channel					*	
D12A	**C&B**	San Joaquin River @ Antioch Water Works		*	**X**			
D15	C	San Joaquin River @ Jersey Point	USBR-CVO					
D16	B	San Joaquin River @ Twitchell Island					*	*
D19	**B**	**Franks Tract near Russo's Landing**	**X**		**X**	**X**	**X**	
D22A	**C&B**	Sacramento River @ Emmaton	USBR-CVO & DWR-CD					
D22	**B**	Sacramento River @ Emmaton (near D22)					*	
D24A	**C&B**	Sacramento River below Rio Vista Bridge		*	**X**			
D24-L	**B**	Sacramento River below Rio Vista Bridge, left bank						*
D26	B	San Joaquin River @ Potato Point			*	*	*	
D28A	B	Old River opposite Rancho Del Rio			DWR-CD	*	*	*
D28B	B	Old River at Bacon Island	DWR-CD					
D29	C&B	San Joaquin River @ Prisoners Point	*		**X**	**X**	**X**	
D41	B	San Pablo Bay near Pinole point			*	*	**X**	*
D41A	B	San Pablo Bay near the Mouth of the Petaluma River			**X**	**X**	**X**	*
DMC1	C&B	Delta-Mendota Canal @ Tracy Pump. Plt.		USBR-CVO				
P8	B	San Joaquin River @ Buckley Cove			*	*	*	*
P8A	B	**San Joaquin River @ Rough and Ready Island**		*				
P12	C	Old River @ Tracy Road Bridge	DWR-CD					

(continued)

Table C, continued

Station ID[1]	Station Type[2]	Station Description[3]	Cont.Rec.[4]	Cont. Multi-para-meter[5]	Discrete Physical/ Chemical[6]	Discr. Phyto-plank-ton[7]	Discr. Zoo-plank-ton[8]	Dis-crete Ben-thos[9]
MD10	B	Disappointment Slough near Bishop Cut			*	*	*	
S21	C	Chadbourne Slough @ Sunrise Duck Club	DWR-SMP					
S35	B	Goodyear Sl. @ Morrow Is. Clubhouse	DWR-SMP					
S42	**C&B**	Suisun Slough 300' south of Volanti Slough	DWR-SMP		**X**	**X**		
S42A	**B**	**Suisun Slough 300' south of Volanti Slough, center channel**					*	
S49	C	Montezuma Slough near Beldon Landing	DWR-SMP					
S64	C	Montezuma Slough @ National Steel	DWR-SMP					
S97	B	Cordelia Slough @ Ibis Club	DWR-SMP					
NZ032	B	Montezuma Slough, 2nd bend from mouth					*	
SLBAR3	C	Barker Sl. at No. Bay Aqueduct	DWR-O&M					
---	C	Sacramento R. (I St. Bridge to Freeport) (RSAC155)	USGS					
---	B	San Joaquin R. (Turner Cut to Stockton) (RSAN050-RSAN061)	?					
---	B	Water supply intakes for waterfowl management areas on Van Sickle Island and Chipps Island	?					

Symbols (IEP EMP):

*	No change from D-1641
X	**New**
(-)	Moved to neighboring station

Fill patterns & fonts:

No change
Ongoing, but not currently mandated monitoring
New monitoring
Reinstated historical monitoring
Moved to neighboring station
C&B monitoring[2] split between neighboring stations

Acronyms not explained in footnotes: see Table B

Footnotes:

1 Most stations use historical "interagency" station identification (ID) numbers as given in SWRCB D-1641 (2000) and D-1485 (1978). Modified station ID numbers (e.g. C3A) identify stations near historical stations. For geographical coordinates see Table 6.

2 C: Compliance monitoring station; B: Baseline monitoring station , C&B: Compliance and baseline monitoring station (letters replace symbols in D-1641, Table 5)

3 Most stations use historical "interagency" station descriptions as given in SWRCB D-1641 (2000) and D-1485 (1978). Stations with modified station ID numbers (e.g. D24A) also have modified names to indicate stations near historical stations with similar numbers and names.

4 Continuous recording (every 15 minutes) of water temperature, EC, and/or dissolved oxygen. For municipal and industrial intake chloride objectives, EC can be monitored and converted to chlorides. Acronyms: station operators for D-1641 stations not operated by the IEP EMP. In parentheses: in D-1485, but not in D-1641.

5 Continuous multi-parameter monitoring (recording every 1 to 15 minutes with telemetry capabilities) includes the following variables: water temperature, EC, pH, dissolved oxygen, turbidity, chlorophyll fluorescence, tidal elevation, and meteorological data (air temperature, wind speed and direction, solar radiation).

[6] Discrete physical/chemical monitoring is conducted near-monthly on alternating spring and neap tides and includes the following variables: macronutrients (inorganic forms of nitrogen, phosphorus, and silicon), total suspended solids, total dissolved solids, total, particulate and dissolved organic nitrogen and carbon, chlorophyll *a*, pH, dissolved oxygen (DO), electrical conductivity (EC (specific conductance)), turbidity, light attenuation, secchi depth, and water temperature. In addition, on-board continuous recording is conducted intermittently for the following variables: water temperature, dissolved oxygen, electrical conductivity, turbidity, and chlorophyll *a* fluorescence.

[7] Near-monthly discrete sampling on alternating spring and neap tides for phytoplankton enumeration or algal pigment analysis.

[8] Near-monthly tow or pump sampling for zooplankton, mysids, and amphipods.

[9] In 2003 and 2004, replicated benthos and sediment grab samples are taken quarterly (every three months) and during special studies events; more frequent monitoring sampling resumes in 2005.

Table D: Proposed IEP EMP baseline monitoring stations not mandated in D-1641.

Station ID[1]	Station Type[2]	Station Description[3]	Cont.Rec.[4]	Cont. Multi-para-meter[5]	Discrete Physical/ Chemical[6]	Discr. Phyto-plank-ton[7]	Discr. Zoo-plank-ton[8]	Dis-crete Ben-thos[9]
NZ325	B	San Pablo Bay near Rock Wall and Light 15					X	
EZ2	B	Entrapment Zone - Location determined when bottom EC values occur @ approximately 2000 us					X	
EZ6	B	Entrapment Zone - Location determined when bottom EC values occur @ approximately 6000 us					X	
YB	B	Yolo Bypass Toe Drain @ DWR screw trap site		X	**X**	**X**		
MI	**B**	**Mildred Island, southern basin**		**X**	**X**	**X**		
TS	B	Threemile Slough	**X (USGS-EMP)**					
MR	**B**	**Mokelumne River Mouth**	**X (USGS-EMP)**					
CB	B	Carquinez Bridge, center channel (north side of center pier)	USGS					
RB	**B**	**Richmond Bridge, center channel**	**X (USGS-EMP)**					

For symbols, fill patterns, and footnotes see Table A.

Acronyms: (Apply to all Tables)

ID:	Station Identification (instead of "station number")
CR:	Continuous Recorder monitoring, s. footnote 4
MP:	Continuous Multi-Parameter monitoring, s. footnote 5
P/C:	Discrete physical/chemical monitoring, s. footnote 6
P:	Phytoplankton monitoring, s. footnote 7
Z:	Zooplankton monitoring, s. footnote 8
B:	Benthos monitoring, s. footnote 9
DWR-CD:	Monitoring by DWR-Central District
DWR-O&M:	Monitoring by DWR-Division of Operations and Maintenance
DWR-SMP:	Monitoring by DWR-Suisun Marsh Program
DWR-MWQI:	Monitoring by DWR-Municipal Water Quality Investigations Program
NERR:	National Estuarine Research Reserve
USBR-CVO	Monitoring by US Bureau of Reclamation-Central Valley Operations
USGS:	Monitoring by US Geological Survey
USGS-NRP:	Monitoring by USGS National Research Program (Menlo Park)
RMP:	Monitoring by the Regional Monitoring Program of the San Francisco Estuary Institute

Table E: Station information summary for proposed EMP stations and for D-1641 stations operated by other programs.

Station ID[1]	Station Type[2]	Station Description[3]	Is this a shore or vessel-based station?[4]	Other monitoring[5]	Does agency flow (F) and/or stage (S) monitoring exist?[6]	Is this a primary or secondary EMP station ?[7]	Analyti-cally link this station with[8]	Move(d) from Station (year)[8]	Study relocatio n to this primary station[8]	Primary EMP station: flux or ambient?[9]	Primary EMP station: Physical Region[10]	Primary EMP station: Lehman Region[11]	Primary EMP station: Jassby Region[12]	Primary EMP station: Habitat Type[13]
C2	C	Sacramento River @ Collinsville	Shore	USBR		Primary	D4			Ambient	S	LS	SB	TRC
C3A	B	Sacramento River @ Hood	Shore	USBR, DWR-MWQI, USGS	USGS (F) At Freeport: USGS (F&S)	Primary		C3 (MP: 1998, all: 2004)		Flux	S	ND	S	TRC
C4	C	San Joaquin River @ San Andreas Landing	Shore	USBR										
C5	C	Contra Costa Canal @ Pumping Plant #1	Shore	USBR										
C6	C	San Joaquin River @ Brandt Bridge site	Shore	DWR-CD	DWR-CD (S)									
C7A	B	San Joaquin River @ Mossdale Bridge (near C7)	Shore		(S)	Secondary		C7 (1984)	C10A					
C8	C	Old River near Middle River	Shore	DWR-CD										
C9	C	Clifton Court Forebay Radial Gates	Shore	DWR-O&M, DWR-MWQI at Banks P.P.	DWR-O&M (F&S)	Primary	C9A			Flux	SD	SD	D	TRC
C9A	B	West Canal @ Mouth of CC Forebay Intake	Vessel			Secondary	C9		C9					
C10	C	San Joaquin River near Vernalis	Shore (Bridge)	USBR, USGS			C10A							
C10A	B	San Joaquin River near Vernalis @ San Joaquin River Club	Shore	USGS, DWR-MWQI	USGS (F&S)	Primary		C10 (2003)		Flux	SD	SD	SJ	TRC
C13	C	Mokelumne River @ Terminous	Shore	USBR										
C14	C	Sacramento River @ Port Chicago	Shore	USBR		Primary	D8			Ambient	Cell	SB	SB	ESC
C19	C	Cache Slough @ City of Vallejo Intake	Shore	USBR										
D4	B	Sacramento River above Point Sacramento	Vessel	USBR, USGS-NRP, RMP		Secondary	C2		C2					

(continued)

Table E, continued

Station ID[1]	Station Type[2]	Station Description[3]	Is this a shore or vessel-based station?[4]	Other monitoring[5]	Does agency flow (F) and/or stage (S) monitoring exist?[6]	Is this a primary or secondary EMP station ?[7]	Analyti-cally link this station with[8]	Move(d) from Station (year)[8]	Study relocation to this primary station[8]	Primary EMP station: flux or ambient?[9]	Primary EMP station: Physical Region[10]	Primary EMP station: Lehman Region[11]	Primary EMP station: Jassby Region[12]	Primary EMP station: Habitat Type[13]
D6	B	Suisun Bay @ Bull's Head Pt. near Martinez	Vessel	USGS-NRP		Secondary	D6A		D6B (200?, center channel)					
D6A	B	Suisun Bay @ Martinez	Shore	USGS	EMP (S)	Primary	D6	D6 (1983)	D6B (200?, center channel)	Flux	Sill			ESC
D7	B	Grizzly Bay @ Dolphin near Suisun Slough	Vessel	RMP		Primary				Ambient		SB	SB	EE
D8	B	Suisun Bay off Middle Point near Nichols	Vessel	USBR, USGS-NRP		Secondary	C14		C14					
D9	B	Honker Bay near Wheeler Point	Vessel	RMP		Primary				Ambient		SB	SB	EE
D10	B	Sacramento River @ Chipps Island	Vessel	USGS-NRP		Secondary	D10A							
D10A	C	Sacramento River @ Mallard Island	Shore	USGS, RMP		Primary	D10	D10 (1984)		Flux	CF	SB	SB	EE
D11	B	Sherman Lake near Antioch	Vessel	RMP		Primary				Ambient	CF	WD	UA	FI
D12	B	San Joaquin River @ Antioch Ship Channel	Vessel	RMP		Secondary	D12A							
D12A	C	San Joaquin River @ Antioch Water Works	Shore	DWR-CD, USBR	EMP (S)	Primary	D12	D12 (1984)		Ambient	CF	WD	UA	TRC
D15	C	San Joaquin River @ Jersey Point	Shore	USBR	USGS (F&S)	Primary				Flux	WD			TRC
D16	B	San Joaquin River @ Twitchell Island	Vessel			Primary	D15, D29			Ambient	CD	CD	CD	TRC
D19	B	Franks Tract near Russo's Landing	Vessel	USBR		Primary				Ambient	WD	LSJ	D	FI
D22	C	Sacramento River @ Emmaton	Shore	USBR		Primary	D22A			Ambient	S	LS	S	TRC

(continued)

Table E, continued

Station ID[1]	Station Type[2]	Station Description[3]	Is this a shore or vessel-based station?[4]	Other monitoring[5]	Does agency flow (F) and/or stage (S) monitoring exist?[6]	Is this a primary or secondary EMP station ?[7]	Analyti-cally link this station with[8]	Move(d) from Station (year)[8]	Study relocatio n to this primary station[8]	Primary EMP station: flux or ambient?[9]	Primary EMP station: Physical Region[10]	Primary EMP station: Lehman Region[11]	Primary EMP station: Jassby Region[12]	Primary EMP station: Habitat Type[13]
D22A	B	Sacramento River @ Emmaton (near D22)	Vessel			Secondary	D22		D24					
D24	C&B	Sacramento River below Rio Vista Bridge	Shore	USGS, USBR	USGS (F&S)	Primary	D24A			Flux	S	LS	S	TRC
D24A	B	Sacramento River below Rio Vista Bridge, center channel	Vessel	USGS-NRP		Secondary	D24							
D26	B	San Joaquin River @ Potato Point	Vessel			Primary	D16, D29		D29	Ambient	CD	CD	CD	TRC
D28A	B	Old River opposite Rancho Del Rio	Vessel			Secondary	D28B							
D28B	B	Old River at Bacon Island	Shore	DWR-CD	USGS (F&S)	Primary	D28A			Flux	SD	CD	D	TRC
D29	C	San Joaquin River @ Prisoner's Point	Shore		Missing!	Primary	D16, D26			Flux	CD			TRC
D41	B	San Pablo Bay near Pinole point	Vessel	RMP, IEP Bay-Study, USGS		Primary				Ambient	Sill	SPB		BS
D41A	B	San Pablo Bay near the Mouth of the Petaluma River	Vessel	RMP, IEP Bay-Study, USGS		Primary	(USGS CR at channel marker 9)			Ambient		SPB		BS
DMC1	C&B	Delta-Mendota Canal @ Tracy Pump. Plt.	Shore											
P8	B	San Joaquin River @ Buckley Cove	Vessel			Secondary	P8A		P8A					
P8A	B	San Joaquin River @ Rough and Ready Island	Shore	City of Stockton, DWR-CD		Primary	P8	P8 (1983)		Ambient	SD	SD	SJ	TRC
P12	C	Old River @ Tracy Road Bridge	Shore											
MD10	B	Disappointment Slough near Bishop Cut	Vessel			Primary				Ambient	CD	ED	UA	TRC
S21	C	Chadbourne Slough @ Sunrise Duck Club	Shore	DWR-SMP										

(continued)

Table E, continued

Station ID[1]	Station Type[2]	Station Description[3]	Is this a shore or vessel-based station?[4]	Other monitoring[5]	Does agency flow (F) and/or stage (S) monitoring exist?[6]	Is this a primary or secondary EMP station ?[7]	Analyti-cally link this station with[8]	Move(d) from Station (year)[8]	Study relocatio n to this primary station[8]	Primary EMP station: flux or ambient?[9]	Primary EMP station: Physical Region[10]	Primary EMP station: Lehman Region[11]	Primary EMP station: Jassby Region[12]	Primary EMP station: Habitat Type[13]
S35	B	Goodyear Sl. @ Morrow Is. Clubhouse	Shore	DWR-SMP										
S42	C	Suisun Slough 300' south of Volanti Slough	Shore	DWR-SMP, NERR (planned)	DWR-SM (S)	Primary	S42A			Ambient				TMC
S42A	B	Suisun Slough 300' south of Volanti Slough, center channel	Vessel			Secondary								
S49	C	Montezuma Slough near Beldon Landing	Shore	DWR-SMP										
S64	C	Montezuma Slough @ National Steel	Shore	DWR-SMP										
S97	B	Cordelia Slough @ Ibis Club	Shore	DWR-SMP										
NZ032	B	Montezuma Slough, 2nd bend from mouth	Shore & Vessel	DWR-SMP	DWR-SM (S)	Primary	S42, S54			Ambient				TMC
---	C	Sacramento R. (I St. Bridge to Freeport) (RSAC155)												
---	B	San Joaquin R. (Turner Cut to Stockton)												
---	C	Barker Sl. at No. Bay Aqueduct (SLBAR3)												
---	B	Water supply intakes for waterfowl management areas on Van Sickle Island and Chipps Island												
NZ325	B	San Pablo Bay near Rock Wall and Light 15	Vessel	RMP		Primary				Ambient				BC

(continued)

Table E, continued

Station ID[1]	Station Type[2]	Station Description[3]	Is this a shore or vessel-based station?[4]	Other monitoring[5]	Does agency flow (F) and/or stage (S) monitoring exist?[6]	Is this a primary or secondary EMP station ?[7]	Analyti-cally link this station with[8]	Move(d) from Station (year)[8]	Study relocatio n to this primary station[8]	Primary EMP station: flux or ambient?[9]	Primary EMP station: Physical Region[10]	Primary EMP station: Lehman Region[11]	Primary EMP station: Jassby Region[12]	Primary EMP station: Habitat Type[13]
EZ2	B	Entrapment Zone - Location determined when bottom EC values occur @ approximately 2000 us	Vessel	USGS-NRP		Primary				Ambient				BC
EZ6	B	Entrapment Zone - Location determined when bottom EC values occur @ approx. 6000 us	Vessel	USGS-NRP		Primary				Ambient				BC
YB	B	Yolo Bypass Toe Drain @ DWR screw trap site	Shore	DWR-DES IEP studies section	DWR-O&M (S at Lisbon)	Primary				Ambient	S			FPD
MI	B	Mildred Island, southern basin	Vessel			Primary				Ambient	CD			FI
TS	B	Threemile Slough	Shore	USGS	USGS (F&S)	Primary				Flux	S			TRC
MR	B	Mokelumne River Mouth	Shore		Missing!	Primary				Flux	CD	(CS)		ESC
CB	B	Carquinez Bridge, center channel	Shore		Missing!	Primary				Flux	Cell	(NB)		BC
RB	B	Richmond Bridge, center channel	Shore		Missing!	Primary				Flux	Cell	(SFB)		BC

Footnotes for Table E, see next page. For agency acronyms, see Table D.

Footnotes for Table E:

[1] Most stations use historical "interagency" station identification (ID) numbers as given in SWRCB D-1641 (2000) and D-1485 (1978). Modified station ID numbers (e.g. C3A) identify stations near historical stations. Bold type: part of the proposed EMP station network.

[2] C: Compliance monitoring station; B: Baseline monitoring station , C&B: Compliance and baseline monitoring station

[3] Most stations use historical "interagency" station descriptions as given in SWRCB D-1641 (2000) and D-1485 (1978). Stations with modified station ID numbers (e.g. D24A) also have modified names to indicate stations near historical stations with similar numbers and names.

[4] This is important for monitoring logistics and costs. Continuous monitoring is more readily accomplished from shore and shore-based monitoring may be less costly. It may also indicate how well monitoring results represent local and regional environmental conditions. Vessel-based monitoring usually occurs at a greater distance from shore and may often yield more representative data than shore-based monitoring.

[5] Monitoring by other programs at or in close proximity of EMP stations. For acronyms, see Table D.

[6] The EMP does not monitor flow. Flow monitoring is, however, very important for flux calculations, especially at the designated "flux stations," see footnote 6. We thus propose to more closely collaborate with agencies conducting flow (and stage) monitoring to obtain flow data and help fill gaps in the current flow monitoring network.

[7] Primary EMP stations have continuous monitoring components (reflecting proposed new program emphasis on continuous monitoring) and/or the EMP is the only monitoring program conducting environmental baseline monitoring at these sites. Secondary EMP stations are discrete monitoring stations linked to primary (continuous) sister stations and many may eventually be consolidated with (*i.e.* moved to) the primary stations, if studies show that this will not compromise long-term data continuity.

[8] For improved monitoring efficiency and products, we propose to more closely link continuous and discrete stations and in some cases consolidate stations at the continuous site. These three columns show station integration (links) and proposed future station relocation (moves). We also indicate which continuous monitoring stations have been previously installed in a different location (*i.e.,* moved) than the historical discrete station whose station name they still bear in D-1641, Table 5, with the year of the historical move given in parenthesis.

[9] Ambient stations: track conditions within regions of interest; Flux stations: track conditions and, in association with flow monitoring, mass fluxes across the estuary.

[10] Regions delineated based on geometry, regional scale hydrodynamic transport processes, and hydrologic influences. S: Sacramento River; CF: Confluence region, WD: Western Delta; CD: Central Delta; SD: South Delta; Sill: shallow area in western estuary; Cell: deeper area between sills in western estuary.

[11] Regions according to individual and combined "crisp" hierarchical cluster analysis of monthly data for 14 water quality variables (s. CDWR 1996 and Lehman and Smith 1991 and similar in Jassby and Cloern 2000). Not all stations shown were considered in these analyses. ND: Northern Delta; WD: Western Delta; LSJ: Lower San Joaquin River; LS: Lower Sacramento River; SD: Southern Delta; ED: Eastern Delta; CD: Central Delta; SB: Suisun Bay; SPB: San Pablo Bay. See also Figure 5

[12] Regions based on a "fuzzy" clustering algorithm applied to EMP chlorophyll a data by Alan Jassby (UCD, 2001). SB: Suisun Bay; S: Sacramento; D: Delta; SJ: San Joaquin; UA: unassigned group membership

[13] Regions (habitats) according to ecologically important physical and chemical habitat characteristics. FPD: Floodplain Drain, 2) FI: Flooded Island (shallow lake), TRC: Tidal River Channel, TMS: Tidal Marsh Slough, ESC: Estuarine Channel, EE: Estuarine Embayment, BC: Bay Channel, BS: Bay shoal.

Table F: Modification description, justification, and future goals for all proposed D-1641 and IEP EMP stations and revised footnotes for D-1641, Table 5.

Modified Table 5: (Symbols: *:no change; x: added, (-): moved to neighboring station) **Explanations:**

Station ID[1]	Station Type[2]	Station Description[3]	Cont. Rec.[4] (CR)	Cont. Multi-para-meter[5] (MP)	Discrete Physical/ Chemical[6] (P/C)	Discr. Phyto-plank-ton[7] (P)	Discr. Zoo-plank-ton[8] (Z)	Dis-crete Ben-thos[9] (B)	Modification description	Justification and outlook
C2	C	Sacramento River @ Collinsville	*						No operational change, but analytical integration of this compliance station with baseline station D4. See also D 4. Obtain funding for multi-depth CR array by the end of the 2003-2005 review cycle	Better integration of existing continuous compliance and discrete baseline stations for improved monitoring products and efficiency. Multi-depth CR array for characterization of vertical temperature and salinity stratification at this deep station. This is important for understanding ecological and hydrodynamic transport processes and for meaningful numerical modeling.
C3	B	Sacramento River @ Greens Landing			(-)	(-)			See C3A.	See C3A.
C3A	B	Sacramento River @ Hood		*	*	*	X		Discrete P/C & P sampling moved from historical station C3 to the neighboring continuous MP station C3A at Hood. Data comparisons for several variables suggest close agreement between these two sites. However, to ensure data continuity for all variables, conduct side-by-side P/C & P sampling for one year, then discontinue discrete sampling at C3. New station ID and description to indicate different station location from historical station C3 (see proposed new Table 6 for coordinates). Reinstate historical C3 zooplankton sampling at C3A (pump).	Consolidation of existing discrete and continuous stations for improved monitoring products and efficiency. C3A is an important rim station for many monitoring programs. Important flux station (imports into the Delta from the Sacramento River watershed). C3A was established in 1998 near the historical station C3. Reinstated zooplankton sampling to monitor zooplankton entering the Delta from the north and for more comprehensive data analyses and interpretation. A separate special study may investigate cross-channel zooplankton variability to determine potential shore bias.
C4	C	San Joaquin River @ San Andreas Landing	*						No operational change.	
C5	C	Contra Costa Canal @ Pumping Plant #1	*						No operational change.	
C6	C	San Joaquin River @ Brandt Bridge site	*						No operational change.	

(continued)

Table F, continued

Station ID[1]	Station Type[2]	Station Description[3]	Cont. Rec.[4] (CR)	Cont. Multi-para-meter[5] (MP)	Discrete Physical/ Chemical[6] (P/C)	Discr. Phyto-plank-ton[7] (P)	Discr. Zoo-plank-ton[8] (Z)	Dis-crete Ben-thos[9] (B)	Modification description	Justification and outlook
C7A	B	San Joaquin River @ Mossdale Bridge		*					New station ID and description indicates different station location from historical station C7 (see proposed new Table 6 for coordinates). During the 2003-2005 review cycle, study data comparability with C10 and C10A (Vernalis) to assess if this station can be discontinued in favor of a new MP station at Vernalis (C10A).	C7A was established in 1984 near the historical van station C7. The proposed station ID has been used in annual data reports to the SWRCB and indicates a different location from the historical discrete baseline monitoring station C7. The multi-parameter station was established in 1984 near C7and completely replaced discrete monitoring at C7 in 1995. Vernalis is more important to most data users as a “rim station" and has a longer, more comprehensive data record. The MP data record at Mossdale is limited and not extensively used. Mossdale equipment could be used at Vernalis. A recommendation about station discontinuation will be included in the next triennial program review due in 2005.
C8	C	Middle River near Old River	*						No operational change.	
C9	C&B	Clifton Court Forebay @ Radial Gates		X	X	*	X		Formally (re-) adopt continous D-1485 compliance monitoring. Reinstatement of D-1485 discrete P/C sampling. Reinstatement of historical zooplankton (pump) monitoring. Separate station ID and description indicates different location from C9A, see proposed new Table 6 for coordinates.	CR monitoring was likely unintentionally excluded from C9 in D-1641, Table 5, since water quality objectives for Chloride and EC exist at the designated compliance and baseline station C9. Continuos multiparameter and phytoplankton monitoring is currently conducted by DWR O&M. Reinstatement of discrete P/C sampling for QA/QC of continuous measurements and to monitor exports of additional water quality variables. Reinstatement of zooplankton sampling to monitor exports through the water projects.
C9-R	B	West Canal @ Mouth of CC Forebay Intake						*	Analytical integration of existing, but not currently mandated, MP monitoring at C9 with D-1641 baseline benthos monitoring at C9-R, right channel bank. During the 2003-2005 review cycle, investigate if discrete benthos sampling at C9A can be moved to C9 without compromising long-term data continuity.	Better integration and potential consolidation of existing continuous and discrete baseline stations for improved monitoring products and efficiency. A recommendation about station consolidation will be included in the next triennial program review due in 2005. Important station near export pumps, flux station (exports).

(continued)

Table F, continued

Station ID[1]	Station Type[2]	Station Description[3]	Cont. Rec.[4] (CR)	Cont. Multi-para-meter[5] (MP)	Discrete Physical/ Chemical[6] (P/C)	Discr. Phyto-plank-ton[7] (P)	Discr. Zoo-plank-ton[8] (Z)	Dis-crete Ben-thos[9] (B)	Modification description	Justification and outlook
C10	C	San Joaquin River near Vernalis	X						Formally reinstate D-1485 CR compliance monitoring currently conducted by the USBR.	CR monitoring was likely unintentionally excluded from C10 in D-1641, Table 5, since water quality objectives for EC exist at the designated "compliance and baseline" station C10 and the USBR (CV Operations) has an active CR station at this site.
C10A	B	San Joaquin River near Vernalis @ San Joaquin River Club		X	*	*	X		After side-by-side P/C & P sampling for at least one year, discontinue discrete baseline sampling at historical station C10 and move it to the new Vernalis MP station C10A, slightly north of current C10 (see proposed new Table 6 for coordinates). Separate station ID and description indicates different location from C10. Add zooplankton sampling (pump).	C10 is a "rim station" with a long, comprehensive, highly utilized data record and an important flux station (imports) with high productivity. The new MP station at C10Ais supported by CALFED and will be used and operated by multiple agency groups. It provides a much safer work environment than the increasingly unsafe historical bridge location. It will be the southern counterpart of the Hood station (C3A) on the Sacramento River. Added zooplankton sampling to monitor zooplankton entering the Delta from the south and for more comprehensive data analyses and interpretation. A separate special study may investigate cross-channel zooplankton variability to determine potential shore bias.
C13	C	Mokelumne River @ Terminous	*						No operational change.	
C14	C	Sacramento River @ Port Chicago	*						No operational change. Analytical integration of continuous data from this compliance station with discrete data from baseline station D8. See D8 for details. Obtain funding for multi-depth CR array by the end of the 2003-2005 review cycle.	Better integration and potential consolidation of existing continuous compliance and discrete baseline stations for improved monitoring products and efficiency. Multi-depth CR array to characterize vertical temperature and salinity stratification at this deep "gravitational circulation cell" station. This is important for understanding ecological and hydrodynamic transport processes and for meaningful numerical modeling.

(continued)

Table F, continued

Station ID[1]	Station Type[2]	Station Description[3]	Cont. Rec.[4] (CR)	Cont. Multi-para-meter[5] (MP)	Discrete Physical/ Chemical[6] (P/C)	Discr. Phyto-plank-ton[7] (P)	Discr. Zoo-plank-ton[8] (Z)	Dis-crete Ben-thos[9] (B)	Modification description	Justification and outlook
C19	C	Cache Slough @ City of Vallejo Intake	*						No operational change.	
D4	B	Sacramento River above Point Sacramento			*	*	*	*	Analytical integration of discrete data from this baseline station with continuous data from compliance station C2. See also C2. During the 2003-2005 review cycle, investigate if discrete sampling at D4 can be moved to C2 without compromising long-term data continuity.	Better integration and potential consolidation of existing continuous compliance station C2 and discrete baseline station D4 at the C2 location for greater monitoring utility and efficiency. A recommendation about station consolidation will be included in the next triennial program review report due in 2005.
D6	B	Suisun Bay @ Bull's Head Pt. near Martinez		(-)	*	*	*	*	Separation of continuous MP monitoring from discrete monitoring at D6 to indicate different station locations, see D6A. Analytical integration of discrete data from this baseline station with continuous data from the neighboring, shore-based MP station D6A. Investigate consolidation with MP station D6A and best location for consolidated station for consideration during the next triennial review. See also D6A.	Better integration and potential consolidation of existing continuous and discrete baseline stations for improved monitoring products and efficiency. Important flux station (exports to San Francisco Bay). A recommendation about station consolidation will be included in the next triennial program review report due in 2005.
D6A	B	Suisun Bay @ Martinez		*					Separate new station ID and description indicates different location from D6, see proposed new Table 6 for coordinates. During the 2003-2005 review cycle, investigate if this continuous baseline monitoring station should be moved to a center channel location through side-by-side sampling and data comparisons. In addition, obtain funding for and test a multi-depth CR array by the end of the 2003-2005 review cycle.	Potential move to new center channel location to avoid shore bias and permit more representative sampling and better integration with USGS and NOAA continuous monitoring of salinity, suspended solids, and flow on Pier 7 of the Benicia Bridge north of the main ship channel. A recommendation about this potential location change and the routine operation of a multi-depth CR will be included in the next triennial program review report due in 2005. Important flux and sill station (exports to Bay) in the western estuary. Multi-depth CR array to characterize vertical temperature and salinity stratification. This is important for understanding ecological and hydrodynamic transport processes and for meaningful numerical modeling, including SWP & CVP operations forecasts.

(continued)

Table F, continued

Station ID[1]	Station Type[2]	Station Description[3]	Cont. Rec.[4] (CR)	Cont. Multi-para-meter[5] (MP)	Discrete Physical/ Chemical[6] (P/C)	Discr. Phyto-plank-ton[7] (P)	Discr. Zoo-plank-ton[8] (Z)	Dis-crete Ben-thos[9] (B)	Modification description	Justification and outlook
D7	B	Grizzly Bay @ Dolphin near Suisun Slough	X		*	*	*	*	New: moored continuous recorder for EC & Temperature	Long-term benthos station, ambient station representing shallow, open estuarine embayment habitat. Important site for monitoring of the invasive clam *Potamocorbula*
D8	B	Suisun Bay off Middle Point near Nichols			*	*	*		Analytical integration of discrete data from this baseline station with continuous data from compliance station C14. See also C14. During the 2003-2005 review cycle, investigate if discrete P/C & P sampling at D8 can be moved to C14 and zooplankton sampling to a channel site close to C14 without compromising long-term data continuity.	Better integration and potential consolidation of existing continuous compliance and discrete baseline stations for improved monitoring products and efficiency. A recommendation about station consolidation will be included in the next triennial program review report due in 2005. A separate special study may investigate cross-channel water quality and zooplankton variability to assist interpretation of integrated data analysis results.
D9	B	Honker Bay near Wheeler Point	X		X	X			Reinstated D-1485 P/C and P monitoring. New: continuous recorder for EC & Temperature.	Ambient station representing ecologically important shallow estuarine embayment habitat
D10	B	Sacramento River @ Chipps Island		(-)			*		Separation of continuous MP monitoring from discrete monitoring at D10 to indicate different station locations, see D10A for details. Improved analytical integration of discrete zooplankton data from this baseline station with continuous data from shore-based MP station D10A.	Better integration of existing continuous and discrete baseline stations for improved monitoring products and efficiency. A separate special study may investigate cross-channel water quality and zooplankton variability to assist interpretation of integrated data analysis results.
D10A	C&B	Sacramento River @ Mallard Island		*	X				Separate new station ID and description indicates different location from D10, see proposed new Table 6 for coordinates. Reinstatement of discrete D-1485 P/C sampling conducted during sensor maintenance. Obtain funding for multi-depth CR array by the end of the 2003-2005 review cycle.	Reinstatement of discrete P/C sampling for QA/QC of continuous measurements. Multi-depth CR array to characterize vertical temperature and salinity stratification. This is important for understanding ecological and hydrodynamic transport processes and for meaningful numerical modeling.

(continued)

Table F, continued

Station ID[1]	Station Type[2]	Station Description[3]	Cont. Rec.[4] (CR)	Cont. Multi-para-meter[5] (MP)	Discrete Physical/ Chemical[6] (P/C)	Discr. Phyto-plank-ton[7] (P)	Discr. Zoo-plank-ton[8] (Z)	Dis-crete Ben-thos[9] (B)	Modification description	Justification and outlook
D11	B	Sherman Lake near Antioch	X		X	X			Reinstated D-1485 P/C monitoring. New: phytoplankton monitoring and continuous recorder for EC & Temperature.	Ambient monitoring in flooded island (shallow lake) habitat. Of proposed flooded island sites, D11 is the "leakiest" and closest to the confluence / estuarine transition zone.
D12	B	San Joaquin River @ Antioch Ship Channel		(-)			*		Separation of continuous MP monitoring from discrete monitoring at D12 to indicate different station locations, see D12A for details. Improved analytical integration of discrete zooplankton data from this baseline station with continuous data from shore-based MP station D12A-1983.	Better integration of existing continuous and discrete baseline stations for improved monitoring products and efficiency. A separate special study may investigate cross-channel water quality and zooplankton variability to assist interpretation of integrated data analysis results.
D12A	C&B	San Joaquin River @ Antioch Water Works		*	X				Separate new station ID and description indicates different location from D12, see proposed new Table 6 for coordinates. This station was listed as D12* in D-1485. Reinstatement of D-1485 station description and P/C sampling. P/C sampling will be conducted during sensor maintenance. Obtain funding for multi-depth CR array by the end of the 2003-2005 review cycle.	Reinstatement of discrete P/C sampling for QA/QC of continuous measurements. Multi-depth CR array to characterize vertical temperature and salinity stratification. This is important for understanding ecological and hydrodynamic transport processes and for meaningful numerical modeling.
D15	C	San Joaquin River @ Jersey Point	*						No operational change. New: analytical integration of data from this USBR-operated station into comprehensive EMP data analyses.	D-1641 compliance station for EC operated by USBR O&M. USGS measures flow here. Important for cross-Delta mass flux calculations. EMP will acquire data from USBR and USGS for flux analyses.
D16	B	San Joaquin River @ Twitchell Island					*	*	No operational change. New: analytical association of D16 discrete monitoring data with continuous and discrete monitoring data from stations D29 and D15.	Long-term zooplankton "index" station. Improved analytical integration of data from existing continuous and discrete monitoring stations for improved monitoring products. A separate special study may investigate water quality and zooplankton variability between stations near D16 to assist interpretation of integrated data analysis results.

(continued)

Table F, continued

Station ID[1]	Station Type[2]	Station Description[3]	Cont. Rec.[4] (CR)	Cont. Multi-para-meter[5] (MP)	Discrete Physical/ Chemical[6] (P/C)	Discr. Phyto-plank-ton[7] (P)	Discr. Zoo-plank-ton[8] (Z)	Dis-crete Ben-thos[9] (B)	Modification description	Justification and outlook
D19	B	Franks Tract near Russo's Landing	X		X	X	X		Reinstated D-1485 P/C and Z monitoring station. Reinstated historical (1975-1979, 1988-1995) P monitoring. New: CR monitoring.	Ambient monitoring in flooded island (shallow lake) habitat. "Leaky," shallow lake in the Western Delta with high SAV and *Corbicula* densities and low algal biomass.
D22A	C	Sacramento River NW of Emmaton	X						No operational change, but formally reinstate D-1485 CR compliance monitoring at existing shore station operated by DWR O&M (EC1120).	CR monitoring at D22A was likely unintentionally excluded from D-1641, Table 5, since water quality objectives for EC exist at the designated compliance and baseline station D22.
D22	B	Sacramento River @ Emmaton					*		Separate new station ID and description indicates (very slightly!) different location from D22A, see proposed new Table 6 for coordinates. Improved analytical association of D22 discrete zooplankton monitoring data with continuous and discrete monitoring data from continuous shore station D22A and D24. See also D22A and D24.	Long-term zooplankton "index" station. Improved analytical integration of data from existing continuous and discrete monitoring stations for improved monitoring products. As separate special study, investigate cross-channel zooplankton variability between D22A and D22 to assist interpretation of integrated data analysis results. Also investigate if D22 zooplankton monitoring can be replaced by reinstated D24 zooplankton monitoring without compromising long-term data continuity.
D24A	C&B	Sacramento River below Rio Vista Bridge		*	X				New: discrete P/C sampling. New station ID to distinguish continuous MP monitoring from discrete monitoring at historical D24.	Discrete P/C sampling for QA/QC of continuous measurements, to improve benthos data interpretations and to provide additional relevant data. Important flux and compliance station.
D24-L	B	Sacramento River below Rio Vista Bridge, left bank						*	Separate new station ID and description indicates different location from D24A, see proposed new Table 6 for coordinates. Improved analytical integration of benthos baseline monitoring data from discrete channel station D24 with data from near-by, shore-based MP station.	Benthos station on left channel bank. Better integration of existing continuous and discrete baseline stations for improved monitoring products. A separate special study may investigate cross-channel water quality and benthos variability to assist interpretation of integrated data analysis results. Investigate moving D22 zooplankton monitoring to this station.

(continued)

Table F, continued

Station ID[1]	Station Type[2]	Station Description[3]	Cont. Rec.[4] (CR)	Cont. Multi-para-meter[5] (MP)	Discrete Physical/ Chemical[6] (P/C)	Discr. Phyto-plank-ton[7] (P)	Discr. Zoo-plank-ton[8] (Z)	Dis-crete Ben-thos[9] (B)	Modification description	Justification and outlook
D26	B	San Joaquin River @ Potato Point			*	*	*		No operational change. New: analytical association of D26 discrete monitoring data with continuous and discrete monitoring data from stations D16 and D29. During the 2003-2005 review cycle, investigate if sampling at D26 can be moved to D29 without compromising long-term data continuity. See also D29.	Long-term zooplankton "index" station. Better integration and potential consolidation of existing discrete baseline and continuous compliance stations for improved monitoring products and efficiency. A recommendation about station consolidation will be included in the next triennial program review report due in 2005.
D28A	B	Old River near Rancho Del Rio	(-)		*	*	*	*	Separation of CR baseline monitoring from discrete monitoring at D28A to indicate different station locations, see D28B for details. New: analytical integration of discrete data from channel station D28A with data from near-by, shore-based continuous station D28B (=EC5250) operated by DWR (Central District). During the 2003-2005 review cycle, investigate if D28A and D28B monitoring can be consolidated at D28B location without compromising long-term data continuity.	Flux station, long-term benthos station. Better integration and potential consolidation of existing continuous and discrete baseline stations for improved monitoring products and efficiency. A recommendation about the consolidation of these stations will be included in the next triennial program review report due in 2005.
D28B	B	Old River at Bacon Island	*						New station ID and description for the shore-based continuous station near D28A operated by DWR, Central District (EC5250). In collaboration with DWR-CD, attempt to obtain funding for station expansion to include MP monitoring by the end of the 2003-2005 cycle.	Formally propose continuous MP monitoring at this station for adoption into the water right decision in the next triennial program review report due in 2005.

(continued)

Table F, continued

Station ID[1]	Station Type[2]	Station Description[3]	Cont. Rec.[4] (CR)	Cont. Multi-para-meter[5] (MP)	Discrete Physical/ Chemical[6] (P/C)	Discr. Phyto-plank-ton[7] (P)	Discr. Zoo-plank-ton[8] (Z)	Dis-crete Ben-thos[9] (B)	Modification description	Justification and outlook
D29	C&B	San Joaquin River @ Prisoners Point	*		X	X	X		Seasonal CR monitoring station expanded to year-around operation with new discrete sampling of P/C, P, and Z. Attempt to obtain funding for station expansion to include MP monitoring by the end of the 2003-2005 review cycle.	Important flux station, northern endpoint for Stockton Ship Channel D.O. monitoring. Analytical association of D29 continuous data with discrete data collected at D26 and D16. Discrete sampling at D29 may eventually replace discrete sampling at D26 (and possibly D16), see D26.
D41	B	San Pablo Bay near Pinole Point			*	*	X	*	No operational change, but formal addition of ongoing Z monitoring.	Though not required in D-1641, zooplankton has been monitored here since 1998. This site is not suitable for continuous monitoring. Hydrodynamically important sill station in the western estuary.
D41A	B	San Pablo Bay near Mouth of Petaluma River			X	X	X	*	Expand to include discrete sampling of PC, P, and Z. Analytical integration of discrete data from D41 A with continuous data from near-by USGS-operated CR station at Channel Marker 9 (turbidity, EC, temperature). Investigate data comparability between these sites to assist interpretation of integrated data analysis results.	Long-term benthos station. Ambient station representing shoal habitat with fluctuating salinity levels. Important site for monitoring of the invasive calm *Potamocorbula*. Better integration of existing continuous and discrete baseline stations for improved monitoring products. Include recommendation about formal adoption of the USGS CR station at channel marker 9 for adoption into the water right decision in the next triennial program review report due in 2005.
DMC1	C	Delta-Mendota Canal @ Tracy Pump. Plt.		*					No operational change.	
P8	B	San Joaquin River @ Buckley Cove		(-)	*	*	*	*	Separation of continuous MP monitoring from discrete monitoring at P8 to indicate different station locations, see P8A for details. Improved analytical integration of discrete baseline monitoring data from discrete channel station P8 with data from near-by, shore-based MP station. During the 2003-2005 review cycle, investigate if discrete sampling at P8 can be moved to P8A without compromising long-term data continuity.	Station integration and potential consolidation improves monitoring products and efficiency. A recommendation about the consolidation of stations P8 and P8A will be included in the next triennial program review report due in 2005. See also P8A .

(continued)

Table F, continued

Station ID[1]	Station Type[2]	Station Description[3]	Cont. Rec.[4] (CR)	Cont. Multi-para-meter[5] (MP)	Discrete Physical/ Chemical[6] (P/C)	Discr. Phyto-plank-ton[7] (P)	Discr. Zoo-plank-ton[8] (Z)	Dis-crete Ben-thos[9] (B)	Modification description	Justification and outlook
P8A	B	San Joaquin River @ Rough and Ready Island		*					No operational change. Separate new station ID and description indicates different location from P8, see proposed new Table 6 for coordinates.	Important San Joaquin River station near southern endpoint for Stockton Ship Channel D.O. monitoring. Frequently occurring D.O. sags, high productivity. Data extensively used by CVRWQCB.
P12	C	Old River @ Tracy Road Bridge	*						No operational change.	
MD10	B	Disappointment Slough near Bishop Cut			*	*	*		No operational change. Attempt to obtain funding for station expansion to include CR monitoring by the end of the 2003-2005 review cycle.	Ambient station, the only eastern Delta representative, smaller "backwater" tidal river channel
S21	C	Chadbourne Slough @ Sunrise Duck Club	*						No operational change.	
S35	B	Goodyear Sl. @ Morrow Island Clubhouse	*						No operational change.	
S42	C&B	Suisun Slough 300' south of Volanti Slough	*		X	X			New: discrete P/C & P sampling.	Discrete P/C and P sampling for QA/QC of continuous measurements, to improve interpretation zooplankton data collected at S42A, and to provide additional relevant data. Ecologically important tidal marsh slough habitat with long-term monitoring history. Planned in vicinity: NERR site.
S42A	B	Suisun Slough 300' south of Volanti Slough, center channel					*		Separate new station ID and description indicates different location from S42, see proposed new Table 6 for coordinates. Improved analytical integration of zooplankton baseline monitoring data from discrete channel station S42A with data from near-by, shore-based CR station S42.	Long-term zooplankton station. Improved analytical integration of data from existing continuous and discrete monitoring stations for improved monitoring products. A separate special study may investigate water quality and zooplankton variability between S42 and S42A to assist interpretation of integrated data analysis results.
S49	C	Montezuma Slough near Beldon Landing	*						No operational change.	
S64	C	Montezuma Slough @ National Steel	*						No operational change.	
S97	B	Cordelia Slough @ Ibis Club	*						No operational change.	

(continued)

Table F, continued

Station ID[1]	Station Type[2]	Station Description[3]	Cont. Rec.[4] (CR)	Cont. Multi-para-meter[5] (MP)	Discrete Physical/ Chemical[6] (P/C)	Discr. Phyto-plank-ton[7] (P)	Discr. Zoo-plank-ton[8] (Z)	Dis-crete Ben-thos[9] (B)	Modification description	Justification and outlook
NZ032	B	Montezuma Slough, 2nd bend from mouth					*		No operational change. New: Improved analytical association of zooplankton data with data from continuous recorder stations S49 and S54 operated by DWR -Suisun Marsh program	Improved analytical integration of data from existing continuous and discrete monitoring stations for improved monitoring products. As separate special study, investigate zooplankton variability at and between the three Montezuma Slough sites to assist interpretation of integrated data analysis results and evaluate station consolidation potential. Ecologically important tidal marsh slough habitat.
SLBAR3	C	Barker Sl. at No. Bay Aqueduct	*						No operational change.	
---	C	Sacramento R. (I St. Bridge to Freeport) (RSAC155)	*						No operational change.	
---	B	San Joaquin R. (Turner Cut to Stockton) (RSAN050-RSAN061)	*						No operational change.	
---	B	Water supply intakes for waterfowl management areas on Van Sickle Island and Chipps Island	*						No operational change.	
NZ325	B	San Pablo Bay near Rock Wall and Light 15					X		Monthly sampling and formal addition of existing, ongoing Z monitoring to D-1641 baseline monitoring.	Long-term zooplankton station to monitor zooplankton export to the SF Bay and X-2 relationships, currently sampled only when surface EC is < 20,000 µs.
EZ2	B	Entrapment Zone - Location determined when bottom EC values occur @ approximately 2000 us					X		No operational change, but formal addition of ongoing Z monitoring to D-1641 baseline monitoring.	Long-term zooplankton station, important for tracking of X2 relationships.
EZ6	B	Entrapment Zone - Location determined when bottom EC values occur @ approximately 6000 us					X		No operational change, but formal addition of ongoing Z monitoring to D-1641 baseline monitoring.	Long-term zooplankton station, important for tracking of X2 relationships.
YB	B	Yolo Bypass Toe Drain @ DWR screw trap site		X	X	X			Formal addition of ongoing MP, P/C, and P monitoring to D-1641 baseline monitoring, expansion from seasonal to year-round station.	Represents ecologically important flood plain habitat with agricultural use during the dry season. Ongoing DWR fish monitoring. The proposed new station ID is consistent with the names of the other MP stations.

(continued)

Table F, continued

Station ID[1]	Station Type[2]	Station Description[3]	Cont. Rec.[4] (CR)	Cont. Multi-para-meter[5] (MP)	Discrete Physical/ Chemical[6] (P/C)	Discr. Phyto-plank-ton[7] (P)	Discr. Zoo-plank-ton[8] (Z)	Dis-crete Ben-thos[9] (B)	Modification description	Justification and outlook
MI	B	Mildred Island, southern basin		X	X	X			New MP (CR and algal fluorescence), P/C, and P baseline monitoring station.	Ambient monitoring in flooded island (shallow lake) habitat. "Lakey" shallow lake in the Central Delta with low SAV and *Corbicula* densities and high algal biomass, occasional algal blooms. The proposed new station ID is consistent with the names of the other MP stations.
TS	B	Threemile Slough	X						New CR baseline monitoring at USGS flow monitoring station in collaboration with USGS.	Important for cross-Delta mass flux calculations because of exchanges between the Sacramento and San Joaquin Rivers through Threemile Slough. May eventually be expanded to MP station.
MR	B	Mokelumne River Mouth	X						New collaborative USGS-EMP CR baseline and flow monitoring station.	Important for cross-Delta mass flux calculations because of Delta Cross Channel operations & central Delta tributary (Mokelumne & Cosumnes) inflows.
CB	B	Carquinez Bridge, center channel (north side of center pier)	X						Formal addition of ongoing, multiple depth, CR baseline monitoring station operated by the USGS to D-1641 baseline monitoring in collaboration with USGS.	Important flux and gravitational circulation cell station in the western part of the estuary, ongoing USGS monitoring of EC, temperature, flow and suspended solids.
RB	B	Richmond Bridge, center channel	X						New CR baseline monitoring station in collaboration with USGS. Replaces IEP-funded USGS "Point San Pablo" CR station. Obtain funding for multi-depth CR array by the end of the 2003-2005 review cycle.	Important flux and gravitational circulation cell station in the western part of the estuary, ongoing USGS monitoring. Multi-depth CR array for characterization of vertical temperature and salinity stratification at this deep station. This is important for understanding ecological and hydrodynamic transport processes and for meaningful numerical modeling.

For symbols and footnotes see next page. For additional acronyms, see Table D.

Table F, Symbols:

*:	no change
X:	added
(-):	moved to neighboring station

Table F, Footnotes:

= Proposed revised footnotes for D-1641, Table 5.

Changes from D-1641, Table 5:

- Individual footnotes added for each table column.
- New column 2 to clarify symbols in D-1641 (2000), Table 5.
- All other changes: Updates and clarifications.

All footnote text modifications indicated by **bold print!**

[1] **Most stations use historical "interagency" station identification (ID) numbers as given in SWRCB D-1641 (2000) and D-1485 (1978). Modified station ID numbers (e.g. C3A) identify stations near historical stations. For geographical coordinates see Table 6.**

[2] **C: Compliance monitoring station; B: Baseline monitoring station , C&B: Compliance and baseline monitoring station.**

[3] **Most stations use historical "interagency" station descriptions as given in SWRCB D-1641 (2000) and D-1485 (1978). Stations with modified station ID numbers (e.g. D24A) also have modified names to indicate stations near historical stations with similar numbers and names.**

[4] **Continuous recording (every 15 minutes) of water temperature, EC, and/or dissolved oxygen.** For municipal and industrial intake chloride objectives, **electrical conductivity (EC) can be monitored and converted to chloride concentrations.**

[5] **Continuous multi-parameter monitoring (recording every 1 to 15 minutes with telemetry capabilities) includes the following variables: water temperature, EC, pH, dissolved oxygen, turbidity, chlorophyll fluorescence, tidal elevation, and meteorological data (air temperature, wind speed and direction, solar radiation).**

[6] **Discrete physical/chemical monitoring is conducted near-monthly on alternating spring and neap tides and includes the following variables: macronutrients (inorganic forms of nitrogen, phosphorus, and silicon), total suspended solids, total dissolved solids, total, particulate and dissolved organic nitrogen and carbon, chlorophyll *a*, pH, dissolved oxygen (DO), EC (specific conductance), turbidity, secchi depth, and water temperature. In addition, on-board continuous recording** is conducted intermittently for the following variables: water temperature, dissolved oxygen, electrical conductivity, turbidity, and chlorophyll *a* fluorescence.

[7] **Near-monthly discrete sampling on alternating spring and neap tides for phytoplankton enumeration or algal pigment analysis.**

[8] **Near-monthly tow or pump sampling for zooplankton, mysids, and amphipods.**

[9] **In 2003 and 2004, replicated benthos and sediment grab samples are taken quarterly (every three months) and during special studies events; more frequent monitoring sampling resumes in 2005.**

Table G: Proposed new D-1641, Table 6, with additional information.

Station ID[1]	Station Type[1]	Station Description[1]	Latitude[2]	Longitude[2]	RKI[3]	Lead Operator[4]	Alias[5]	Comments[6]
C2	C	Sacramento River @ Collinsville	38.07395	-121.85010	RSAC081	USBR-CVO	Collinsville	Collocated with DWR-SM "Collinsville" station since 2001.
C3A	B	Sacramento River @ Hood	38.36772	-121.52051	RSAC142	IEP-EMP	70	Collocated with DWR-MWQI "HOOD" station. Established in 1998 to replace historical C3 (Green's Landing)
C4	C	San Joaquin River @ San Andreas Landing	38.10319	-121.59128	RSAN032	USBR-CVO	San Andreas	Collocated with DWR-CD station "5100"
C5	C	Contra Costa Canal @ Pumping Plant #1	37.99520	-121.70244	CHCCC006	USBR-CVO	Contra Costa	
C6	C	San Joaquin River @ Brandt Bridge site	37.86454	-121.32270		DWR-CD	5740	
C7A	B	San Joaquin River @ Mossdale Bridge	37.78604	-121.30666	RSAN087	IEP-EMP	10	Replaced historic van station C7
C8	C	Middle River near Old River	37.82208	-121.37517	RMID041	USBR-CVO	Union Island	Historical C8 station description: "In Middle River 1.7 km north of junction with Old River." This station has been moved south and is now at the junction with Old River.
C9	C&B	Clifton Court Forebay @ Radial Gates	37.83075	-121.55703		DWR-O&M	KA000000	Historical C9 used to be just outside of the Forebay on the other side of the levee.
C9-R	B	West Canal @ Mouth of CC Forebay Intake	37.82818	-121.55275	CHWST0	IEP-EMP	C9	C9 - Right bank benthic monitoring
C10	C	San Joaquin River near Vernalis	37.67575	-121.26500	RSAN112	USBR-CVO	Vernalis	
C10A	B	San Joaquin River near Vernalis @ San Joaquin River Club	37.67934	-121.26472		IEP-EMP	Vernalis	New station to be shared by IEP-EMP and DWR-MWQI
C13	C	Mokelumne River @ Terminous	38.11691	-121.49888	RSMKL008	USBR-CVO	Staten Island	USBR description: "Mokelumne River (South Fork) @ Staten Island"
C14	C	Sacramento River @ Port Chicago	38.05881	-122.02607	RSAC064	USBR-CVO	Port Chicago	
C19	C	Cache Slough @ City of Vallejo Intake	38.29687	-121.74784	SLCCH016	USBR-CVO	Cache Slough	Also described as "Cache Slough near end of Hastings cut"
D4	B	Sacramento River above Point Sacramento	38.06214	-121.81792	RSAC084	IEP-EMP		Benthic sampling is done close to the left shore
D6	B	Suisun Bay @ Bulls Head Pt. near Martinez	38.04427	-122.11764	RSAC056	IEP-EMP		Benthic sampling is done at a slightly different location
D6A	B	Sacramento River @ Martinez	38.02762	-122.14052	RSAC054	IEP-EMP	40	

(continued)

Table G, continued

Station ID[1]	Station Type[1]	Station Description[1]	Latitude[2]	Longitude[2]	RKI[3]	Lead Operator[4]	Alias[5]	Comments[6]
D7	B	Grizzly Bay @ Dolphin nr. Suisun Slough	38.11708	-122.03972	LSBB11	IEP-EMP		
D8	B	Suisun Bay off Middle Point nr. Nichols	38.05992	-121.98996	RSAC068	IEP-EMP		
D9	B	Honker Bay	38.07245	-121.93923		IEP-EMP		Reinstated D-1485 monitoring station
D10	B	Sacramento River @ Chipps Island	38.04631	-121.91829	RSAC075	IEP-EMP		
D10A	C&B	Sacramento River @ Mallard Island	38.04288	-121.92011	RSAC075	IEP-EMP	60	Collocated with DWR-MWQI "Mallardis"
D11	B	Sherman Lake near Antioch	38.04228	-121.79951		IEP-EMP		Reinstated D-1485 monitoring station
D12	B	San Joaquin River @ Antioch Ship Channel	38.02162	-121.80638	RSAN007	IEP-EMP		
D12A	C&B	San Joaquin River @ Antioch	38.01770	-121.80273	RSAN007	IEP-EMP	50	Collocated with USBR-CVO "Antioch", DWR-CD 5020
D15	C	San Joaquin River @ Jersey Point	38.05190	-121.68927	RSAN018	USBR-CVO	Jersey Point	Collocated with USGS-SAC 337190
D16	B	San Joaquin River @ Twitchell Island	38.09690	-121.66912	RSAN024	IEP-EMP		
D19	B	Frank's Tract near Russo's landing	38.04376	-121.61477		IEP-EMP		Reinstated D-1485 monitoring station
D22A	C	Sacramento River NW of Emmaton	38.08406	-121.73912	RSAC092	USBR-CVO	Emmaton	Collocated with DWR-CD 1120
D22	B	Sacramento River @ Emmaton	38.08453	-121.73914	RSAC092	IEP-EMP		
D24A	C&B	Sacramento River below Rio Vista Bridge	38.15891	-121.68721	RSAC101	IEP-EMP	30	Collocated with DWR-CD 1212 and USGS-SAC 455400
D24-L	B	Sacramento River @ Rio Vista, left bank	38.15550	-121.68113		IEP-EMP		D24 - Left bank benthic site
D26	B	San Joaquin River @ Potato Point	38.07667	-121.56696	RSAN035	IEP-EMP		
D28A	B	Old River near Rancho Del Rio	37.97038	-121.57271	ROLD21	IEP-EMP		
D28B	B	Old River @ Bacon Island	37.96980	-121.57210	ROLD024	DWR-CD	5250	Collocated with USGS-SAC 313405 and DWR-MWQI "OLDRIVBACISL"
D29	C&B	San Joaquin River @ Prisoners Point	38.05793	-121.55736	RSAN037	IEP-EMP	80	
D41	B	San Pablo Bay near Pinole Point	38.03016	-122.37287	RSAC032	IEP-EMP		
D41A	B	San Pablo Bay near Mouth of Petaluma R.	38.08472	-122.39067		IEP-EMP		
DMC1	C	Delta Mendota Canal @ Tracy Pump Plt.	37.78165	-121.59050	CHDMC006	USBR-CVO	DMC Headworks	
P8	B	San Joaquin River @ Buckley Cove	37.97815	-121.38242	RSAN056	IEP-EMP		
P8A	B	San Joaquin River @ Rough and Ready Island	37.96277	-121.36587	RSAN058	IEP-EMP	20	Collocated with DWR-CD 5660

(continued)

Table G, continued

Station ID[1]	Station Type[1]	Station Description[1]	Latitude[2]	Longitude[2]	RKI[3]	Lead Operator[4]	Alias[5]	Comments[6]
P12	C	Old River @ Tracy Road Bridge	37.80493	-121.44929		DWR-CD	5380	
MD10	B	Disappointment Slough near Bishop Cut	38.04229	-121.41935	SLDPT07	IEP-EMP		
S21	C	Chadbourne Slough @ Sunrise Duck Club	38.18476	-122.08315	SLCBN002	DWR-SMP		
S35	B	Goodyear Slough @ Morrow Island Clubhouse	38.11881	-122.09580	SLGYR003	DWR-SMP		
S42	C&B	Suisun Slough 300' south of Volanti Slough	38.18053	-122.04696		DWR-SMP		
S42A	B	Suisun Slough 300' south of Volanti Slough, center channel	38.18027	-122.04779	SLSUS12	IEP-EMP		
S49	C	Montezuma Slough near Beldon Landing	38.18686	-121.97080	SLMZU011	DWR-SMP		
S64	C	Montezuma Slough @ National Steel	38.12223	-121.88800	SLMZU025	DWR-SMP		
S97	B	Cordelia Slough @ Ibis Club	38.15703	-122.11378	SLCRD006	DWR-SMP		
NZ032	B	Montezuma Slough, 2nd bend from mouth	38.16990	-122.02112		IEP-EMP	NZ032	
SLBAR3	C	Barker Slough @ North Bay Aqueduct	38.27474	-121.79499	SLBAR002	DWR-O&M	KG000000	
---	C	Sacramento R. (I St. Bridge to Freeport)			RSAC155			
---	B	San Joaquin R. (Turner Cut to Stockton)			RSAN050-RSAN061			
---	B	Water supply intakes for waterfowl management areas on Van Sickle Island and Chipps Island						

Footnotes for Table G:

1 See Table C, Footnotes 1-3.
2 Coordinates are geographic North American Datum 1983 and have been verified to be accurate for 1:24,000 scale mapping
3 River Kilometer Index
4 IEP-EMP: Interagency Ecological Program -Environmental Monitoring Program. Other lead operator acronyms: see Table D. The lead operator is responsible for compliance monitoring at compliance stations and for most baseline monitoring and/or station maintenance.
5 Alternative station I.D. used by the lead agency.
6 Comments about additional monitoring by other agencies and station history.

Appendix 1: Milestones and participants in the 2001-2002 review of the IEP Environmental Monitoring Program

1. Milestones

Technical Review Phase:

- First public meeting: Orientation. Romberg-Tiburon Bay Conference Center. May 8, 2001.
- Subject Area Team (SAT) meetings. May-June 2001
- Second public meeting: Presentation and discussion of SAT review results. UC Davis. July 30, 2001
- SAT leader and EMP core team meeting to integrate results and prioritize recommendations. SFEI, Richmond. August 22, 2001
- Briefing and discussion meeting with IEP Water Quality Project Work Team. DWR-Sacramento. September 25, 2001
- Completion of EMP Review and Recommendations Report, Draft I, November 2001, posting on EMP web site for review by review participants
- Third public meeting to discuss draft plan. Romberg-Tiburon Bay Conference Center. November 14, 2001.
- Completion of EMP Review and Recommendations Report, Draft II, December 2001, posting on EMP web site for review by review participants and IEP Science Advisory Group (SAG)
- Briefing meeting for staff from other DWR water quality monitoring programs, DWR-Sacramento, January 22, 2002
- Presentations about the EMP and the 2001-2002 review at the annual IEP workshop in Asilomar, CA, February 2002
- Meeting of EMP review core team with IEP SAG to initiate SAG review of the EMP. Stanford University. April 4, 2002.
- Written SAG review completed and sent to IEP management and EMP May 22, 2002.

- Many core team meetings and discussions with SAT leaders to respond to SAG recommendations and revise the EMP Review and Recommendations Report

- Presentation about the EMP and the state of the 2001-2002 review at the IEP monitoring forum at UC Davis on June 19, 2002.

- Completion of EMP Review and Recommendations Report, Draft III. This completes the technical review phase. Documents posted on EMP web site and sent to EMP review core team, and SAT leaders, IEP Water Quality PWT, agency program managers, IEP Management Team, IEP Coordinators, State Water Contractor Representatives, SWRCB staff, Central Valley Regional Water Quality Control Board staff for review/approval. October 2002

Management Review Phase:

- Briefing meeting for State Water Contractors, State Water Contractor's offices in Sacramento, October 8, 2002

- Briefing meeting for Regional Water Quality Control Board staff, Sacramento, October 29, 2002

- Briefing meetings for DWR Office and Division Chiefs and USBR management to discuss how EMP revisions will affect their programs, November 12 and 13, 2002

- Meeting of review core team members with SWRCB, DWR, and USBR legal staff regarding preparation of final documents, December 2, 2002

- Communications with IEP Management Team about the EMP review, December 2002-January 2003.

- Joint USBR-DWR request for 61-day extension to allow review completion sent to SWRCB December 20, 2002.

- Briefing of DWR Bay-Delta Hearing Coordination Committee, January 31, 2003.

- Revision of EMP Review and Recommendations Report, Draft III based on all new comments received after meetings, etc. resulting in Draft IV. Drafting of final report and documents for "EMP review package." February, 2003.

- IEP Asilomar meeting: update IEP SAG, MT, and others. February 28, 2003.

- Request approval of agency deputy directors to submit package to the SWRCB.

- Submittal of EMP Package to SWRCB for approval, March 30, 2003. Includes Final EMP Review and Recommendations Report as Appendix C.

- Notification of "Water Rights Community" with workshop invitation and attached review documents expected April 2003.

- SWRCB Staff Workshop (2 hour presentation) expected May, 2003.

2. Participants in the technical review of the EMP

Name	Organization	Role in Review
Heather Peterson	USGS, Biologist	Benthos SAT, Lead
Jan Thompson	USGS, Biologist	Benthos SAT
Cindy Messer	DWR, Biologist	Benthos SAT, EMP staff
Bruce Thompson	SFEI, Biologist	Benthos SAT
Zach Hymanson	DWR/CALFED, Biologist	Water Quality SAT, Lead; Core Team; EMP Program Manager
Jon Burau	USGS, Hydrologist	Water Quality SAT, Lead; Core Team
Ken Lentz	USBR, Biologist	Water Quality SAT; Core Team; EMP Program Manager
Larry Schemel	USGS, Chemist	Water Quality SAT
David Briggs	CCWD, Engineer	Water Quality SAT
Mike Simpson	USGS, Engineer	Water Quality SAT
Rainer Hoenicke	SFEI, Biologist	Water Quality SAT
Cary Burns	USGS, Biologist	Water Quality SAT
Hank Gebhard	DWR, Engineer	Water Quality SAT
Joe Dolmalgalski	USGS (NAWQA)	Water Quality SAT
Tom Morstein-Marx	USBR operations	Water Quality SAT
Art Hinojosa	DWR O&M Operations Studies	Water Quality SAT
Anke Mueller-Solger	DWR, Biologist	Phytoplankton SAT, Lead; Core Team, EMP staff
Peggy Lehman	DWR, Biologist	Phytoplankton SAT, EMP staff
Sang-Kyu Park	UC Davis, Biologist	Phytoplankton SAT
Wim Kimmerer	SFSU, Biologist	Zooplankton SAT, Lead
Lee Mecum	DFG	Zooplankton SAT, EMP staff
Jim Orsi	DFG (Retired), Biologist	Zooplankton, SAT
Erwin Van Nieuwenhuyse	USBR, Biologist	All-Participant Meeting(s); Core Team, EMP staff
Carolyn Penny	Consultant	All-Participant Meeting(s), Facilitator
Nick Wilcox	SWRCB	Public Meeting(s) only
Gita Kapahi	SWRCB	Public Meeting(s) only
Kim Taylor	CALFED Science	Public Meeting(s) only
Tina Swanson	Bay Institute	Public Meeting(s) only
Rick Sitts	MWD	Public Meeting(s) only
John Andrew	CALFED Drinking Water	Public Meeting(s) only

(continued)

Review participants, cont.

Name	Organization	Role in Review
Mike Chotkowski	USBR	Public Meeting(s) only
Sam Harader	CALFED Drinking Water	Public Meeting(s) only
Barbara Marcotte	CALFED ERP	Public Meeting(s) only
Elaine Archibold	Consultant	Public Meeting(s) only
Fred Lee	Consultant, Enviroqual	Public Meeting(s) only
Claus Suverkropp	SRWP / LWA	Public Meeting(s) only
Tom Grovhoug	SRWP / LWA	Public Meeting(s) only
Elizabeth Soderstrom	NHI	Public Meeting(s) only
Khalil Abu-Saba	RWQCB	Public Meeting(s) only
Bruce Herbold	EPA	Public Meeting(s) only
Lester McKee	SFEI, Biologist	Public Meeting(s) only
Marc Vayssieres	DWR, Ecologist	Public Meeting(s) only, EMP staff
Steve Hayes	DWR, Section Chief	Public Meeting(s) only, EMP staff
Karen Gehrts	DWR, Biologist	Public Meeting(s) only, EMP staff
Scott Waller	DWR, Staff	Public Meeting(s) only, EMP staff
Kitty Triboli	DWR, Staff	Public Meeting(s) only, EMP staff
Casey Ralston	DWR, Staff	Public Meeting(s) only, EMP staff
Shaun Phillipart	DWR, Staff	Public Meeting(s) only, EMP staff
Stephen Monismith	Stanford U.	IEP SAG (chair)
Si Simensted	U. Washington	IEP SAG
Jim Cloern	USGS	IEP SAG
Edward Houde	U. Maryland	IEP SAG
Terry Short	USGS	IEP SAG (Temporary)
Jonathan H. Sharp	U. Delaware	IEP SAG (Temporary)
Alan Jassby	UC Davis	IEP SAG (Temporary)

(Acronyms see next page)

Acronyms:

CALFED	Consortium of Bay-Delta State and Federal Agencies. Beginning 1-1-03: "Bay-Delta Authority"
CD	DWR Central District
DFG	California Department of Fish and Game
DWR	California Department of Water Resources
EPA	Environmental Protection Agency
EMP	Environmental Monitoring Program
IEP	Interagency Ecological Program, 1994-present
LWA	Larry Walker and Associates
MT	IEP Management Team
MWD	Metropolitan Water District of Southern California
NHI	Natural Heritage Institute
O&M	DWR Division of Operations and Maintenance
RWQCB	Regional Water Quality Control Board
SAG	IEP Science Advisory Group
SAT	IEP EMP Review Subject Area Team
SFEI	San Francisco Estuary Institute
SFSU	San Francisco State University
SRI	Stanford Research Institute
SRWP	Sacramento River Watershed Program
SWRCB	State Water Resources Control Board
USBR	United States Bureau of Reclamation
USGS	United States Geological Survey

Appendix 2: IEP EMP Special Studies Guidelines

Special studies are vital for maintaining and improving complex long-term monitoring programs. EMP special studies should provide information to improve monitoring efficiency, quality, and products. They should be clearly related to EMP monitoring, but can be carried out and funded independently. The following guidelines for designing special studies are intended to encourage EMP staff and other interested parties to clearly communicate and discuss study ideas, design, and results. While smaller studies such as instrument and methods tests can be handled at the PWT level, more substantial study plans should be brought to the attention of and approved by the IEP Management Team and Coordinators following the usual IEP guidelines. In addition, EMP staff are also encouraged to seek funding and collaborators outside the IEP, if appropriate.

I. IEP EMP Special Study Categories

1. Evaluations of methods and instrumentation
2. Special (additional) monitoring
3. Special data analyses
4. Investigations of ecological processes necessary to understand water quality monitoring data (Note: special studies in this category should primarily be proposed to and funded by the IEP, CALFED, etc.)

II. Procedures for approval of IEP EMP Special Studies

Ideas for IEP EMP special studies are brought to the attention of the IEP Water Quality PWT, other PWTs, and, depending on the scope of the proposed study, to the IEP Management Team, CALFED, etc. Written proposals to the IEP WQ PWT are required for approval and/or funding of special studies by the IEP WQ PWT. Proposals are reviewed by the IEP Water Quality PWT members, discussed, and approved via majority vote. For more substantial studies, additional funding (e.g. IEP, CALFED) may be necessary, and proposals need to be prepared and submitted according to guidelines and schedules set forth by the funding entities.

III. How to write a proposal for an IEP EMP special study

A. Introduction

The following excerpt from a “Proposal Writer’s Guide” developed at the University of Michigan gives some perspective on proposal writing. This guide was written for people with little or no experience in writing proposals for sponsored activities.

The full document is available at
http://www.research.umich.edu/research/proposals/proposal_dev/pwg/pwgcomplete.html

"Writing a proposal for a sponsored activity such as a research project or a curriculum development program is a problem of persuasion. It is well to assume that your reader is a busy, impatient, skeptical person who has no reason to give your proposal special consideration and who is faced with many more requests than he can grant, or even read thoroughly. Such a reader wants to find out quickly and easily the answers to these questions.

- What do you want to do, how much will it cost, and how much time will it take? How does the proposed project relate to the sponsor's interests?
- What difference will the project make to: your university, your students, your discipline, the state, the nation, the world, or whatever the appropriate categories are?
- What has already been done in the area of your project?
- How do you plan to do it?
- How will the results be evaluated?
- Why should you, rather than someone else, do this project?

These questions will be answered in different ways and receive different emphases depending on the nature of the proposed project and on the agency to which the proposal is being submitted. Most agencies provide detailed instructions or guidelines concerning the preparation of proposals (and, in some cases, forms on which proposals are to be typed); obviously, such guidelines should be studied carefully before you begin writing the draft."

So: Please follow the standard format and guidelines for IEP EMP proposals outlined in the next section!

B. Standard format for IEP EMP special study proposals

The standard format and guidelines below address all information needs identified for IEP research proposals in the 2002 IEP Planning Directivities, s. V. Written proposals should follow this format. All proposal elements listed below should be addressed, although the order of the proposal elements may be changed. (Do not change the order if the proposal is to be submitted for additional IEP funding!).

1. Proposed Program Element Title and Date
2. Proposal author(s) and/or Principal Investigator(s) (Include phone numbers and email addresses)
3. Other Participants
4. Project Summary (BRIEFLY highlight the main points of the proposal)

5. Table of contents (Required only if the proposal is longer than 3 pages, without attachments)
6. Introduction: Problem Statement
   a) Purpose/objectives of the study
   b) Hypotheses or questions, possibly with a “conceptual model”
   c) Significance of the proposed research
7. Background and justification (What is the background/history behind this study that makes it important? What is the context? What has been done so far? What do you already know about this topic? Why is this study necessary? - Cite, reference, and/or attach literature and other documents as appropriate.)
8. Approach
   a) Study Design (How will you carry out this study? Be specific! Describe as many of the following aspects as possible and appropriate: Spatial and temporal aspects (e.g. study area(s), sampling frequency/schedule, etc), experimental design, description of study components, types and amounts of samples/data collected, sampling and sample analysis methods, QA/QC, etc. – attach tables and figures as necessary)
   b) Description of data analysis, storage, and QA/QC (Where, when, and how will data be recorded, analyzed, and stored?)
9. Expected products and product dissemination and evaluation (What types of products do you expect from this study? How will they be made available, evaluated, and used by others? At a minimum, a written final report has to the submitted to the WQ PWT. Other possible products include IEP Newsletter articles, presentations at annual workshop or other scientific group meeting, and peer reviewed papers.)
10. Project organization and resources (Who will do what, where, when, for how long, using what? How long will the whole project take? All of this may be summarized in a table. At a minimum, include a work plan with completion dates for the identified program components including field work, sample and data analysis, and submission of products (final report etc., see 9.))
11. Budget (dollar amounts or estimates of effort, e.g., number of days per person/boat/lab analysis/data analysis, etc.)
12. References
13. Attachments
   a) Tables and Figures (can also be embedded in the proposal)
   b) Documents relevant to the project and not readily available elsewhere

After successful study completion, results should be presented at the PWT or general IEP level and published in the IEP newsletter, technical reports, scientific journals, etc., as opportunities allow!