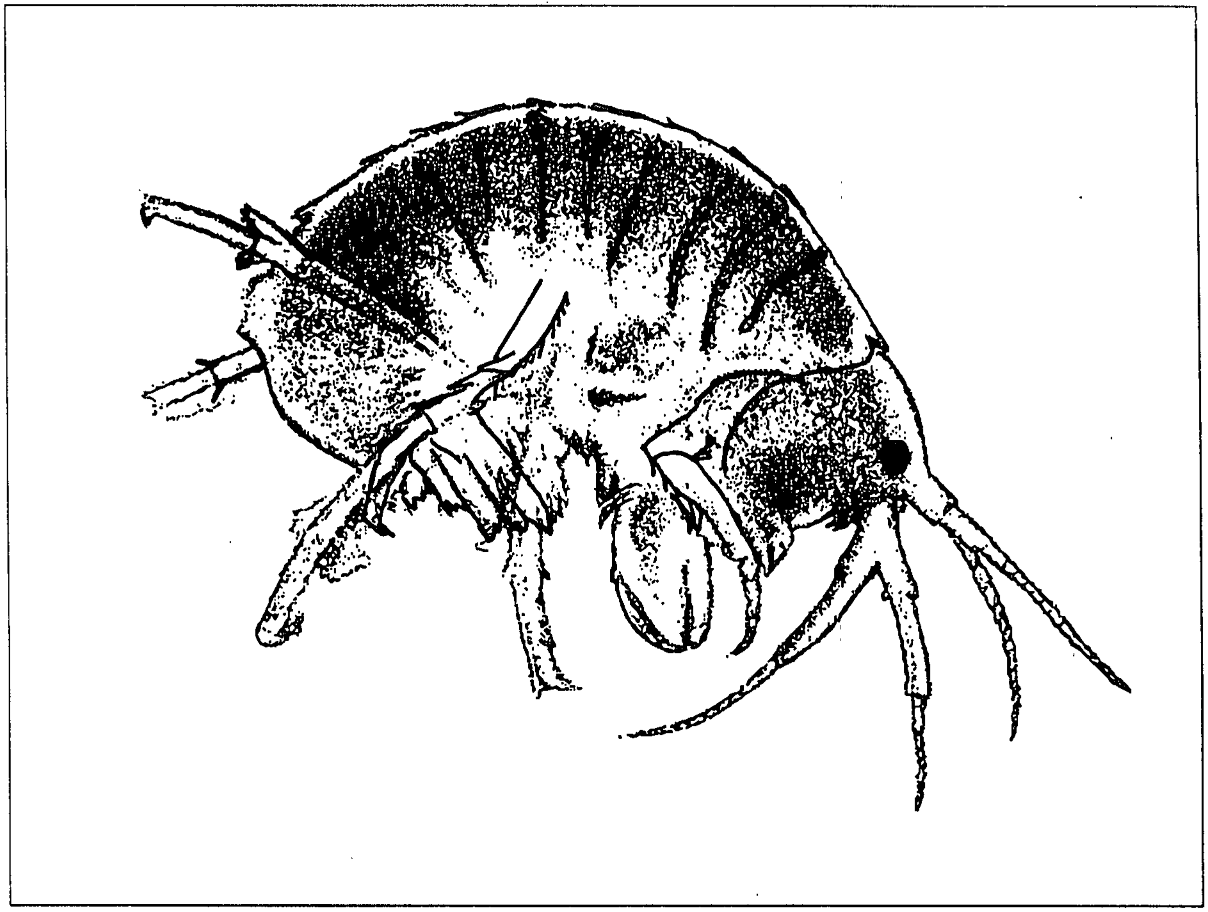

WORKPLAN FOR THE DEVELOPMENT OF SEDIMENT QUALITY OBJECTIVES FOR ENCLOSED BAYS AND ESTUARIES OF CALIFORNIA

91-14-WQ

June 1991

WATER RESOURCES CONTROL BOARD
STATE OF CALIFORNIA

STATE OF CALIFORNIA
Pete Wilson, Governor

OFFICE OF ENVIRONMENTAL PROTECTION
James M. Strock, Secretary

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COVER:
Hyalella azteca - amphipod commonly used in toxicity testing of freshwater sediments.

SOURCE:
Division of Water Rights.

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Workplan for the Development of Sediment Quality objectives for enclosed Bays and Estuaries of California

STATE WATER RESOURCES CONTROL BOARD
RESOLUTION NO. 91-54

APPROVAL OF THE WORKPLAN FOR THE DEVELOPMENT OF SEDIMENT QUALITY OBJECTIVES FOR ENCLOSED BAYS AND ESTUARIES IN CALIFORNIA

WHEREAS:

1. California Water Code Section 13392.6 requires the State Water Resources Control Board (State Board) to adopt and submit to the Legislature by July 1, 1991 a workplan for the development of sediment quality objectives;

2. The State Board sponsored, on February 6 through 8, 1991, a technical workshop in sediment quality assessment and the development of sediment quality objectives;

3. The attached workplan was developed after full consideration of the recommendations of the Technical Workshop; and

4. California Water Code Section 13393 requires the State Board to adopt sediment quality objectives pursuant to the workplan, and that the adoption of sediment quality objectives be conducted pursuant to the procedures for adopting and amending water quality control plans.

THEREFORE BE IT RESOLVED THAT:

1. The workplan for the development of Sediment Quality Objectives for Enclosed Bays and Estuaries in California is adopted.

2. The workplan shall be submitted to the Legislature by the Executive Director no later than July 1, 1991.

3. The development of sediment quality objectives proceed as set forth in the workplan and that adoption of the sediment quality objectives be included as amendments to the Water Quality Control Plan for Enclosed Bays and Estuaries of California, other Statewide Plans or the Basin Plans.

4. This approval is the start of a process that will involve public participation and that modifications will be required to the workplan.

5. Such modifications of the workplan will be made as needed by the Executive Director only after notification of the State Board, and opportunity for public input.

CERTIFICATION

The undersigned Administrative Assistant to the State Board, does hereby certify that the foregoing is a full, true, and correct copy of a resolution duly and regularly adopted at a meeting of the State Water Resources Control Board held on June 20, 1991.

Maureen Marché
Administrative Assistant to the Board

WORKPLAN FOR THE DEVELOPMENT OF SEDIMENT QUALITY OBJECTIVES FOR ENCLOSED BAYS AND ESTUARIES OF CALIFORNIA

91-14 WQ
June 1991

PREPARED BY:

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Water Resources Control Board
State of California

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WORKPLAN FOR THE DEVELOPMENT OF SEDIMENT QUALITY OBJECTIVES FOR ENCLOSED BAYS AND ESTUARIES OF CALIFORNIA

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EXECUTIVE SUMMARY

The State Water Resources Control Board (State Board) is required to adopt and submit to the Legislature a workplan for the development of sediment quality objectives [California Water Code (Water Code) Section 13392.6]. This report has been developed to satisfy the Water Code requirements. It is organized into six chapters. Chapters I, II and III provide general background information on regulatory considerations and existing approaches to sediment quality assessment. Chapter IV presents budgetary considerations. Chapter V describes the method which is anticipated to be used for deriving numerical sediment quality objectives. Chapter VI describes specific tasks which are to be undertaken to develop sediment quality objectives for California.

The approach taken in the workplan is to generate a broad body of information in order to bring several estimators of sediment quality together into a single sediment quality objective. The estimators of sediment quality to be used are the Equilibrium Partitioning approach developed by the U.S. Environmental Protection Agency, the Apparent Effects Threshold Approach developed for use in Puget Sound, and the Spiked Bioassay Approach used for general characterization of toxicity responses. Several tasks are presented for the work elements associated with each of these estimators. These tasks initially focus on the calibration and verification of efficacy of the methods. Additional tasks are described for developmental work designed to refine assessment capabilities.

Several regulatory tasks, such as the adoption of specific sediment quality objectives are described. Finally, a number of implementation activities that will serve as the core of the program of implementation for sediment quality objectives are also described.

The tasks presented in the workplan are expected to be completed within a seven year period. Funding for the work will be provided through the fee supported Bay Protection and Toxic Cleanup Fund. (The fee system was under development at the time the workplan was developed.) The total costs for sediment quality objectives development are estimated to be $3,224,000. Of this amount, $1,867,000 is considered to be the minimum required to develop objectives and the balance is required to provide precision and accuracy in the objectives.

Nothing in this workplan is intended to impede or preempt existing efforts by Regional Water Quality Control Boards to actively manage polluted sites.

The goal at the completion of the workplan activities is to have a core of sediment quality objectives for important constituents of concern and to have established a method for the development of additional objectives which does not require extensive developmental work for each substance of concern.

CHAPTER I
REGULATORY BACKGROUND

The State Water Resources Control Board (State Board) is required to adopt and submit to the Legislature a workplan for the development and adoption of sediment quality objectives (California Water Code (Water Code), Section 13392.6). The State Board is also required to adopt sediment quality objectives developed pursuant to the workplan and in accordance with procedures established in the Water Code for adopting and amending water quality control plans.

This workplan has been developed to satisfy the requirements of Water Code Section 13392.6. It describes the activities to be undertaken in order to develop sediment quality objectives and contains the State Board's estimates of time and costs required for the development of sediment quality objectives for California's enclosed bays and estuaries. Due to uncertainties in sediment quality assessment development of new information arising from the identified workplan activities may lead to modifications of other workplan activities which will in turn lead to improved sediment quality objectives.

Water quality management of California's enclosed bays and estuaries is directed by the State Board and seven of the nine Regional Water Quality Control Boards (Regional Boards). (The other two Regional Boards do not have boundaries that extend to coastal waters.) The programs for water quality management are developed and implemented pursuant to both the Federal Clean Water Act (Public Law 92-500 as amended) and the State's Porter-Cologne Water Quality Control Act (Water Code, Division 7). A fundamental responsibility encompassed in these laws is the protection of beneficial uses of the waters of the State from the effects of adverse water quality conditions. In 1989, this responsibility was refined somewhat by the addition of new State statutes specifying, among other things, that the State Board develop sediment quality objectives to protect the beneficial uses of bays and estuaries from the adverse affects of toxic substances (Water Code Section 13390 et seq.). A specific deadline for adoption of objectives was not imposed but a workplan which identifies the tasks to be completed in the development of sediment quality objectives must be submitted to the State Legislature by July 1, 1991.

In addition to the requirement for sediment quality objectives, a number of other elements were included in Water Code Sections 13390 through 13396.5. The State and Regional Boards are required to develop a bays and estuaries water quality control plan, identify toxic hot spots in bays and estuaries, develop a consolidated database of toxic hot spots, create a prioritized ranking of the hot spots, develop toxic hot spot cleanup plans, and amend water quality control plans and waste discharge requirements. The State Board established the Bay Protection and Toxic Cleanup Program (BPTCP) in April 1990 to coordinate the implementation of the new statutes.

State law defines sediment quality objectives as "that level of a constituent in sediment which is established with an adequate margin of safety, for the reasonable protection of beneficial uses of water or prevention of nuisances" (Water Code Section 13391.5). Sediment quality objectives to protect designated beneficial uses (e.g., aquatic life or human health) should be based on sound scientific rationale and must represent the highest (i.e., most protective) sediment quality which is reasonable (Water Code Section 13241, 40 CFR 131). Factors to be considered in establishing water quality objectives, including sediment quality objectives, include but are not limited to:

- Past, present and probable future beneficial uses;
- Environmental characteristics of the hydrographic unit under consideration;
- Water quality conditions that could reasonably be achieved through the coordinated control of all factors which affect the water or sediment quality of the area;
- Economic considerations; and
- The need for developing housing within the Region (Water Code, Section 13241).

Water Code Section 13393 provides further definition of a sediment quality objective: "...sediment quality objectives shall be based on scientific information, including but not limited to chemical monitoring, bioassays or established modeling procedures, and shall provide adequate protection for the most sensitive aquatic organisms." Sediment quality objectives can be either numerical values based on scientifically defensible methods or narrative descriptions implemented through toxicity testing.

The responsibility of the State and Regional Boards to reasonably protect beneficial uses requires that an extremely broad group of organisms which are affected by water quality conditions be considered. These include benthic (living in sediments) and epibenthic (living on the surface of sediments) organisms, organisms living in the water, waterfowl and shorebirds, and terrestrial animals (including humans) which eat aquatic organisms or drink the water. Aquatic resources can have complex food webs and interactions that are often poorly understood. Therefore, to protect beneficial uses, regulatory mechanisms need to provide confidence that the most sensitive of these organisms are being reasonably protected to ensure environmental integrity is maintained. Implicit in this approach is that the State and Regional Board's regulatory programs do not need to function at the limit of toxicity. An exact determination of the threshold of toxic effects for each substance of concern is not required. However, as part of a complete regulatory program, sediment quality objectives should provide assurance that concentrations of toxic pollutants in the environment reasonably protect beneficial uses.

Aquatic life protection is not the only consideration in sediment quality objective development. Sediment objectives must protect the most sensitive beneficial use (40 CFR 131.11). In many instances, human health is the most sensitive beneficial use to be protected. State law requires that objectives be based on a human health risk assessment if there is a potential for exposure of humans to pollutants through the food chain (Water Code Section 13393).

In addition to understanding that sediment quality objectives define levels that protect aquatic life and human health, we should explain how sediment objectives are proposed to be used in the regulatory system. There are three uses of sediment quality objectives: (1) evaluating the overall quality of water body, (2) developing effluent limitations, and (3) triggering the need for determining further actions (e.g., toxic hot spot cleanup plans, additional site characterization, etc.). Objectives provide a means for evaluating the overall quality of a waterbody. Data from ambient sampling, collected either as part of ongoing monitoring programs or surveillance activities, can be compared to sediment quality objectives to determine if impairment is occurring. If impairment is occurring then corrective actions can be undertaken. Sediment quality objectives also serve as a screening mechanism for prioritizing resource allocations and corrective actions. Objectives provide a means for identifying where impacts are occurring (e.g., toxic hot spot identification) and, therefore, allow for comparison of the resources at risk and potential costs of corrective actions.

A second use of sediment quality objectives is for the development of control measures including effluent limitations which are enforceable limits placed on individual dischargers and nonpoint source controls including the implementation of Best Management Practices (BMPs). Effluent limits define the contributions of pollutants allowable from a particular discharge. Effluent limitations also establish long term planning goals in the design of facilities and for the evaluation of best management practices and nonpoint source control measures. Established methods for the translation of sediment quality objectives into effluent limitations do not currently exist.

Several approaches will be considered for use in the development of permit provisions. Some examples of what might be considered are: (1) a trial and error approach where effluent limits are repeatedly revised downward until satisfactory sediment quality is attained, (2) multiplication of an effluent concentration by a partitioning ratio (e.g., mass of pollutant in effluent/mass of pollutant in sediment) where the sediment component of the ratio is derived from the sediment quality objective, or (3) application of fate and transport models. Several different methods may be incorporated into the regulatory programs based on specific circumstances. Development of these methods and selection of appropriate methods to be applied to specific discharge situations will be addressed in the Section on the implementation of sediment quality objectives contained in this workplan.

CHAPTER II
REVIEW OF EXISTING APPROACHES FOR ASSESSING SEDIMENT QUALITY

The State Board staff used a two-step approach for the development of the sediment quality objectives workplan: (1) development of the workplan based on a technical workshop on the state of knowledge related to the evaluation of sediment quality assessment tools and strategies for developing sediment quality objectives; and (2) public review of the workplan and consideration of the workplan by the State Board.

Several approaches to assessment of sediment quality have been developed. Of these, four are the most appropriate for consideration of development of sediment quality objectives. These approaches are the Equilibrium Partitioning approach (EPA 1989a, EPA 1990) developed by EPA, the Apparent Effects Threshold approach (PTI 1988, EPA 1989b) developed by the State of Washington and EPA Region X, the Spiked Bioassay approach (Giesy and Hoke 1990, Swartz et al. 1988), and a Weight of Evidence approach (Long and Morgan 1990).

Equilibrium Partitioning (EqP) Approach

Using this approach, sediment quality objectives would be established at chemical concentrations in sediment that ensure interstitial concentrations do not exceed EPA water quality criteria. The EqP approach assumes that pollutants are generally in a state of thermodynamic equilibrium and that the relative concentration of a pollutant in any particular environmental compartment (sediment, pore water, ambient water, etc.) can be predicted using measured partitioning coefficients for specific substances in equilibrium equations. The development of a regulatory level relies on the assumption that pore water is the dominant route of exposure. In California, adopted water quality objectives would be used as the protective level for pore water concentrations. Acceptable sediment concentrations would be derived using the appropriate partitioning coefficients. The EqP approach is currently limited to nonpolar, nonionic compounds although methods for metals are under development. The protection of sediment ingesting organisms is not addressed in this approach. Also the assumptions stated above have not been adequately tested.

Apparent Effect Threshold (AET) Approach

The AET approach is an empirical method applying the triad of chemical, toxicological, and benthic community field survey measures to determine a concentration in sediments above which adverse effects are always expected (statistically significant difference of adverse effects are predicted at $p \leq 0.05$). Each suite of measures consists of chemical and toxicological measures taken from subsamples of a single sample and benthic analysis conducted on separate samples collected at the same time and place. A large suite of chemical measures and a large number of sites are required before an AET value can be estimated. The method assumes a single toxicant is responsible for effects measured at a given site. In addition, the value generated is by design, an effect level rather than a protective level. While above the AET one can expect adverse effects, the method does not recognize that below the AET adverse effects may be attributed to the substance of concern. A major limitation of the method is that the observed relationships between effects and chemical concentrations are based on correlations only (the relationship does not demonstrate cause and effect).

Spiked Sediment Bioassay Approach

The spiked bioassay approach generates an organism's response following the addition of known quantities of a toxicant to a sediment sample and subsequent bioassay. Known mixtures of toxicants can also be tested. The dose response relationship can then be used to identify appropriate effect and no effect levels. Because of a number of complicating factors in the handling and measurement of the sediments and toxicants this approach can only be considered a rough approximation of the in situ effects of toxicants in the environment. Several factors appear to indicate that toxicants in spiked bioassays are more available and, therefore, the test may over estimate toxicity. However, other factors indicate that these tests may not reflect the important routes of exposure (like injestion of benthic organisms) and, therefore, may under estimate toxicity. In combination with corroborating field information spiked bioassays can be a powerful tool.

Weight of Evidence Approach

This approach relies on a preponderance of evidence to indicate when effects produced by specific pollutants are likely to occur. The most comprehensive use of this approach is the work of Long and Morgan (1990) in which information from the National Oceanic and Atmospheric Administation's National Status and Trends Program and other sources were evaluated. Long and Morgan assembled chemical data, which had accompanying biological data, and ordered the data in ascending order of chemical concentration. The data used were from studies which either predicted or observed effects in association with increasing concentrations of specific analyses in sediment. Two values were identified: (1) the 10th percentile of the ordered data, which is assumed to represent the point at which adverse effects begin to occur; and (2) the 50th percentile of the ordered data, which is assumed to represent the point above which adverse effects are expected for most species. This approach has the benefit of utilizing a large portion of available data and producing a discrete numeric range of concern. However, the data used have been collected using various methods which are not necessarily comparable. The use of percentiles for demarcation of the effects range, while useful, may not provide equivalent protection across all substances.

Each of these methods provides useful information but all appear to need additional development to satisfy California's statutory requirements for sediment quality objectives. The AET and weight of evidence approaches describe effect levels, while the EqP and Spiked Bioassay approach have significant limitations on their applicability to field conditions. Development of addtional information and the use of some of these methods in concert may provide the best means of developming sediment quality objectives.

Sediment Quality Assessment Technical Workshop

The State Board sponsored a technical workshop on sediment quality assessment in February 1991. Over 20 experts in sediment quality assessment from around the country attended. The purpose of the workshop was to assist State Board staff in the design of a specific strategy for California, determine which existing evaluation tools were appropriate for use in California, and identify critical areas for new research and development.

Several fundamental considerations came out of the workshop.

- Existing evaluation tools such as toxicity tests are powerful methods which provide useful information that allow the characterization of specific sites. Each evaluation tool provides an estimate of the effects of pollutants on organisms in the environment. To broaden these estimates and to generalize this information in the form of sediment quality objectives these tools must be linked together (e.g., field effect measures with toxicity tests).

- The available tools should be validated by comparing the tools with field measurements (correlation of laboratory measures with field measures and observations) in order to refine our descriptions of protective levels.

- In light of our current capabilities, the emphasis on field measurements requires a weight of evidence approach to understanding conditions in California's waters. Existing tools, even when coupled, are not likely to provide one discrete statement which depicts sediment quality. A strictly mechanistic cause and effect understanding is beyond current capabilities and any description of sediment impacts should be based on the range of responses observed.

- Comparative measures, either gradients in the field or gradations in responses described by a number of field sites should be used wherever possible in validations of tools and development of sediment quality objectives.

- A long term goal should be to develop a predictive capability of moderate effects from exposure to toxicants, based on relatively few and simple measurements.

Two additional considerations which came from the workshop but were not clearly articulated in the proceedings are:

- An implication of the weight of evidence approach is that assumptions about the relative importance of particular pieces of evidence will be required in order to make regulatory decisions. Every effort should be made to clearly state key assumptions.

- o The reliance on field measures requires that the greater variability of field conditions compared to lab conditions be addressed. This implies that decisions will be made with less precision in the data (larger confidence intervals around decision points, more uncertainty) than is typical when using only lab data or model systems.

A summary of the workshop proceedings is being prepared by the Aquatic Habitat Institute (AHI) and should be available in mid 1991.

CHAPTER III
GENERAL SEDIMENT ASSESSMENT STRATEGY

Sediment quality objectives describe the general conditions considered to be protective of the most sensitive beneficial uses. To account for the variety of environmental conditions and arrive at an objective, assessment of many different sites must be undertaken. A consistent approach to these site assessments is critical to the development of scientifically sound sediment quality objectives.

The process for developing sediment quality objectives has eight steps: (1) identify beneficial uses to be protected, (2) identify relevant existing information, (3) develop narrative sediment quality objectives, (4) develop site ranking criteria, (5) develop a toxicity sediment quality objective, (6) develop chemical specific sediment quality objectives, (7) develop appropriate implementation measures, and (8) review and revise sediment quality objectives, implementation measures, or criteria developed in steps 3 through 7. The overall goal is to develop a flexible system for predicting sediment quality impacts.

The workplan is designed to implement the steps listed above. Included in the workplan are activities that can be implemented immediately on a limited scale using existing resources. Improvement in these areas and development of the remaining areas requires that a number of tasks be undertaken. In some instances, activities undertaken by the State can be coupled with efforts of other agencies, sharing costs and information, to complete a given task.

CHAPTER IV
BUDGET CONSIDERATIONS

The estimated cost for the identified tasks is $3,224,000 in contract funds over a seven year period. Of this amount $1,867,000 is estimated for the highest priority tasks and the balance, $1,357,000 is estimated for tasks of moderate priority. A few specific tasks will be undertaken exclusively by State or Regional Board staff. However, most of the work will be conducted employing a combination of State and Regional Board staff, contracts, and collaborative efforts of other agencies. Purely staff activities are identified in the workplan. It is estimated that at least 10 percent of the cost for each of the high and moderate priority categories will be contributed or completed by collaborating agencies. Discussions are presently underway with both NOAA (Long, personal communication) and EPA (Young, personal communication) regarding collaborative efforts involving either shared costs or in-kind services. The BPTCP has budgeted $403,000 and one position for FY 1991-92. An additional $40,000 is expected in collaborative funding. State board funds will come from the Bay Protection and Toxic Cleanup fund (fee supported). Annual expenditures will be adjusted consistent with fee collection.

Some examples of ongoing shared interests are field measurements of partitioning of organic chemicals being conducted by the EPA in conjunction with the U.S. Navy; sediment quality research being conducted by the Southern California Coastal Water Research Project; and U.S. Geological Survey contribution to development of a waste load allocation for South San Francisco Bay. Table 1 lists a number of agencies which may be interested in collaborative efforts and their general area of interest.

TABLE 1. Agencies currently involved in sediment quality assessment, that may be interested in cooperative efforts in California.

AGENCY	AREA OF INTEREST
Regional Water Quality Control Boards	Toxic hot spot identification and characterization, sediment quality objectives, sediment toxicity testing, sediment transport modeling.
U.S. EPA	Management of contaminated sediments, remediation, sediment quality criteria, partitioning theory and toxicity testing development, sediment chemistry.
U.S. EPA, Region 9	Standards development, coastal dredging and disposal.
U.S. Geological Survey	Sediment transport studies, benthic community ecology, bioaccumulation and trophic transfer.

TABLE 1 (Continued)

National Oceanic and Atmospheric Administration	National status and trends, national mussel watch program, sediment toxicity, benthic surveillance, sediment quality criteria.
U.S. Navy	Pollutant fluxing, sediment quality assessment.
U.S. Army Corps of Engineers	Dredging and dredge spoils disposal, sediment toxicity testing, benthic analysis.
California Department of Fish and Game	Sediment toxicity testing, benthic analysis, sediment quality standards.
University of California and California State Universities	Sediment transport modeling, sediment chemistry, sediment quality standards
Other State governments and Canadian provincial governments	Sediment quality standards.
Southern California Coastal Water Research Project	Sediment quality assessment, benthic ecology characterization, identification of impacts of waste water discharges.

CHAPTER V
STRUCTURE OF CHEMICAL SPECIFIC SEDIMENT QUALITY OBJECTIVES

The precise methods for calculating sediment quality objectives will be fully explained when the chemical specific objectives are proposed as amendments to the water quality control plans. We will use the most current information and techniques available when amendments are proposed. The following description gives our best estimate of the information required and calculation methods that will be used.

We anticipate developing sediment quality objectives for individual chemicals by combining AET values, Equilibrium Partitioning values, and the Lowest Observed Effect Level from spiked bioassay. These three measures could be combined by taking the geometric mean of the values and then multiplying by an uncertainty factor which accounts for the concordance of the data. The correction factor would be equal to the inverse of the range of the three measures. For example, if the range of AET, EqP, and spiked bioassay values were 2 then the sediment quality objective would be one half of the geometric mean of these values. If the range were 10 the sediment quality objective would be set at one tenth of the geometric mean. If the resulting value does not fall below the lowest of the observed effect levels, then the lowest observed effect divided by 2 will serve as the objective.

The selection of these particular measures allows for the integration of empirical data developed for AETs, theoretical information used in EqP, and cause and effect relationships established by spiked bioassays.

The combination of these three methods balances the uncertainties and limitations of any one method by incorporating the strengths of the other two methods to produce a single value. The use of an uncertainty factor ensures a value below known effect levels, and the use of the inverse of the range of the effects levels encompasses increasing confidence in the prediction which comes with a narrow range of the effects values. A sediment quality objective should provide a descriminating measure that identifies both clean and polluted sites. Accordingly, the final proposed objectives will rely on best professional judgment to establish a suitable objective that incorporates reasonable safety factors.

CHAPTER VI
WORKPLAN ELEMENTS

Activities identified in the workplan can be divided into nine developmental areas: (1) identification of key species, (2) development of ranking criteria, (3) development and verification of AET values, (4) proposed adoption of a toxicity objective, (5) field validation of EqP approach, (6) expanded spiked bioassay data, (7) adoption of Sediment Quality Objectives, (8) investigation of additional evaluation tools, and (9) development of implementation measures.

Many of the tasks identified below reflect considerations from the technical workshop. Many of the tasks listed are characterized by a heavy reliance on field work and a broad scope of investigation utilizing a number of evaluation tools. Regional Board monitoring activities, hot spot identification efforts, and general surveillance activities of the Regional Boards will be integrated into the sediment quality objectives development activities. The estimated costs to implement the workplan are presented in Table 2. The timeline for completion of the tasks identified below is contained in Table 3.

State law requires a description of the nature of actions necessary to achieve objectives (Water Code Section 13242(a)) and the development of toxic hot spot cleanup plans which include provisions to reduce the accumulation of pollutants and the creation of new hot spots (Water Code Section 13394). (A toxic hot spot is defined as a location ... which exceeds an adopted sediment quality objective (Water Code Section 13391.5)). Implementation of sediment quality objectives present unique problems related to identification of contributing sources and the duration of the impacts resulting from polluted sediments. In order to provide direction in the implementation of sediment quality objectives and clarify the intended use of these objectives, activities required for implementation are included in the workplan. Various elements of these activities are currently under development through other State and Regional Board programmatic activities. We anticipate rounding out the development of these implementation methods simultaneously with the development of sediment quality objectives so that a clear program of implementation can be presented at the time of adoption of sediment quality objectives.

1. <u>IDENTIFICATION OF KEY SPECIES</u>

   A fundamental step in the development of sediment quality objectives is the identification of the community of organisms to be evaluated. In general, the assumption will be made that the benthic community represents the most sensitive community needing protection from pollution of sediments. This assumption is based on the intimate contact and long duration of contact (in some instances entire life cycles) experienced by the benthic organisms. However, sediment pollution can also affect non-benthic species, either through direct exposure to suspended sediments, exposure to pollutants diffusing from sediments, or through consumption of organisms contaminated by polluted sediments and the subsequent trophic accumulation of pollutants. Therefore, efforts may be made to define routes of exposure and sentinel species that can serve as keys to protection of non-benthic species including humans. Where evidence indicates problem exposures of higher trophic level organisms, these organisms will be considered specifically. State and Regional Board staff will be responsible for identifying key species.

Task A: Human Health Risk Assessment

The Department of Health Services will, under contract to the State Board, conduct a feasibility study and workplan for a human health risk assessment for contaminated sediments. Assuming the feasibility study identifies a reasonable program a human health risk assessment will be undertaken.

Cost: $425,000 (assuming $125,000 for the feasibility study and workplan and $300,000 for the risk assessment.)
Time: 30 Months

2. DEVELOPMENT OF RANKING CRITERIA

Water Code Section 13393.5 requires the adoption of criteria for the assessment and priority ranking of toxic hot spots. Initial efforts in the assessment of sediment quality will be developed for inclusion as part of the required ranking criteria. In addition, for programmatic purposes it is important to classify sites as either (1) clean, (2) a potential hot spot, or (3) a known hot spot. It is anticipated that using the methods of Long and Morgan (1990) we will establish three categories of sites: (1) below the Lowest Observed Effect Level (LOEL) will be considered clean, (2) between the LOEL and 50th percentile will be considered in need of characterization (a potential hot spot), and (3) above the 50th percentile will be considered adversely effected (a known hotspot). These criteria will be refined and brought before the State Board for approval in 1992.

Task A: Data Update

New data, not included in the evaluation of Long and Morgan, will be collected and evaluated for acceptability. These data will be incorporated with the data used by Long and Morgan. Data for additional substances will be compiled as well.

Cost: $45,000
Time: 3 Months

Task B: Revision of Effects Levels

The data from Task A will be ordered and the Lowest Observed Effect Levels (LOEL) and 50th percentiles identified. A list of the effects ranges for all substances for which sufficient data has been compiled will be generated.

Cost: $25,000
Time: 3 Months

Task C: Develop Narrative Sediment Quality Objectives

Based on a review of the data assembled in Task A, narrative sediment quality objectives will be developed and proposed for State Board adoption, during the triennial review of the Water Quality Control Plan for Enclosed Bays and Estuaries of California. This planning process is subject to the usual public notice and review procedures for water quality control plan amendments. State Board staff will develop these objectives.

3. DEVELOPMENT AND VERIFICATION OF AET VALUES

Apparent Effects Threshold values will be developed. These values require "matched data", i.e., synoptically collected chemistry and toxicity. It has been demonstrated that toxicity responses in bioassays often correlate poorly with bulk sediment chemistry, but strong correlations exist between sediment concentrations when adjusted for percentages of various parameters such as total organic carbon. Several of these "normalizing" parameters have been suggested for use. Appropriate toxicity tests and chemical normalization parameters must be selected so that a consistent data set can be developed. The selection process for both toxicity tests and normalization parameters will include first, an initial selection based on a review of existing information and then field verification of tests and parameters. The tests to be employed in the program are primarily those in current use. However, promising new methods may be identified for developmental work where they pose significant benefits to the program. To expedite the process, work will initially focus on the following select group of constituents of concern: Cadmium (Cd), Copper (Cu), Mercury (Hg), DDT and metabolites, Flouranthene, Penathrene, Anthracene, and PCBs. These substances were recommended by the workshop and are distinguished by a rich literature and a large amount of field data.

The BPTCP is also identifying a suite of acceptable methods for use in regional monitoring programs. The monitoring program list is expected to be complete before the list of acceptable methods for use in derivation of AETs. Once both lists are generated the sediment methods for the monitoring programs will be compared and reconciled with the AET methods. Methods on the reconciled list will satisfy the needs of both AET development and monitoring programs. Monitoring data will, therefore, be usable for development of AET values. Data derived from the use of these methods will be stored in the consolidated database.

Task A: Toxicological Methods

At least six test methods will be selected to measure toxicological response in sensitive estuarine or marine species (at least two of which are suitable for use in range of salinity from 5 to 25 parts per thousand) and three tests of toxicological response in sensitive freshwater organisms.

Cost: $30,000
Time: Four Months

Task B: Chemical Methods

Selection of chemical analytical methods in sediment for both developmental work and for use by commercial labs in routine analysis will be completed for each of the substances of concern. Selection of candidate normalization parameters for each substance will also be completed. Quantitative immunoassay techniques will be considered for development purposes. Techniques for improving data interpretation will also be considered.

Cost: $30,000
Time: Four Months

Task C: Biological Methods other than Toxicity Testing

Verification of the suitability of the selected toxicity tests requires comparing the toxicity test results with measurements from the field of both exposure and effect. The field measurements to be used may include biomarkers, community level analysis, sentinel species, pathology, etc. Selection of biological field measurements will be based on a review of the literature.

Cost: $50,000
Time: Six Months

Task D: Standard Sampling and Handling

In order to provide reliable information from the development work, consistent use of selected protocols must be employed at all sites. Procedural steps needing clarification will be identified during the methods selection. Practical options for the identified procedural steps will be tested and acceptable sampling and handling protocols established. At a minimum comparisons and determination of the acceptability of core samplers verses grab samplers; oxygenated, anoxic, and redox potential discontinuity layer effects on chemistry and toxicity, and storage time and methods must be completed. Information from this task will be incorporated in Regional monitoring programs.

Cost: $60,000
Time: 6 Months

Task E: Selection of Reference Sites

Apparent Effects Thresholds require the comparison between a clean reference site and the sites under investigation. Reference sites should have physical characteristics similar to the site under investigation. Since a number of different sites will be evaluated in the development of AETs, several reference sites will be necessary. Candidate sites will be identified and characterized using the toxicity tests, chemical methods, and field biological methods selected above. A minimum of four reference sites will be required; one site of fine grained material relatively high in organic matter, one site of fined grained material low in organic matter, one site of heterogeneous grain size exposed to saline ocean currents, one site of heterogeneous grain size exposed to riverine flows. In order to determine the range of conditions that may be expected at a given site the characterizations will be conducted in both wet seasons and dry seasons. Because only limited areas of estuaries are truly fresh water systems the initial sites selected will be in brackish or marine waters.

Cost: The specific suite of tests to be conducted will be decided after initial evaluation and selection of methods (see above). Costs for this task are based on the following assumptions. Each site will consist of 10 stations where the following measures will be undertaken: 5 toxicity tests with 5 replicates each (average cost $500/test), 2 biomarkers (average cost $500/test), bulk sediment chemical analysis for priority pollutants and other selected substances (average cost $1,150/station), chemical analysis of normalization parameters, physical characteristics (grain size, pH, etc., average cost $200/station), benthic community analysis (average cost $500/station), bioaccumulation (average cost $1,700/station). Sampling and handling costs are estimated to be $12,000/site. Total per site cost is estimated to be $83,000. The total cost of four sites characterized in each of two seasons is therefore $664,000.

Time: 18 months per site (may be done simultaneously)

Task F: <u>Verification of Toxicity Test Reliabilty/Gradation of Effects</u>

The ability of toxicity tests to identify effects in the field will be described by simultaneously measuring toxicity and the suite of selected field measures, then evaluating the results of concordance of various end points. In order to examine a breadth of conditions the monitoring efforts of the Regional Boards will be augmented at selected sites. Selected methods will be added to those employed by the Regional Boards to provide a more complete characterization of sites. Sites will be selected to incorporate gradations in field effects. Information from all sites tested will be pooled to establish gradations of effects. The data will be evaluated to determine possible subcategories of gradations such as gradations within grain size distributions. Toxicity test results will be correlated with gradation information to determine effects identifiable through toxicity testing endpoints.

Cost: Assuming the following augmentation of Regional Board monitoring at each of 30 sites each year: 2 additional toxicity texts, 1 additional biomarker measurement, 1 additional benthic analysis = $95,000/year. Estimated 2-year expenditure with evaluation to determine if this should be an ongoing expenditure. Total Cost: $190,000

Time: Ongoing

Task G: Normalization of Chemical Measurements

Analysis and comparison of the normalization parameters will be conducted to determine if significant improvements in correlation of chemical concentration with biological endpoints are realized from the use of normalized data. Those parameters which yield significant improvements in correlations will be used in further analysis and will be recommended for use in Regional Board monitoring programs.

Cost: $25,000
Time: 3 Months

Task H: Development of AETs

The data from the augmented Regional Monitoring Programs will be evaluated and those tests demonstrating the best combination of cost efficiency and reliability will be selected for development of AETs. Normalized chemical data will be used for this process. AETs will initially be developed for the selected constituents of concern in order to expedite the development of sediment quality objectives. Toxicity tests used for AET development will be recommended for ongoing Regional Board monitoring programs.

4. PROPOSED ADOPTION OF A TOXICITY OBJECTIVE

Once a suitable suite of tests are available (i.e., the evaluations listed above are completed) a toxicity objective will be proposed for adoption as an amendment to the Water Quality Control Plan for Enclosed Bays and Estuaries of California. Reflecting the weight of evidence approach, it is currently envisioned that the toxicity objective will require that two tests from the suite demonstrate toxicity at a site before the site will be considered to be impaired. The proposed adoption of a toxicity objective will be subject to the normal public review and hearing process and will be presented to the State Board for there consideration. State Board staff will develop the toxicity objectives.

5. FIELD VALIDATION OF EQUILIBRIUM PARTITIONING

Field validation of equilibrium partitioning theory requires both a verification of predicted pore water concentrations and characterizations of the likelihood that equilibrium conditions will be established. Another factor of concern is the change in toxicity that occurs when sediments are resuspended. If establishment of equilibrium takes a long time relative to the frequency of disturbance of the sediments then a greater exposure is likely and an increase in toxicity associated with a given sediment concentration can be expected.

Task A: Verification of Predicted Sediment and Pore Water Concentrations

Measurements of concentrations of the constituents of concern will be conducted on various fractions of field samples (e.g., organic matter, pore water, dissolved organic carbon, mineral fraction) and compared to predicted values.

Cost: Assembling 25 stations at 5 different sites and investigate in both wet season and dry season. Each station will be analyzed for normalized sediment concentrations, dissolved organic carbon and pore water concentrations, physical characteristics, and 50 trace organics (25 PCBs, 25 PAH). $400,000

Time: 24 Months

Task B: <u>Characterization of the Likelihood of Equilibrium Conditions</u>

Adsorption/desorption rate constants will be determined in laboratory analyses in selected sediment types for the constituents of concern. These rates will be compared to field information describing the likely residence time of sediments, in order to determine the likelihood of equilibrium conditions being established.

Cost: $50,000 per chemical (assuming several are done simultaneously). A minimum of four chemicals will be evaluated for a total cost of $200,000.

Time: 6 to 24 Months

Task C: <u>Effects of Resuspension on Toxicity</u>

Selected toxitity tests or biomarker studies will be conducted to determine the effects of resuspension of sediments on exposure and toxicity. Intervals of resuspension short enough to preclude equilibrium conditions from establishing, as well as resuspension that disrupts established equilibrium conditions will be evaluated. Substances to be evaluated will be chosen in order to demonstrate the range of effects likely to occur in order to develop a potential correction factor to apply to values developed through the EqP approach.

Cost: $250,000
Time: 24 Months

6. <u>SPIKED BIOASSAYS</u>

Once a suite of toxicity tests have been evaluated and selected for ongoing use in AET development, two or three toxicity tests will be selected to use for spiked bioassays.

Task A: <u>Evaluation of Spiking Techniques</u>

In spiking sediments for bioassay use the intent is to provide a sediment with a uniform concentration of the pollutant of concern in a state that resembles exposure an organism would experience from field sediments. Literature will be reviewed to identify techniques for spiking the constituents of concern into sediments. Where ambiguity exists in the selection of appropriate methods, alternative techniques will be tested and acceptable spiking methods selected. Information from the evaluation of the likelihood of equilibrium conditions will be used to design optimum spiking protocols.

Cost: $100,000
Time: 12 Months

Task B: Dose response of toxicity test/spiked bioassays

Clean sediment will be spiked with appropriate pollutants, serially diluted and tested for toxic effects using the selected tests. Bulk and normalized chemical concentrations will be measured for each dilution. Where possible, dose-response curves will be generated for each sediment/pollutant combination. At a minimum, Lowest Observed Effects Levels (LOEL) will be determined.

Cost: $300,000
Time: 18 Months

7. ADOPTION OF SEDIMENT QUALITY OBJECTIVES

Where AET values, EqP values, and Spiked Bioassay values are available a sediment quality objective may be proposed for adoption. The method described in Chapter V will be used to develop objectives. In some cases these three measures already exist and objectives can be proposed immediately. Much of the work identified above will serve to refine any objective developed in the short run as well as serve as the basis for additional sediment quality objectives. Where possible, information used to refine a sediment quality objective will be developed for general application to groups or classes of substances. All the activities listed above may not be undertaken for each chemical for which a sediment quality objective is developed. The proposed adoption of sediment quality objectives will be subject to the usual notice and public review requirements for water quality control plan amendments. State Boad Staff will develop sediment quality objectives.

8. INVESTIGATION OF ADDITIONAL EVALUATION TOOLS

In order to improve our assessment capability a number of additional tasks are included which are aimed at specific issues in sediment quality characterization. Throughout the process of assessment and objectives development, techniques which are not fully developed but offer improvements in measurement capability or economy will be identified. These methods will be fully developed for use in regulatory programs as opportunity allows.

Task A: Correlation of Toxicity Tests/Field Gradient

Field sites will be identified which exhibit a gradient in chemical concentration of a constituent of concern. At each of the gradients identified, the full suite of toxicity tests and the full suite of field measurements will be conducted. Results of these tests and measurements will be evaluated in order to establish a "dose response" relationship between field level effects or toxicity test endpoints and chemical concentrations. Thresholds of effect will be identified.

Cost: $170,000 per site
Time: 18 Months

Task B: Dose Response of Toxicity Test/Dilution

As an alternative to spiked bioassays field sediments known to be highly polluted with one or a few pollutants will be collected and serially diluted with clean sediment. Selected toxicity tests will then be conducted on each dilution. Bulk and normalized chemical concentrations will be measured for each dilution. Dose response curves will be generated for each sediment/pollutant combination.

Cost: $70,000
Time: 18 Months

Task C: Biomarkers as Predictors of Effects

Biomarkers are biochemicals which can be used to identify either exposure of organisms to toxicants or effects from such exposures. The literature will be reviewed and promising biomarkers selected for investigation. The selected biomarkers will be measured either at the gradient sites or at sites selected for routine monitoring. Biomarker measurements will be correlated with both results of toxicity tests and with other biological measures such as community indices to determine if and to what extent these measures of exposure are predictive of effects. Twenty to thirty sites will be investigated.

Cost: $90,000
Time: 24 months

Task D: Identification of Pulse Loading Events

Identification of magnitude and duration of significant pulse loadings of pollutants will be undertaken initially by characterizing loadings during and immediately after storm events. Some activities in this area are currently underway. These existing and ongoing efforts to understand pulse loading will form the basis for design of further investigations. Other important pulse events such as high riverine dischargers will also be investigated.

Cost: $100,000 per loading site
Time: 12 Months

9. INFORMATION NEEDED TO IMPLEMENT SEDIMENT QUALITY OBJECTIVES:

Due to the long residence time of many pollutants in sediments and, in some cases, the complexities of tracing back to sources from a site identified as adversely effected, efforts to prevent or minimize the production of waste materials become of foremost importance in the program of implementation contained in Water Quality Control Plans. Water Code Section 13391 relates to the development of a comprehensive program for toxic hot spot management and states, in part, "...the state and regional boards shall, to the extent feasible, identify specific discharges or waste management practices which contribute to the creation of toxic hot spots, and shall develop appropriate prevention strategies...". This added statutory emphasis dovetails with the program of implementation needs for sediment quality objectives.

A number of activities will be undertaken to identify appropriate prevention and minimization options for constituents of concern. Existing regulatory mechanisms such as effluent limitations, conditional waivers of waste discharge requirements, implementation of BMPs, cease and desist orders, cleanup and abatement orders, etc. will be used as needed to effectively control problem discharges or remediate polluted sites. Much of the information developed as part of this task will be needed for the development of regional and Statewide Toxic Hot Spot Cleanup Plans. These tasks will be funded as these plans are developed.

A. PREVENTION AND WASTE MINIMIZATION

Task 1: Technical Workshop in Implementation Measures

Staff will evaluate the need for a technical workshop covering various aspects of implementating sediment objectives. Each of the tasks listed below serve as a potential area to be addressed in a technical workshop. In addition, the need to establish technical advisory committees for various aspects of implementation will be considered as the existing information is reviewed.

Task 2: Identify Processes of Generation

For each constituent of concern the literature will be reviewed to determine major uses or processes which lead to the generation of the substance as a waste. Public and private sector entities involved in the identified uses and processes will be contacted to assist in determining quantities of waste associated with the process or use. Results of the evaluation will be published as a staff report.

Task 3: Identify Process Points to Target for Reduction of Pollutants

Working with the Regional Boards and identified public and private entities, potential methods for reduction of waste generation will be identified. Specific process points to target for reduction will be identified. If necessary, technical advisory groups will be established to assist in the identification of potential waste minimization activities. General methods and evaluation techniques will be published as a staff report. Specific methods and techniques will be addressed on a case specific basis.

Task 4: Loading and Source Identification

Water quality data will be reviewed to identify and quantify loading of pollutants of concern. Monitoring of ambient water and sediment will be undertaken to identify and quantify additional loading. If necessary, targeted monitoring of specific areas will be undertaken to confirm or quantify loadings.

Task 5: Recommended Control Measures for Significant Loadings

Information from the above listed activities will be reviewed and significant points of loading identified. Recommended control measures for these loading points will be developed and published as a staff report.

B. REMEDIATION AND TREATMENT

Task 6: Toxicity Identification Evaluations

A toxicity identification evaluation (TIE) will be conducted on a selected site as a demonstration project. The goal of the TIE will be to identify toxic agents at the site and to demonstrate effective techniques for determining which substances are contributing to toxicity. Several steps in the TIE may need considerable development time.

Task 7: Hydrodynamic Modeling

Models of transport of sediments will be valuable tools in design of remediation and treatment alternatives at specific sites. Generic models may be of great benefit if customized for the specific local conditions at the remediation site. A number of modeling efforts are currently underway. As opportunities arise, the development of generic sediment transport models will be supported. Particular emphasis will be placed on understanding wave action in shallow water environments, flocculation and settling speed.

Task 8: Identification of Appropriate Methods

Information on technical approaches to the treatment (both as effluent and as in place sediments) and remediation of polluted sites will be reviewed. Useful and promising methods will be identified.

Task 9: Technical Advisory Committee

A subcommittee of the Bay Protection Toxic Cleanup Program's Monitoring and Surveillance Task Force (Water Code Section 13392.5) will be established to assist in the identification of appropriate methods. The committee will also serve to advise on methods suitable for use at specific sites requiring remediation. Experts in these areas will be invited to participate in the subcommittee.

TABLE 2. DRAFT WORKPLAN FOR DEVELOPMENT OF SEDIMENT QUALITY OBJECTIVES ESTIMATED CONTRACT COSTS* OF COMMITMENTS BY TASK

TASK		DESCRIPTION	AMOUNT	HIGH PRIORITY AMOUNT
1		BENEFICIAL USE IDENTIFICATION		
	A	Human Health Risk Assessment	$ 425,000	$ 125,000
2		DEVELOPMENT OF RANKING CRITERIA		
	A	Data Update	45,000	45,000
	B	Revision of Effects Level	25,000	25,000
	C	Narrative Sediment Quality Objective		
3		DEVELOPMENT AND VERIFICATION OF AETs		
	A	Toxicological Methods	30,000	30,000
	B	Chemical Methods	30,000	30,000
	C	Biological Methods	50,000	50,000
	D	Standard Sampling and Handling	60,000	60,000
	E	Selection of Reference Sites	664,000	332,000
	F	Verification of Toxicity Tests	190,000	95,000
	G	Normalization of Chemical measures	25,000	25,000
	H	Development of AETs		
4		PROPOSED ADOPTION OF TOXICITY OBJECTIVE		
5		FIELD VALIDATION OF EQUILIBRIUM PARTITIONING		
	A	Verification of Pore Water Concentration	400,000	200,000
	B	Likelihood of Equilibrium Conditions	200,000	200,000
	C	Effects of Resuspension on Toxicity	250,000	250,000
6		SPIKED BIOASSAYS		
	A	Evaluation of Spiking Techniques	100,000	100,000
	B	Dose Response of Toxicity Test	300,000	300,000
7		ADOPTION OF SEDIMENT QUALITY OBJECTIVES		
8		ADDITIONAL EVALUATION TOOLS		
	A	Toxicity Tests/Field Gradient	170,000	
	B	Dose Response of Toxicity Test/Dilution	70,000	
	C	Biomarkers of Effects	90,000	
	D	Identification of Pulse Loading	100,000	
		TOTAL	$3,224,000	$1,867,000

* It is anticipated that 10 percent of these costs may be contributed, either as grants or in-king services, by collaborating agencies.

TABLE 3. SUMMARY DRAFT WORKPLAN FOR DEVELOPMENT OF SEDIMENT QUALITY OBJECTIVES DURATION OF TASKS, ESTIMATED COMPLETION DATE OF KEY PRODUCTS, AND PERCENTAGE OF PROGRAM EXPENSES BY YEAR

TASK	DESCRIPTION	1991	1992	1993	1994	1995	1996	1997
1)	Identification of Key species	I-------	-------I					
	Risk Assessment Feasibility Study		X					
2)	Develop Ranking Criteria	I-------	---------I					
	Narrative Sediment Quality Objectives		X					
3)	Development and Verification of AETs		I-------	--------	--------	--------	--------	-------I
	Methods Selection		X					
	Reference Site Characterization				X			
4)	Proposed Adoption of Toxicity Objective				I--------I			
	Proposed				X			
	Adopted					X		
5)	Validation of Equilibrium Partitioning		I-------	--------	--------	--------	--------	-------I
	Likelihood of Equilibrium					X		
	Effects of Resuspension						X	
6)	Spiked Bioassays		I-------	--------	--------	--------	--------	-------I
	Techniques			X				
7)	Adoption of Sediment Quality Objectives				I-------	--------	--------	-------I
	Initial Objectives Proposed				X			
	Additional Objectives Proposed						X	X

TASK	DESCRIPTION	1991	1992	1993	1994	1995	1996	1997
8)	Investigation of Additional Tools				I------	------	------	------I
	Field Gradient						X	
	Dilution Dose Response							X
	Pulse Loading							X
ANTICIPATED EXPENDITURES IN $1,000's of Dollars		415	450	605	525	459	380	300
Percentage of Workplan Expenditures		13	24	21	16	14	12	9

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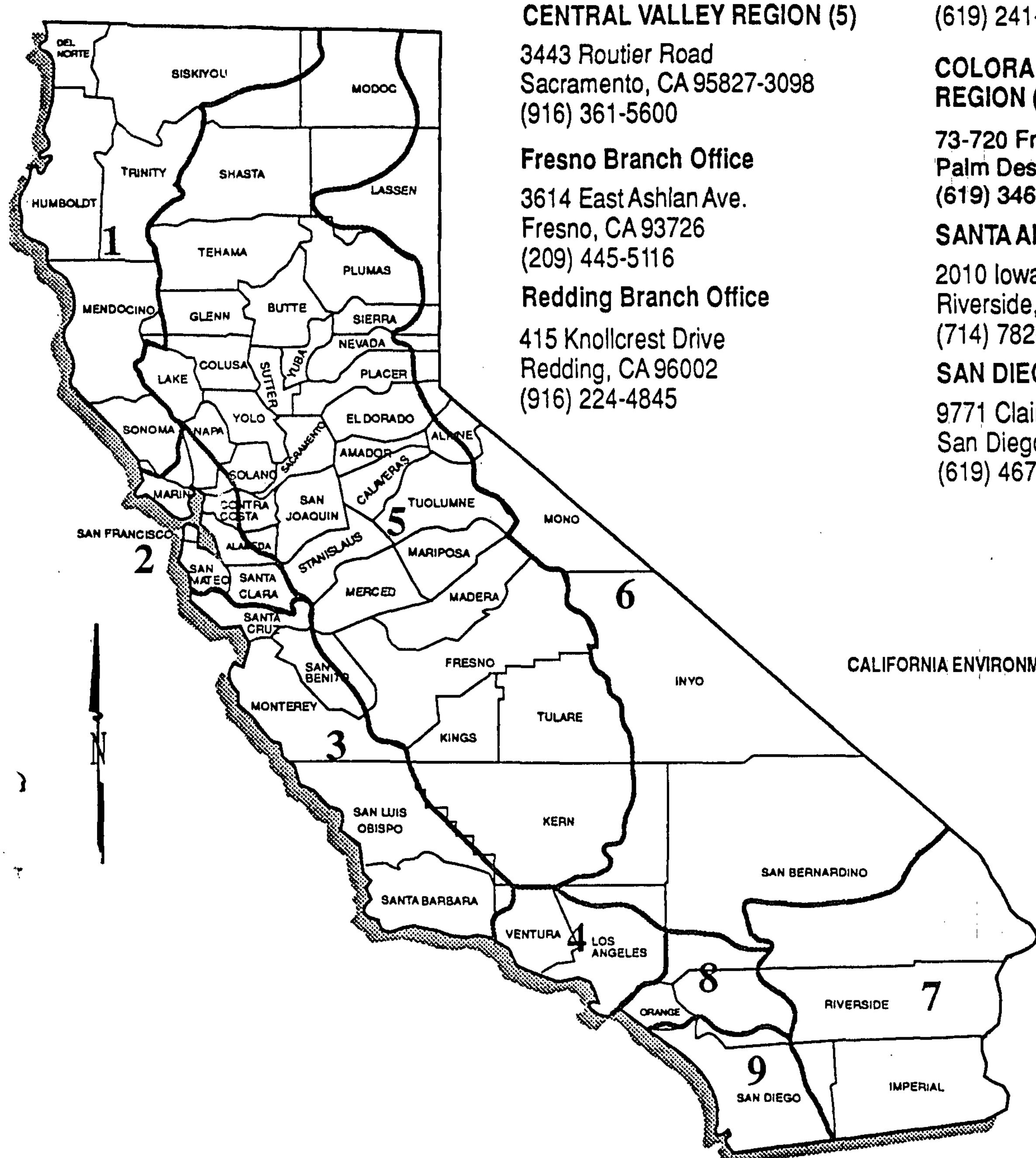

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5/22/92