

Five-Year Program Review Regional Monitoring Program for Trace Substances in the San Francisco Estuary

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FIVE-YEAR PROGRAM REVIEW

REGIONAL MONITORING PROGRAM FOR TRACE SUBSTANCES *in the* SAN FRANCISCO ESTUARY

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EXECUTIVE SUMMARY

The Regional Monitoring Program for Trace Substances in the San Francisco Estuary (RMP) has successfully produced high-quality data on chemical contaminants and their toxicity throughout San Francisco Bay. Since its inception in 1993, it has combined shared support, direction, and participation by regulatory agencies and regulated organizations/industries in a model of collective responsibility. As a result, it is developing an expanding database of information that has helped to address important decision-making needs of regulatory agencies and other program Participants.

This report presents the findings and recommendations of an in-depth review of the RMP carried out during its fifth year of operation. This review was an integral part of the program's initial five-year plan and was carried out by a panel of nationally recognized experts in a range of fields. Its objectives were to:

- determine the successes and shortcomings of the RMP
- identify parts of the program that should be retained or amplified to maintain performance at a high level
- suggest changes or additions to meet present and future needs.

The RMP has faithfully addressed its guiding objectives and has achieved notable successes during its first five years of operation. These include:

- establishing and carrying out a large, complex technical program with few, if any, problems
- gathering extremely high-quality data that describe the present state of the Bay
- producing data that have been used in a variety of environmental management decisions by regulatory agencies, dischargers, and industry
- establishing a climate of cooperation and a commitment to participation among an extremely wide range of regulators, dischargers, industry representatives, and scientists
- fostering the involvement of other government and academic scientists with valuable knowledge and expertise
- preparing and widely disseminating thorough and accurate yearly reports on the program's data and accomplishments
- implementing a thorough quality control system for laboratory analysis and data management
- setting up a World-Wide-Web site to make the program's data more widely available to potential users.

As a result of these successes, the Review Panel found widespread support for the RMP, many instances of its usefulness, and a firm commitment that it should be continued for at least another five years.

The Review Panel also found, however, that these very successes, along with five years' experience and the benefit of hindsight, have raised serious issues that must be addressed if the RMP is to fulfill its potential. The Review Panel believes that complex programs such as the RMP must

continue to evolve in response to their users' needs if they are to avoid the 'monitoring trap' of simply collecting data for its own sake. In the RMP's case, two core themes consistently arose in the evaluations the Panel carried out from a variety of perspectives (basic objectives, study design, data analysis, information management, organizational dynamics, and management).

The first theme is the need for more detailed definitions of all aspects of the RMP, in particular of

- core program objectives
- specific management and scientific questions needed to focus study design and data analysis
- the roles, responsibilities, and authorities of all parties to the RMP
- decision-making processes
- methods of identifying and resolving healthy conflict.

The RMP's original objectives provided effective guidance during the program's early years. However, at present they are not sufficiently detailed or specific enough to effectively focus the program's efforts on management's key information needs. As a result, much of the current data analysis, interpretation, and reporting is diffuse and not particularly relevant. Similarly, the program's commitment to consensus-based management has helped build an important degree of involvement and commitment on the part of all parties to the RMP. On the other hand, it has also resulted in an inability to directly address important issues, such as developing more detailed objectives, where there is disagreement among some of the parties. The Panel recommended that the RMP make it a high priority to address the issues listed above as part of developing a new five-year plan.

The second theme is the need for the RMP to broaden its scientific horizons in order to increase the usefulness of its results in decision making. The Panel strongly recommended that the RMP undertake modeling and analysis to place the RMP data in the context of other data from San Francisco Bay. In particular, historical data can provide a larger perspective within which to interpret the relatively short time series of data developed to date by the RMP. These other datasets represent a valuable resource that is currently being under-utilized.

In addition, the Panel recommended that the RMP address a wider range of fundamental scientific issues that are key to any attempts to interpret the implications of the RMP's monitoring data. These issues include such questions as the annual input of key pollutants to the Bay, the response of the Bay system to past reductions in pollutant input, and the relationship between observed patterns and trends of key pollutants and various kinds of sources, both human and natural.

The Review Panel believes that such issues are not unique to the RMP but are challenges that typically face complex environmental monitoring and management programs. The Panel further believes that the parties to the RMP have the commitment, understanding, and ability to successfully meet these challenges and to continue to make the RMP a model of cooperative environmental problem solving.

1.0 INTRODUCTION

The Regional Monitoring Program for Trace Substances in the San Francisco Estuary (RMP) is an innovative and successful program aimed at collecting data on chemical contaminants in the water and sediments of San Francisco Bay, evaluating the *in situ* bioaccumulation potential of trace contaminants by biota in the Bay, and determining the potential for water and sediments of San Francisco Bay to cause toxicity in bioassay organisms. The RMP has combined shared support, direction, and participation by regulatory agencies and regulated organizations and industries in a trend setting model for collective responsibility in assessing the overall condition of San Francisco Bay. Such a model for collaboration and cooperation deserves national and international recognition. Such a partnership does not, to our knowledge, exist anywhere else in the nation or the world.

1.1 A Planned Comprehensive Review

Preliminary Bay-wide studies of contaminant concentrations began in 1989 with seed money from the USEPA. Additional Bay-wide sampling was undertaken beginning in 1991 within the Bay Protection and Toxic Clean-up Program. The RMP was formally implemented in 1993. At the time of this writing, the RMP is in the fifth year of its routine Bay-wide core sampling program. A variety of special and pilot studies sponsored by the RMP have been carried out for shorter periods. The RMP has evolved dramatically through these five years. It has developed an expanding base of high-quality data on samples from stations located in mid-bay (the spine) and generally away from the confounding influences of point-sources of environmental pollutants. In addition, valuable information from special and pilot studies has assisted in refining understanding of the data from the core program and suggest potential new areas for eventual inclusion in the RMP.

A comprehensive program review was anticipated as part of the initial RMP design, and was set to occur in the fifth year of the study. Notwithstanding this planned review, the RMP and the study plan have been subject to constant review and evaluation between 1993 and 1997. Regular meetings of the RMP Steering Committee (SC) and occasional meetings of the SFEI Committee of Scientific Advisors (CSA) have watched over the program and have recommended changes and improvements. Program development and evolution have also been influenced by the results of pilot and special studies. The RMP Five-Year Review reported herein, however, is the first time the program has been comprehensively and formally evaluated by independent scientists and specialists from outside the San Francisco Bay area.

1.2 Review Objectives

The objectives of the Five-Year Review were to determine the successes and shortcomings of the overall program during the first five years of its existence by examining the structure and performance of the RMP and its staff, contractors, and administrative infrastructure. The review was intended to recommend which parts of the existing program should be retained or amplified to maintain performance at a high level, and to suggest changes, additions, or deletions that might improve the program.

To that end, a panel of seven experienced individuals was contracted and assembled to examine all aspects of the RMP and to interview RMP participants familiar with its scientific, logistic, adminis-

trative, management, planning, and quality assurance aspects. The review process was focused on providing answers to general questions, such as:

- Are the stated objectives of the RMP different from the implicit objectives of the Program? If so, do the explicit and implicit objectives conflict?
- Are the expectations of the RMP's sponsors and participants being met? If not, how can the program be modified to meet their expectations?
- What is the larger scientific, environmental, and management context for the RMP? Should the RMP expand to better fit within that context?
- Is the RMP focused on relevant questions and objectives? If not, what relevant questions and objectives should be incorporated into the RMP?
- Is the overall management of the RMP adequate to support the program? If not, what is required to bring better management to the program?
- Is the RMP set up to coordinate with other monitoring programs in the Bay Area? If not, should such coordination be implemented, and in what ways?
- Is there adequate use and dissemination of the results from the RMP? If not, what can be done to better use the information?
- Is the management decision-making process in the RMP clear and adequate? If not, how can the process be improved?
- Is the conflict-resolution process in the RMP clear and adequate? If not, in what way(s) can conflict resolution be improved?
- Is the RMP producing quality data of use in San Francisco Bay or in the larger management context for the RMP? If not, what steps need to be taken to improve the quality of data and their use(s)?

This planned report, answering these and more specific questions and containing specific recommendations, is hereby submitted to the RMP Steering Committee for evaluation and, where possible, for implementation.

1.3 The Review Process

The review process included:

- selecting and contracting recognized experts (Review Panel members) to take part in the review process
- gathering and disseminating RMP information to Review Panel members
- first-hand data gathering activities on the part of the Review Panel, including an on-site information gathering workshop held at the San Francisco Estuary Institute in February 1997, at which time Review Panel members conducted in-person interviews with RMP participants, managers, and administrators
- preparing a draft report in which preliminary evaluations of the RMP were put forth for review by the Panel and certain key participants in the RMP. The draft report preparation process included a second on-site workshop of all Review Panel members at SFEI in April 1997

- preparing a final draft report for submission to the RMP Steering Committee as a basis for considering how to implement recommendations deemed suitable and useful for improving the overall quality of the RMP

Members of the RMP Five-Year Review Panel were:

- Dr. Donald Boesch, University of Maryland, Center for Estuarine and Environmental Studies
- Mr. Robert Cushman, Oak Ridge National Laboratory, Carbon Dioxide Information Analysis Center
- Mr. William Crooks, private consultant
- Dr. Alan Mearns, NOAA Ocean Assessment Division
- Dr. Susan Metzger, Lawler, Matusky and Skelly Engineers
- Dr. Thomas O'Connor, NOAA National Status and Trends Program
- Dr. Allan Stewart-Oaten, University of California at Santa Barbara

The review was facilitated by two coordinators, Drs. Brock Bernstein and Joseph O'Connor.

1.4 Overview of Report Scope and Structure

The final report for the RMP Five-Year Review addresses all aspects of the project. It consists of seven chapters in addition to the Introduction and Executive Summary. These chapters address objectives, data analysis and study design, quality assurance and data/information management and transfer, organizational dynamics, management, resources, and implementation. Each chapter evaluates the RMP from a different perspective, draws conclusions about the successes and/or shortcomings within each area of interest, and makes appropriate recommendations. As described more fully in the Executive Summary, it is significant that the same core themes consistently arose from the separate analyses from different perspectives.

It is the overall conclusion of the Review Panel that the RMP, after five years of operation, is a highly successful program that is meeting its original objectives and is of great value to its participants. The Review Panel notes that the program has not remained static over the first five years of operation. Nor should it! Approaches, methods, analyses, and questions of concern have all evolved with the gradual accumulation of data and experience. In all technical areas, the direction of the RMP's evolution has been positive. The RMP of 1997 has matured to the point where it would benefit from a collaborative effort among all participants to provide more detailed statements of the project's overall goals; an expanded, clearer set of program objectives; a more precise set of scientific questions to be answered; and a more distinct definition of roles, responsibilities, and decision-making processes.

2.0 PROGRAM OBJECTIVES

Summary: The RMP's original objectives have provided effective guidance during the program's first five years and have been largely met by the existing sampling and data analysis designs. Recently, some parties to the RMP have suggested that the program's objectives should be reconsidered and modified in order to address a broader set of issues. This has created a healthy tension within the RMP. The Review Panel believes that the RMP's objectives should evolve over time and that an expanded set of objectives is needed to better integrate the RMP into the environmental management system for the Bay. However, the Review Panel also believes that a successful reevaluation of the RMP's objectives depends on a better and clearer definition of the roles and responsibilities of the various parties to the RMP.

The impetus for the Regional Monitoring Program for Trace Substances (RMP) was the Comprehensive Conservation and Management Plan (CCMP) produced in 1993 by the San Francisco Bay Estuary Project. Specifically, the CCMP identified as one of its objectives:

effectively monitor and conduct research on flow regime, pollutants, dredging and waterway modification, fish and other aquatic resources, wildlife, wetlands, and land use within the boundaries of the Estuary, using new and existing facilities, programs, and public involvement groups.

The CCMP identifies as an action item the development and implementation of a Regional Monitoring Strategy (RMS) to integrate and expand on existing efforts and eventually be part of a comprehensive Regional Monitoring Program.

The RMP for Trace Substances was created as one component of the anticipated Regional Monitoring Program through the leadership of the San Francisco Bay Regional Water Quality Control Board (Regional Board), which encouraged the participation and financial support of sponsors (regulated dischargers, public facilities, and industries). These sponsors are referred to as RMP Participants. The RMP has operated under formal objectives (Box 1) since its beginning in 1993. These objectives were developed by the staff of the Regional Board, RMP Participants, and San Francisco Bay Estuary

Box 1: Original and Current Objectives

- To obtain high quality baseline data describing the concentrations of toxic and potentially toxic trace elements and organic contaminants in the water and sediment of the San Francisco Estuary
- To determine seasonal and annual trends in chemical and biological water quality in the San Francisco Estuary
- To continue to develop a data set that can be used to determine long-term trends in the concentrations of toxic and potentially toxic trace elements and organic contaminants in the water and sediments of the San Francisco Estuary
- To determine whether water quality and sediment quality in the Estuary at large are in compliance with objectives established by the Basin Plan
- To provide a database on water and sediment quality in the Estuary that is compatible with data being developed in other ongoing studies in the system, including, but not limited to, wasteload allocation studies and model development, sediment quality objectives development, in-Bay studies of dredged material disposal, Interagency Ecological Program (IEP) water quality studies, primary productivity studies, local effects biomonitoring programs, and state and federal mussel watch programs

Institute (SFEI) staff. Because of the regulatory issues surrounding discharge permits, the RMP objectives have focused principally on contaminant concentrations in Bay water, sediments, and bivalve tissues and on biological responses relevant to determining water and sediment quality as revealed through bioassays.

2.1 Meeting the Objectives

A review of the activities and products of the RMP shows that, to a very large degree, it has been faithful in addressing its original objectives, both implicitly and explicitly. RMP Participants expressed satisfaction with the way SFEI and the prime contractor (Applied Marine Sciences of Livermore CA) have kept the RMP focused on meeting these objectives. The high quality measurements that have been made are sufficient to quantify existing conditions in the center of the Bay. Analyses of data completed through 1995 (SFEI 1997b) attempt to describe spatial and seasonal patterns that might be discernible from the data (see Chapter 3 for discussion on data analysis and design). Comparisons have been made among years, although too few years of data are available to assess interannual variability or long-term trends. The data on contaminant concentrations allow determination of the extent to which open Bay waters are in compliance with the numerical criteria for water quality established in the Basin Plan.

A database on water and sediment quality has been developed and maintained. RMP data are available to the environmental community directly from SFEI or through the RMP/SFEI Website. Although the database is generally compatible with data from other studies in other parts of the Bay, some comparability problems inevitably occur as a result of different sampling and analytical protocols. Interpretative reports by the RMP have attempted to reconcile these differences in comparisons. The RMP has clearly addressed Objective 5 by providing a database compatible with these other studies. However, it has been less successful in fostering integrative analyses involving, for example, the Interagency Ecological Program, Mussel Watch, or dredged material disposal monitoring data.

2.2 Pilot and Special Studies

In addition to the routine monitoring measurements, RMP support funds pilot studies and special studies. Pilot studies are intended to assess methods under consideration for incorporation into the RMP program. Special studies are aimed at improving interpretation of RMP data (Box 2). Pilot studies and special studies have helped to improve analysis, enhance the comparability of results, enhance the relevance and sensitivity of bioassay tests, and examine the distribution of contaminants in some areas (the South Bay and wetlands) in greater detail.

Box 2: Pilot and Special Studies Conducted by the RMP

Pilot Studies

- Phytoplankton monitoring, 1993
- Benthic macrofauna, 1994-1997
- Monitoring contamination in tidal wetlands, 1995-1996
- Fish tissue contamination, 1996-1997
- Episodic aquatic toxicity, 1997
- Air deposition, 1997
- Dioxin methods development, 1997

Special Studies

- Power testing for water metals, 1993
- Optimal sampling design for water monitoring, 1994
- Development of sediment indicators, 1994-1996
- Ecological indicators workshop, 1994
- Methods for analysis of spatial and temporal patterns in water 1995
- Trends in bivalve bioaccumulation, 1996

RMP Participants do not all agree on the value or the relevance of the pilot and special studies. On the one hand, many Participants believe that pilot and special studies have been effective in exploring new methods or approaches and assisting interpretation of monitoring data. On the other hand, some Participants are concerned as to whether some pilot and special studies depart from the original RMP objectives. Some special studies deal with issues of interest to some Participants and not others. And, the upshot of such conflict is that opinions on pilot and special studies differ depending on the perspective of the Participant. For example, the Regional Board's interest in surveys of toxicants in fish was not shared by many discharger Participants. However, agreement was eventually reached that a special study on toxicants in fishes would be carried out, although at a reduced frequency.

The RMP Technical Review and Steering Committees (see Chapter 5) have mechanisms in place for resolving differences regarding the scope and relevance of proposed pilot and special studies. The Review panel believes (as noted in Chapter 5) that the current consensus-based mechanism for resolving such disagreements would profit immensely from clarifying both the roles and responsibilities of RMP Participants as well as decision-making processes. The planning, evaluation, and funding for pilot and special studies would also profit from attention to the recommendations in Chapters 3 and 5 regarding improving the overall focus of the study design.

2.3 Meeting User Needs

The complex nature of the RMP, with different entities responsible for design development, contracting, logistics, sampling, analysis, testing, and reporting made it impossible to perform a unit-cost evaluation. The RMP Participants and representatives of federal and state regulatory agencies (USEPA, Corps of Engineers, and the Regional Board) expressed satisfaction with the quality and usefulness of the monitoring program results and offered numerous examples of how RMP data have been used. Participants agreed that they are receiving a quality product for a reasonable cost. The Review Panel concurs in this conclusion. However, some representatives of the dredging community questioned the utility of RMP results in addressing problems associated with regulatory testing requirements for dredged material disposal.

Regional Board staff use RMP results in a variety of ways. They help to determine discharge permit requirements and are being used to establish background sediment contaminant concentrations and in the development of sediment quality criteria. However, the full extent to which RMP results are used by the Regional Board was not apparent to the Review Panel, and is not always clear to the regulated dischargers who support the RMP. The differences in opinion and perception on this issue reflect, to a large extent, the absence of clear detail about how RMP data should be analyzed and on what questions/problems these analyses should focus (see Chapter 3 for more discussion). An exception is determining compliance with numeric Basin Plan objectives.

One incentive for the Participants to continue supporting the program is the expectation that their continued participation will be rewarded with reduced self-monitoring requirements specified in discharge permits issued by the Regional Board. Another incentive is that continued participation will be rewarded with increased regulatory flexibility. Some Participants believe these benefits are being realized, while others believe that they have not yet been fully achieved. It is significant that the Participants who have reaped such benefits (e.g., POTWs, the larger dredgers) attributed this to their own in-house ability to use RMP data to address and argue questions of specific interest. As discussed further below, this reflects an implicit assumption in the RMP's objectives that the RMP's

function does not extend to application of RMP data to problems of specific regulatory interest to the Participants.

2.4 Evolving Objectives

The RMP for Trace Substances addresses only a fraction of the activities specified for the Regional Monitoring Program that the CCMP called for (San Francisco Estuary Project, 1993: p. 184). The RMP does not address the broader issues in the CCMP mission statements that include restoring and protecting diverse, balanced, and healthy populations of Bay organisms; protecting beneficial uses; and eliminating and preventing pollution at its source (San Francisco Estuary Project, 1993: p. 28). For example, the original RMP objectives (see Box 1) do not include the development of inventories of contaminants or any activities related to identifying sources of contaminants. Both might be helpful in linking RMP monitoring results to pollution elimination and prevention, determining effects of contaminants on populations of Bay organisms (other than as reflected in bioassays), and assessing effects on beneficial uses of the Bay's resources.

As a result, several parties to the RMP, including SFEI and some Participants, believe that the RMP's objectives (Box 1) should be modified. In order to structure this discussion, Dr. Bruce Thompson of SFEI (1997a) proposed a new Objectives Framework for the RMP that reflects a series of internal conversations among RMP Participants. The proposed Framework, currently being considered by the Steering Committee, would modify the original objectives to include the statements shown in Box 3. The proposed Framework is based on four tiered steps:

1. Revised monitoring objectives (statement of broad goals for the RMP, Box 3).
2. Statement of environmental values (important ecosystem attributes).
3. Explicit formulation of monitoring questions (linking the above values with measurements and indicators).
4. Choice of monitoring measurements and indicators (specific measurements required to address questions).

The Steering Committee has provided little comment on the proposed Framework. However, several concerns about this expansion in scope were voiced to the Review Panel. First, the RMP Participants are very concerned about the growing costs of the existing program and the greater potential costs of a program with broader objectives.

Second, there is concern that the RMP might lose its focus on contaminants and, instead, emphasize broader concerns about ecosystem and human health that may have little relevance to regulated discharges. However, Participants are receptive to efforts that might determine sources of contamination, particularly insofar as they might demonstrate that riverine, atmospheric, and nonpoint sources contribute more contaminants to the Bay than point-source waste discharges.

Third, RMP Participants are, to varying degrees, concerned about broadening the interpretation and dissemination of results, fearing that additional interpretation has the potential for going

Box 3: Proposed Monitoring Program Objectives

1. Determine compliance with water quality objectives and evaluate sediment and tissue concentrations in terms of other guidelines.
2. Assess estuarine condition in terms of selected beneficial uses.
3. Assess contributions from general sources of contamination.
4. Report, interpret and synthesize RMP information for a variety of audiences.

past scientific results into the realm of policy and advocacy.

Regional Board staff have also expressed concern about expanded RMP objectives. They believe that it is the role and responsibility of the Regional Board to interpret monitoring results with regard to regulatory actions. They are concerned that expanding biological measurements to assess ecosystem health may produce data that are difficult to interpret, and for which there are no existing criteria. It is difficult to judge the degree of the Regional Board staff's concern because of transition of staff responsible for interfacing with the RMP and the fact that Regional Board staff members have somewhat different views on this subject. Overall, however, Regional Board Staff are sensitive to any changes in the RMP's objectives that blur the boundary between technical interpretation of the data and the regulatory and policy responsibilities reserved to the Board.

In addition to these concerns expressed by those directly involved in the RMP, SFEI's Committee of Scientific Advisors (CSA) (Swartz et al., 1995) reviewed the RMP and stressed the need for a strategy to guide the RMP into the future. This would help the RMP avoid the fate of many monitoring programs, i.e., collecting data that are never properly analyzed or used effectively in management decisions. The CSA stressed the importance of synthesis and interpretation, the need for direct biological measurements of effects to complement chemistry and toxicity tests, and summaries of contaminant inputs. The CSA endorsed the continued focus of the RMP on contaminants, but recommended better integration of the RMP with critical parts of other monitoring programs. These recommendations correspond with the Review Panel's recommendations in Chapters 3 and 5 on the need for more explicit links between program objectives, questions of specific concern to decision makers, and the sampling and analysis designs.

The mismatch between the limited objectives for the RMP (Box 1) and the desire in some quarters for broader monitoring and assessment objectives creates tension among the RMP Participants, the Regional Board, and SFEI. The Review Panel stresses that such tension can be healthy (Chapter 5) if it leads all parties involved to reevaluate their expectations and roles. In fact, such tension is inevitable, because the nature of environmental problem solving precludes drawing perfectly clear boundaries between monitoring, analysis, interpretation, and objective setting. However, as discussed in more detail in Chapter 5, such tension can be counterproductive when there is no well-defined process for addressing and resolving conflicts. The Review Panel identified three areas of tension in particular:

1. **Contaminant Sources:** In order to relate contaminants in the Bay to sources it is inevitable that the RMP begin to develop inventories of sources, calculate budgets, and develop models. That process produces concern among point-source and stormwater dischargers, owners of upstream agricultural sources, and dredged material disposers regarding the relative importance of their impacts on the Bay ecosystem.
2. **Data Interpretation:** There are differing opinions about the extent to which SFEI should interpret RMP data, especially in the area of relating contaminant concentrations in the Bay to the efficacy of current regulations. The RMP's scientists understand interpretation to mean pursuing descriptions, hypotheses, and patterns with the ultimate goal of drawing conclusions about cause-effect relationships. Regional Board staff are particularly concerned about interpretations that impinge upon the Regional Board's prerogatives in considering multiple factors (economic, policy, and technological, as well as environmental) in regulatory policy making. The Review Panel found that much of this tension stems from imprecise use of the term "interpretation" to cover a broad range of activities. The Panel believes that much of this tension would dissipate

were discussions about interpretation to focus instead on specific questions and the analytical and data presentation methods used to address them.

3. **Assessments:** As the RMP matures and naturally moves in the direction of asking "is it" questions, there are differing opinions about whether the RMP should address the broader goals of restoring and protecting beneficial uses of San Francisco Bay. Some Participants believe that the RMP should focus only on the initial objectives concerning trace substances (Box 1), that they have a limited responsibility for these broader goals, and that they should not foot the bill for addressing the broader monitoring objectives arising from the CCMP.

Overall, the various governing, advisory, and consultative bodies involved in the RMP have not yet agreed on the future objectives of the RMP. A major problem in this regard is the fact that the roles of the RMP Steering and Technical Review committees (in tracking accomplishment of present objectives, assessing their continued suitability, and incorporating new findings into the objectives) are neither explicit nor clear (see Section 5.5.).

2.5 Role of Monitoring in Environmental Management

As pointed out by the National Research Council (1990), monitoring should be an integral component of an environmental management system. Monitoring should be effectively linked with research and modeling to inform managers and to help them answer management questions. The NRC report outlined a conceptual model relating the technical design, implementation, and interpretation of monitoring programs to environmental quality objectives and decision making. Similarly, the subsequent NRC (1993) review of wastewater management in urban areas described the role of monitoring as an important element in the integrated management of coastal issues.

The RMP set out to provide data for two general purposes: 1) to determine whether water quality in the Bay is in compliance with the Basin Plan, and 2) for broader environmental management. However, neither the original objectives (Box 1) nor the study design were developed to ensure that regional monitoring serves as an integral element of environmental management (see Chapter 3 for specific examples related to data analysis and study design). The proposed program objectives (Box 2) place greater emphasis on impairment of beneficial uses; sources of contamination; and synthesis, interpretation, and reporting. By doing so, they seek to integrate the RMP in the environmental management systems for San Francisco Bay. The Review Panel supports such efforts. Modified objectives would provide a basis for formulating more appropriate questions to guide study design, data analysis, and interpretation (see Chapter 3). The Objectives Frameworks discussion paper (SFEL, 1997) can serve as a point of departure for this process. However, The Panel believes that the success of such discussions will depend largely upon implementing the Panel's recommendations (Chapters 3, 5, and 6) regarding better defining the roles and responsibilities of all parties to the RMP.

2.6 Recommendations

Based on the foregoing considerations, the Review Panel makes the following recommendations regarding the objectives of the RMP:

- a. The RMP should continue to focus on toxic and potentially toxic trace elements and organic contaminants. In addition, the scope of the RMP should extend to issues other than those related

to contaminants, only to the degree that additional sponsors and funding allow. However, efforts underway to reconsider the RMP's objectives should be continued, with the aim of integrating the RMP more fully into the environmental management system for the Bay.

- b. Assessing the contributions from sources of contaminants to San Francisco Bay should be a high priority for the RMP. Mass-balance inventories of contaminants should be developed which can, in turn, lead to models that attempt to account for the distribution, fate, and residence time of contaminants in the Bay. This will provide a functional connection between the RMP and efforts to identify, eliminate, and prevent sources of pollution. To further this effort, SFEI should strive to improve the linkages with other historic and ongoing estuarine research and monitoring programs.
- c. Although relating contaminant distribution and effects to Bay resources and their beneficial uses is an appropriate objective, care must be taken to define better the resources and uses that may be impaired and how impacts on these are to be determined. Any addition of direct biological measurements to complement the chemical and bioassay measurements should be highly strategic, i.e., tied to the effects of contaminants.
- d. Synthesis and interpretation are appropriate and necessary activities of the RMP. They are essential for converting raw data to information useful in decision making, for planning and adjusting future sampling, validating the quality of data, and for engaging creative scientists and managers in the monitoring process. Synthesis and interpretation can be done without making judgments concerning the appropriateness of regulations or of compliance with those regulations. SFEI, the RMP Steering Committee, and the Regional Board staff should develop a joint policy with operational guidelines for interpretation of RMP data.
- e. RMP information should be broadly available to interested parties, the scientific community and the public. Various communication media, including newsletters, the World Wide Web, issue reports, and scientific journals, should be aggressively used, with due attention to policy implications as described above.

3.0 DATA ANALYSIS AND STUDY DESIGN

Summary: To date, the RMP has produced high quality data describing the present state of the Bay. Because of their quality, these data will remain useful into the indefinite future as a description of conditions in certain portions of the Bay. However, there is a disconnect between the questions of most interest to sponsors and the descriptions of conditions produced so far by the RMP. This is reflected in the character of the data analysis approaches used by the RMP, which are mostly unfocused descriptive data presentation, relatively little focused summarization, and hypothesis testing that is oversimplified or of little relevance to decision making. The Review Panel found that this stems largely from the absence of clearly defined, specific questions that can link monitoring to decision making and that can be addressed with the appropriate range of analysis and modeling approaches. The Review Panel believes, quite strongly, that developing the ability to frame clearer questions and to better articulate management's needs for scientific information is an organizational issue involving the entire RMP. Once such questions have been developed, the overall study design can then be reevaluated in terms of its ability to help answer them, and the Panel did identify aspects of the study design that might be streamlined. At present, however, the absence of detailed guiding questions and the lack of any formal justification for the existing design restricted the Panel's ability to complete such an evaluation.

3.1 Introduction

The fundamental justification for the RMP is to provide information to better manage the San Francisco Bay ecosystem and protect beneficial uses. The National Research Council (NRC, 1990), in its nationwide study of marine environmental monitoring, noted that monitoring programs must recognize the difference between data and information in order to provide useful input to such management goals. They emphasized that "... raw data collected in a monitoring program frequently do not [alone] directly address public concerns or the information needs of decision makers." Rather, monitoring data must be gathered, analyzed, and interpreted with the intention of addressing specific management objectives and related scientific questions or problems. While there is a wide range of approaches to crafting policy and making decisions about environmental issues, the successful ones all share this emphasis on the development of appropriate monitoring and other scientific data that can direct, set limits on, or otherwise inform management decision making.

Monitoring data come from well-managed sampling and analysis programs, but useful information can only result from sampling/analysis programs whose design reflects a clear perception of what questions are important to decision making. In the words of Drucker (in NRC, 1990), "Information is data endowed with relevance and purpose. Converting data into information thus requires knowledge." The following sections review the RMP's data analysis methods and study design in terms of their ability to create useful information. They also identify specific areas for improvement, particularly in better defining detailed questions to guide data analysis, synthesis, and interpretation.

3.2 Data Analysis

Analyses in RMP reports are of two kinds, descriptive and inferential. Understanding the differences between these is important for assessing the relevance and usefulness of RMP analyses and for identifying opportunities for improving these. Descriptive analyses display or summarize the data without assessing their reliability or attempting to target the description at a specific question

in the real world. Inferential analyses usually involve formal hypothesis testing and are appropriate only for addressing specific, well-formed questions. Inferential analyses also necessarily involve assumptions about sources of variability and uncertainty in the data, issues intimately connected to the monitoring design itself.

3.2.1 Description - Unfocused and Focused

3.2.1.1 Unfocused Description - Well-presented unfocused descriptions are standard and reasonable. They are an archive of the year's results, and allow any reader to make or check theories or suspected patterns for any variable of interest. They make it possible, in principle, for any reader to detect anomalous results, whether due to a data reporting error or to a change in pattern that requires attention from regulators or researchers.

The majority of RMP analyses to date consist of unsummarized, unfocused description of raw data. By unsummarized we mean that each data point appears explicitly, and there is no summarization except for the processing and averaging used in chemical analysis. By unfocused we mean that the descriptions provided are not aimed at answering any specific question or elucidating any particular pattern. Bar charts give values for stations at a particular time, and time series plots give values for times at particular stations. There are a few tables such as those giving stations and times where sample measurements exceeded Basin Plan guidelines. Other bar charts, plots, and tables use a small amount of summarization to combine stations at a given time, usually by giving the range of raw values. Some of the plots describing toxicity testing results use standard errors, but these measure only sampling error, due to variation between animals, and not between places or times.

Some of these plots and tables need more careful presentation. It is confusing to present data by "Cruise number" instead of by the more informative identifier *date*. In some articles on toxicity testing, error bars in plots are not described, and calculation methods are not given. It should be stated whether error bars are standard deviations, standard errors, or ranges. In some tables, sample sizes were not given. Presentation of time plots is partly a matter of taste, but spikes as in Figs. 49-54, pp. 55-65 of the 1995 Report are distracting and decrease the data-to-ink ratio. More careful proofreading of tables would be helpful to ensure consistency of format and readability.

Such raw descriptions, no matter how well presented, are, however, mainly useful as an archive since they do not give an overall picture of the Bay with respect to any variable. There are too few data for a synoptic picture. But, paradoxically, there are also too many data for the human mind, unaided, to construct an informative global picture. It is similar to trying to imagine a portrait based on a list giving the coloring of each square millimeter.

The problems inherent in unfocused description, and those pertaining to the style of presentation, make such analyses of only marginal use for decision-making. They are even less useful for planning or designing future sampling. These activities require more focused summarization, inference, and modeling. The Review Panel believes that the problems associated with unfocused descriptive analysis should decline as the RMP database expands to support more sophisticated analysis.

3.2.1.2 Focused Description - The goal of focused descriptive analyses should be to find ways to display the data so that they reveal or suggest patterns obscured by more simple unfocused descriptive analyses. Thus, the RMP should, at a minimum, concentrate on filling in the empty spaces in

maps of the Bay with interpolation and other methods, combining values into comprehensible patterns, and smoothing the less reliable values.

Displays of such regional patterns are, however, rare in the RMP reports; they usually appear not in regular reports by SFEI personnel but in special studies or reports prepared by consultants or by USGS. This may be due partly to the amount of spatial filling in required, since the USGS sampling is much more intensive both spatially and temporally. But it might also reflect SFEI's sensitivity to concerns about the degree to which it interprets the monitoring results (see also Chapters 2 and 5).

The Review Panel believes it would be useful to experiment with choices of display methods (symbols, colors, shading, connecting lines, etc.) and with finding ways to include more information without loss of clarity. Contouring, shading, or using estimates or interpolated values at unsampled points could be effective. A combination of such methods could display spatial variation in two variables at once. There are several helpful books and papers available, since this is an active area of statistical research. A report could well contain many such displays, given the large numbers of variables (and variable combinations) of concern, and this could markedly improve the usefulness of the Annual Reports.

It may be that the most read parts of the Annual Reports are the Executive Summary and parts of the Conclusions (e.g., the Summary of Estuary Condition). These are focused summaries that usually avoid judgments by simply adding the numbers of exceedances of various official standards and guidelines at each station or group of stations. They are useful in two ways. First, they suggest the contaminants of most concern, and second, they focus attention on the appropriate data sets and reports. However, they leave out information, as any summary must. And these summaries may leave out important items such as whether an exceedance is great or marginal, the reliability of the determination, or how well-based or appropriate to the Bay the standard is. Such summaries are therefore most useful when placed in the context of attempts to answer the kinds of more concrete questions important to decision making (see below, this Chapter; also Chapter 2 relating to the development of a new objectives framework).

The Review Panel feels that the lack of synthesis and focused description hinders users' ability to comprehend the RMP's results. As suggested by interviews with Participants, Regional Board Staff, and scientists making use of the RMP reports, a greater degree of data synthesis is recommended, accompanied by greater attention to focused, descriptive analysis.

3.2.2 Inference

Inferential analyses attempt to draw clear conclusions about specific suppositions or hypotheses, accompanied by a measure of their reliability. These analyses are framed as a related set of conceptual, mathematical, and statistical models. They thus require that the question being asked be formulated very specifically so that the relevance and appropriateness of these models can be evaluated.

This can be a difficult task, however, and there is often a strong temptation to convert difficult inference problems into standard ones, with the result (often unintended and/or unnoticed) of simplifying or changing the question. While succumbing to this temptation avoids approximate, uncertain answers, it also leads to asking and answering questions that may be of little interest or relevance. *The likelihood that inference will address the wrong question is even greater if detailed questions have not been clearly articulated ahead of time, in this case by the Regional Board and the RMP Participants.*

Hypothesis testing is used frequently in the RMP reports. However, with the benefit of 20/20 hindsight, the Review Panel believes that, in most cases, the hypotheses being tested are overly simplified or of little relevance to actual decision making. An example follows.

Pages 44-52 in the 1995 Annual Report present results of ANOVA and pairwise t-tests to compare South, Central, and North Bay means for the total and dissolved fractions of ten elements on each of eight cruises. The form of these tests permits asking only whether these portions of the Bay were different. In fact, the question as to whether these parts of the Bay are different is rather uninteresting. Given the known contrasts in depth, kinds and amounts of riverine and urban inputs, degree of mixing, and amount of ocean exchange, it seems a foregone conclusion that these tests would find differences among the three portions of the Bay. In fact, it would have been surprising had they not.

Furthermore, the form of the test only permitted asking whether these parts of the Bay were different on such and such a cruise, which is an even more limited, and less-interesting, question. Documenting such differences does accord with the RMP's objective of developing high-quality baseline data and the knowledge that such differences exist might be of interest to the Regional Board and the Participants. However, the lack of any larger scientific and management context for the analysis seriously reduces the usefulness of these results. Thus, it is not clear, for example, whether a difference of any particular size is of more interest or import, whether these differences can or should be related to sources, whether the differences are related to biological impacts of concern, or the relative importance of anthropogenic and natural processes in generating and maintaining such differences.

Such weaknesses in the use of inferential analyses are not the fault of any of the organizations involved in the RMP, nor do they invalidate any of the excellent work done by the RMP. Rather, they highlight the need for more explicit questions to guide study design and data analysis as the RMP evolves beyond its early years. The Review Panel suggests that these questions might include topics such as:

- What is the annual input of key pollutants to the Bay?
- How has the Bay system responded to past reductions in pollutant input?
- What is the response time of the Bay, i.e., when might current and planned management actions produce visible and meaningful changes in levels of pollutants in the Bay?
- What is the relationship between observed patterns and trends of key pollutants and various kinds of sources, both human and natural?
- How do RMP data fit into longer historical trends available from other data sources?
- What are the characteristics of recently observed episodic occurrences of water column toxicity?
- What are the causes of toxicity in sediment bioassays?

The Review Panel believes that attempting to answer clearly defined, specific questions such as these is the key to creating useful information from raw monitoring data. Addressing such questions requires 1) that they be articulated in the first place, 2) that they be evaluated with a wider and more appropriate range of analysis and modeling approaches, and 3) that they be assessed within a larger context of knowledge about the processes and mechanisms in the Bay that control the input, distribution, and fate of trace substances. The Review Panel also believes, quite strongly, that developing the ability to frame clearer questions and to better articulate management's needs for scientific information is an organizational issue involving the entire RMP (see Chapter 5 for further discussion).

At present, the RMP data may be too sparse for the kind of in-depth inference the Panel advocates. There are completed reports on only nine cruises and data for only twelve. This is rarely enough for inference tests that deserve to be taken seriously. This does not mean that no conclusions can be

drawn or that data analysis is pointless. *It does, however, emphasize the importance of integrating the RMP data with other data on historical trends, sources of inputs, and contaminant impacts. It also underscores the necessity of creating a larger conceptual framework, such as (even crude) mass balance models, that provide a means of articulating, checking, and improving assumptions and predictions about the behavior of trace substances in the Bay.* At present, there is little such synthesis and integration of RMP and other data in the Annual Reports.

In summary, archival analysis (unfocused description) is done well. The several kinds of focused analyses, including inference, are rarely done and are not done well. Where they are performed, investigators make up their own (often implicit) questions, especially for formal inference. *The main reason for this is that there are few or no focused questions from the RMP's clients to provide the guidance needed for such analyses.*

3.3 Study Design

3.3.1 Design Rationale

The Review Panel could not effectively evaluate the study design because little formal rationale has been given for the RMP's design. It was particularly difficult to understand the number and placement of stations and the choices of sampling times. What rationale was available either lacked specificity, took key issues for granted, was anecdotal in nature, or provided extensive technical detail without relating this detail to explicit information needs for management. This section reviews an example of such a weakness and then poses some questions the RMP managers might address to better justify, focus, and streamline the design.

An illustrative example is the choice of sampling stations along the spine of San Francisco Bay. These stations were chosen so the data could be used to interpret "temporal and spatial variability in the data without the confounding variable of contaminant input from nearby sources." This justification raises more questions than it answers. This design is useful for estimating longitudinal variability along the length of the Bay, but not spatial variability between the shore and the middle of the Bay. While such longitudinal designs are traditional in estuarine sampling programs because of the influence of salinity and other gradients, there is no explanation of how and why such gradients might be important in this case. That is to say, there has been no explicit question articulated that could guide the process of making decisions about where RMP stations might be sited. Confounding the issue, some stations that have been added to the design since 1993 are not on the spine. The rationale for including these stations was "to better monitor areas around major tributaries." This contradicts the first rationale, since tributaries are precisely those "confounding" sources of contamination avoided in the initial design that sited stations on the spine of the Bay. While both sets of stations may be perfectly reasonable, there is no clear statement as to how these two objectives relate to each other, whether the newer stations were chosen to improve the linkage between source monitoring and Baywide averages, or what kinds of analyses to establish such a linkage would be compatible with the sampling design.

Nor is there documentation that explains why the spine stations are the best choice for estimating Baywide averages and trends in averages. Such averages depend on the relation between the spine and the Bay as a whole and on how the average itself is changing over time. There is a range of plausible scenarios (e.g., nonlinear relationships, changing patterns of inputs, time delays in system response to changes in inputs) that could undermine the validity of this sampling design. There seems to be an implicit assumption that data taken from the spine will have a higher signal-to-noise

ratio than data taken from a more broadly distributed array of stations. However, this assumption is never evaluated, either conceptually or with data.

The point of these comments is not that the spine stations are wrong, but that little justification has been given for them, either in strictly scientific terms or in terms of the kinds of more detailed questions important to the Regional Board and the Participants. Decisions about these and other key design questions require clear statements about study goals, models that organize assumptions about system behavior, estimates of variation and correlation, and more comprehensive synthesis and use of other (particularly historical) data.

3.3.2 Other Issues

Tidal Cycles: Some interviewees suggested that the timing of samples relative to the tidal cycle could lead to misinterpretation of results. If a particular cruise track circles through the Bay following a rising tide, then subsequent samples could be roughly following the same packet of water as it moves in and around the Bay. It is not clear how often this might occur or what its effect might be. For example, ocean water may intrude below Bay water, and not much affect either the top one meter where water samples are taken or the sediments. Even if there is an effect, it might not corrupt trend estimation provided there is enough mixing of Bay and ocean water and sample timing is similar every year. However, if this is a problem, estimates of Bay contamination could in fact be estimating a varying weighted average of the ocean and the Bay, making trends more difficult to estimate.

Power Analysis: It is customary and useful to estimate the statistical power of monitoring designs. This may be difficult for the RMP, given the many sources of variability and how little is known about them. However, the discipline of defining statistical models, identifying and estimating sources of variability, and calculating statistical power provides two important benefits. First, it forces program managers to make their assumptions explicit, an important first step in validating the soundness of the monitoring design. Second, it can provide insight into whether the design will be able to find the kinds and amounts of change that have either been predicted or are important to document.

The absence of any formal power analysis of the overall RMP perhaps reflects the fact that there is no statement about the kind and amount of change the program should detect. For example, it is not clear how much of a change from year to year, nor what sort of a long-term trend the design should detect, or is hoping to detect. Without such guidance from managers, it is impossible to determine whether the trend monitoring program is technically adequate and cost-effective (see Section 3.4 on Setting Study Goals).

3.3.3 Refining the Present Design

At the present time there are sufficient data to describe the concentrations and distribution of trace chemicals in San Francisco Bay. Part of the RMP's planning for the next five-year period should be an evaluation of how well the present design meets the original objectives. This should be done with an eye toward assessing the numbers of sites, the frequency of sampling, and/or the numbers of constituents analyzed. Such evaluations might have the effect of reducing sampling and analysis efforts while preserving the core RMP program and meeting the original objectives (see Chapter 2, Box 1). That might well enable the RMP to free up financial resources for studies related to broader

RMP objectives (see Chapter 2). The question of sampling site location has already been touched on (see above); other examples of issues related to modifications of the study design follow:

The RMP has begun to develop regressions between total aqueous concentrations of many trace contaminants and total suspended solids (TSS). This should be expanded to test the validity of using only TSS measurements to monitor exceedances of water quality criteria. It seems that this should be possible because invariably those exceedances are due to high concentrations of particle-bound copper, mercury, nickel, or PCB. These data strongly suggest that present exceedances are due in large part to the historical pool of contaminants in Bay sediments. The Review Panel suggests that this implication be considered in any attempt by the RMP to link water quality patterns to current sources of contamination.

The number of sites should also be examined. As presently designed, the RMP aims to describe trace contamination in the open part of San Francisco Bay along its spine. With the data now in hand, the possibility should be tested that fewer stations would be sufficient to define the chemical condition of each major region of the Bay.

The original objectives assumed that trace chemical concentrations and toxicity varied with season or place in the water year. Now, with four years of seasonal data, that assumption can be tested, although not very powerfully. If it were determined that the influence of season is weak, then less frequent sampling might be considered. This would be particularly true if such seasonality were shown to have little impact on regulatory decisions, source detection, or longer-term trends.

There are data for only four years, which are too few to reliably estimate interannual trends. However, with data from the USGS on chemical concentrations in dated sediment cores, it should be possible for the RMP to estimate the time required for particles to be buried so deeply that they no longer contribute trace contaminants to surface sediments or (through resuspension) to TSS. This needs to be known in order to gauge the number of years required for surface sediment and TSS to respond to changes in contaminant inputs.

The preceding discussions are intended only as examples. Other parts of the RMP program should also be reevaluated. Such reevaluations of initial assumptions are an extremely useful part of any periodic program review and the Review Panel strongly recommends that they be included as a key part of the development of the program's next five-year plan.

3.4 Setting Study Goals

As emphasized throughout this chapter, a prerequisite for effective study design is a description of explicit study goals and objectives. The Review Panel recognizes that *the RMP's original objectives have served it well by providing the direction needed to begin essential high-quality baseline and trends monitoring. However, the RMP must develop more precise statements of objectives if it is to fulfill its potential, make effective use of the data already gathered, and meet the information needs of its Participants.* As described in the proposed new Framework for the RMP (SFEI 1997a), several levels of detail are needed. At the first, aims may be relatively imprecise, e.g., to "track the health of the Bay," "monitor trends," and so on. However, these must eventually be defined and made more quantitative in order to adequately focus monitoring and special studies. In addition, target levels for uncertainty must be set to put some boundary around sampling and analysis effort.

A necessary element in creating these more detailed goals and thereby focusing the monitoring design is a set of expectations, or predictions, about how the Bay will respond in the future. For example, the expectation that measures to control contaminant inputs to the Bay will lead to measurable reductions of contaminants in Bay sediments in five years would dictate one kind of trend monitoring program. The expectation that measurable reductions will only be evident in 50 years (because of existing loads and their residence times) would lead to a very different trend monitoring program. *The Review Panel believes that the RMP would benefit immensely from even a relatively preliminary effort to develop such predictions, based on system-wide mass balances, residence times of key pollutants, and other modeling parameters.*

Setting study goals and objectives is not a strictly technical exercise. This is because answers to the kinds of design questions posed throughout this chapter depend on knowing what managers and decision makers want to know. This will involve a dialog among managers, regulators, and scientists concerning what is both desirable and possible. Such dialogs are most effective when they are ongoing and when they continually consider new information both from the RMP and from other sources. The Review Panel stresses that establishing and maintaining a dialog of this sort is an organizational and management issue rather than a technical one. Specific recommendations for the content of the dialog are made below, and in Chapters 4 and 5.

3.5 Recommendations

- a. The rationale for each aspect of the sampling design should be explicitly documented, and the information needs of the Participants should be fully articulated.
- b. Both data analysis and study design should respond to key questions of concern to the sponsors of the program. Therefore, the aims of the RMP should be carefully documented at an increasing level of detail, beginning with the general wishes of the Regional Board and Participants and ending with parameters to be estimated and desired accuracy.
- c. These key questions should be expanded beyond the initial five fairly general objectives to include issues such as the annual input of chemicals to the Bay, mass balance inventories, the response time of the Bay water column and sediment to changes in inputs, the relationship between human and natural sources, historical trends, the nature of episodic events, and the causes of toxicity in sediment bioassays.
- d. Efforts to address such questions would profit from increased efforts to integrate results and analyses from other monitoring programs in the Bay/Delta region as well as from the large historical database from past studies in San Francisco Bay.
- e. Focused data interpretation provides needed depth to raw data presentation. The RMP should increase the amount of interpretation in reports and other technical publications, providing such interpretation is focused on key questions articulated by program sponsors. It should also perform interpretations using alternative analysis approaches and/or testing alternative explanations of results, in order to provide additional context to data analysis.
- f. The RMP should make increased use of more sophisticated data presentation methods to summarize the data.
- g. RMP data suggest that exceedances of water quality criteria are due in large part to the historical pool of contaminants in Bay sediments. Therefore, the RMP should test the validity of using only TSS measurements to monitor exceedances of water quality criteria.

- h. As presently designed, the RMP aims to describe trace contamination in the open part of San Francisco Bay along its spine. The data now in hand should be used to test whether fewer stations would be sufficient for defining the state of contamination in each major region of the Bay and whether that definition would satisfy the needs of the sponsors.
- i. The original objectives assumed that trace chemical concentrations and toxicity varied with season or phases of the water year. The available data, along with relevant historical data from other sources, should be used to test this assumption. A lack of demonstrable seasonality would argue for less frequent sampling, particularly if such seasonality has little impact on regulatory decisions, source detection, or longer-term trends.
- j. The RMP should use data from the USGS on chemical concentrations in dated sediment cores to determine the time required for particles to be buried so deeply that they no longer contribute trace sediments to surface sediments or (through resuspension) to TSS. This needs to be known to gauge the number of years required for surface sediment and TSS to respond to changes in contaminant inputs. This in turn is needed to properly scope the RMP's trend monitoring design.
- k. Uncertainties due to temporal and spatial variation, sampling error (from replicate station samples), and errors in chemical or biological analyses should be estimated and used in evaluating the suitability of the study design and adjusting it where necessary.
- l. The RMP should consider the possibility that the timing of cruises with respect to tidal movements could dilute or distort information.
- m. The RMP data are a unique resource for understanding the distribution and behavior of trace substances in the Bay. Their value will be increased further to the extent that the RMP succeeds in integrating them with other relevant data from the Bay. The RMP should use other data and should encourage the increased involvement of scientists from the SFEI Committee of Scientific Advisors and from outside SFEI and the RMP in the analysis and interpretation of the data. This will increase the return on the sponsors' investment in the RMP, improve understanding of the distribution and fate of trace substances in the Bay, and increase the likelihood that RMP data will lead to insights that can improve regulation and management of such substances.

4.0 QUALITY ASSURANCE AND DATA/INFORMATION MANAGEMENT AND TRANSFER

Summary: Quality assurance and quality control (QA/QC) are integral to the success of the RMP. The RMP is clearly producing high-quality data and reporting accurately on them. There are no critical shortcomings in the RMP database or in the QA/QC procedures that require immediate attention. There is a commendable emphasis on numerical data quality objectives, quality assurance and control, use of state-of-the-art laboratory analysis methods, careful tracking of sample custody and data, and well-written reports. The scope, content, and format of data and information products should reflect the goals of the RMP and the intended uses of its information in decision making and management. What problems exist with RMP data and information products are related to the fact that overall RMP goals are not well-defined and fail to guide choices about data management approaches, data presentation methods, or data access standards (see also Chapter 3).

4.1 Quality Assurance/Quality Control of Laboratory Analysis

RMP contract labs have been routinely participating in the annual NOAA-sponsored intercalibrations, in which many labs measure the same unknowns. In 1995, the BADA labs also participated. Intercomparison exercises such as this deter "analytical boredom" (i.e., routine analysis leading to carelessness). Without intercomparisons, the only checks of accuracy are either standard reference materials (SRMs), in which the "correct" result is known, or previous years' results with samples from the same location. Data from previous years' samples are not a check on accuracy, but they can serve to flag absurd results. Some specific QA/QC questions are considered in the following paragraphs.

Polychlorinated Biphenyls (PCBs): The individual PCB congeners measured in the RMP are not all common to all samples. For example, among water samples there are small differences in the congener list between 1993 and 1994 and then a larger difference in 1995. This reflects the changes in laboratories in 1995. In 1995, 45 PCB congeners were measured in water, bivalves, and sediment. For 13 of the 45 congeners, coelution is a problem that is acknowledged by the lab doing the analysis of bivalves and sediment. In contrast, the laboratory analyzing water samples does not acknowledge coelution of PCB congeners as a problem. In 1995 there are some PCB congeners that were measured only in water and 28 that were not measured in water but were measured in bivalves and sediment. One PCB congener was measured only in bivalve tissues. Adding up all the congeners to get "Total PCBs" is not appropriate when the totals for each type of sample do not include the same congeners. This is not a major issue, since the uncommon congeners usually do not add much to the total. However, the rationale for such inconsistencies should be documented or they should be removed.

Polycyclic Aromatic Hydrocarbons (PAHs): There may be a large discrepancy in aggregated total PAH concentrations between sample types. In 1995, 25 individual PAH compounds were measured in bivalves and in sediment, but only 13 of those were also measured in water. The appendices in the Annual Reports describing methods for trace organic analyses are incorrect with regard to bivalves and sediments, since the methodological descriptions apply only to the

analysis of water and suspended particles. The derivation of the MDLs (method detection limits) listed throughout the RMP reports, and in the database, is not given.

Standards and Controls: The measures of accuracy and precision listed in RMP reports for analyses measured in water are said, in footnotes, to be from periodic analysis of standard samples within the analytical stream. There are no such footnotes for the sediment and bivalve analyses, so it is not clear that controls were run. Since there are accuracy and precision measurements, it is obvious that sediment and tissue standard reference materials were analyzed, but it is not clear that they were run in every sample batch.

Method Detection Limits (MDLs): MDLs have not been clearly documented. Since MDLs may be determined in several different ways it is essential that the MDLs used in the RMP analyses be carefully described for each analytical protocol, and each analytical laboratory.

Censored Data: If measured concentrations are less than MDLs they are edited to < or to INDI in the RMP database. These designations are not equivalent. Real numbers have been censored to < in the data. Users of the data can consider measured concentrations less than MDLs to be zeros, set them to the MDLs, use a random number in between, or apply another convention.

4.2 Design of the RMP Data System to Meet Programmatic Objectives

The design of the RMP data system is consistent with the program objectives of compiling baseline data, quantifying seasonal and annual trends, and analyzing compliance of water and sediment quality with criteria. There is little evidence in the RMP reports that historical data from other monitoring programs in the San Francisco Bay area have been integrated with the RMP. This integration must be carried out in order to attain the objective of determining long-term trends, since analysis of long-term requires implies integration with historical data sets and data from other Bay Area monitoring programs.

The data from special and pilot studies do not appear to be treated the same as the data from the core program. They are typically not included in appendices to the annual reports nor available via SFEI's World-Wide-Web site. Because of this they are less accessible, making it more difficult to quality-assure and interpret the entire RMP dataset and to achieve maximum benefits from special and pilot studies.

4.3 Data Management, Quality Assurance/Quality Control, and Documentation

The staff of SFEI, AMS, and subcontractors are highly skilled in data management. Given the changes that are underway in handling RMP's data (i.e., the direct flow of data from contract laboratories to SFEI), the role of SFEI's data management staff will become even more critical. Fortunately, SFEI's data management staff (in particular Jung Yoon, database manager, and Todd Featherston, network administrator) are trained and skilled in such areas as systems and database design.

While the hardware and software aspects of data management are being handled very thoroughly and professionally, the Review Panel believes there is insufficient documentation describing the data path, i.e., exactly what is done with the data between the moment of sam-

pling and the ultimate release of data to users. For example, there is no description of what QA checks are performed by AMS, subcontractors, and SFEI. Based on its examination, the Review Panel has concluded that the data are being managed better than is documented. Interviews and inspections showed that spreadsheet files are spot-checked against data entry sheets, macro-generated flat files are spot-checked against the source spreadsheet files, station names are changed for consistency, and checks against data quality objectives and for outlying values are made. However, these QA/QC measures and other data-handling procedures should be documented to ensure consistency, provide visible operating standards, and enhance the credibility of the data. *The lack of such documentation does not invalidate any specific values in the RMP database; rather, proper documentation would protect the investment that has been made in the RMP and give more credibility to the RMP database. More thorough documentation would also make the data more useful to other scientists and buttress the quality of the data in case of scientific or legal challenge.*

The RMP data are very accessible, either directly from the RMP Oracle database (via query from the SFEI World-Wide-Web site) or by request from users to SFEI staff. Data are considered publicly available when the corresponding RMP annual report has been published. Before that time, requests are considered on an *ad hoc* basis by SFEI. A data distribution policy is in place and precedes access to RMP raw data on the SFEI Web-site.

The data storage system is very appropriate for the needs of the RMP. The RMP database is backed up on a daily basis to another disk drive/directory on the network, and weekly backup tapes are stored on-site in a fireproof safe (a 3-month history can be restored). Backup tapes are not removed to an off-site location. Using only on-site storage could result in a catastrophic loss of the data should an accident occur at the Richmond Field Station. The Review Panel believes that off-site storage of RMP data is critical, logical, and easy to implement.

4.4 Reporting Mechanisms and Data Distribution

SFEI regularly produces several data/information-related products specified in the memorandum of understanding (MOU) between the Regional Board and SFEI. These include: an annual report with analysis and interpretation (printed), data available for public review (available through SFEI's World-Wide-Web site and, on request, in hard copy), and an annual meeting of the program sponsors. In addition, SFEI produces the newsletter *Regional Monitoring News* and stand-alone pieces such as *Monitoring Results* (prepared as an insert to the IEP newsletter). The contents and format of the annual report, the database, and the annual meeting are not specified in the MOU, nor is there any specification of the level of interpretation to be applied to RMP data. *The Review Panel believes that more explicit guidance is needed for RMP data analysis, interpretation and presentation. Such guidance can only come from RMP Participants, and only after RMP Participants have fully articulated their needs and expectations (see Chapters 3 and 5).*

4.5 Usage of Data/Information Products

It is not clear whether RMP information products meet the needs of its users in all cases. The Review Panel found that RMP products are not used to a uniform extent by the Regional Board and RMP Participants, nor is there a full appreciation for the extent to which RMP results are used. Users' needs are diverse and include making pollutant loadings estimates, developing

sediment criteria, assessing general compliance with water quality objectives and criteria, reducing testing requirements, assessing the relative likelihood of impacts from different contaminants, determining sources, and providing public relations benefits. Mismatches between products and needs arise primarily from the lack of a clear understanding among SFEI, the Regional Board, and the Steering and Technical Review Committees concerning the amount and types of information needed and how these should be packaged into particular products (see also Chapters 3 and 5).

4.6 Recommendations

- a. The content, level of detail, and format of all data and information products of the RMP should be specified by the Regional Board and the Steering Committee. RMP staff should also discuss with the Regional Board and the Steering Committee the desirability of data and information products not specifically called for in the MOU, e.g., newsletters and draft press releases.
- b. SFEI (with contributions from AMS and subcontractors, as appropriate) should document the entire data management system. The current data documentation (the annual report series) should list and describe all files that constitute the RMP database: file name, location, variables, definitions of technical terms and abbreviations, units, etc. The data documentation should describe the entire data path by specifying exactly what is done to the data, and by whom, as detailed in the UPDATE_INFORMATION table. It should also describe changes in station number that are made by AMS to the data submitted by subcontractors; data-reduction algorithms used on raw data before incorporation into the final RMP database; data quality assurance checks performed by subcontractors, AMS, and SFEI; and instances of suspect values and their resolution, i.e., which data points were considered suspect, which data points were changed (and why), and which data points were not changed (and why not). It is important to retain the ability to reanalyze original data if the need arises. It would be helpful if users received guidance on what applications of the data are valid or not (based on the experimental design and methods and data management approach). Online users of the RMP World-Wide-Web site should be pointed to the data documentation (i.e., the appropriate annual report).
- c. More resources should be considered for data and information management. This would permit additional quality assurance of data and, even more importantly, documentation of data and data management procedures, further development of the RMP World-Wide-Web page, linking to and/or incorporation of related monitoring data, and inclusion of pilot and special studies data into the RMP database.
- d. In order to improve efficiency and cost-effectiveness, SFEI should develop a systematic computer-assisted approach to data quality checking, especially for the core program portion that is well defined and continuing. For example, computer programs could identify (for follow-up validation) values that lie outside specified data quality objectives. This is *not* to suggest that outlying values would automatically be purged from the data set.
- e. SFEI should ensure a continued commitment to laboratory intercomparisons in the future. The NOAA exercise has the advantage of many participants, though a similar exercise

would also suffice. In addition, SFEI could maintain a useful contact with past contract labs by having them rerun some samples already processed by the present labs, in order to make analysts aware that even routine samples are subject to independent analysis.

- f. Data from the RMP core program should be integrated with data from special and pilot studies and other relevant monitoring programs. Relevant historical data sets should be identified, obtained, and made available to RMP Participants and other data users by means of the RMP data system.
- g. Off-site storage of backup tapes should be implemented. Given the ease and trivial cost, weekly removal of back-up data tapes to off-site storage would minimize the possible catastrophic loss of data.
- h. SFEI should provide the opportunity for continued professional development of its data management staff by permitting attendance at conferences or training sessions focusing on data visualization, metadata, Web page design, and other topics relevant to the management and dissemination of RMP data.
- i. Resources, including time, should be provided for RMP staff to author peer-reviewed papers as a means of demonstrating the value of the RMP and publicizing its findings and as a means of providing additional quality assurance of RMP data through the peer review process.
- j. Proper and prominent credit should be given to contributing scientists, regardless of the medium used (e.g., legends in tables or figures, header records in data files). This will enhance the RMP's relationships with other scientists and also provide an important record of the source of data used in the RMP's products.
- k. SFEI should undertake (and periodically update) a citation analysis of the use of RMP data and reports by non-RMP researchers. This would identify publications in addition to those of RMP researchers.
- l. SFEI should compile and distribute usage statistics for the Web site (and also for non-Web data requests) to quantify and document the number and affiliations of users of the RMP data.
- m. For the sake of accuracy, total PCBs should be for a specific list of congeners.
- n. Methods for trace organic analyses should be correctly described.
- o. The derivation of accuracy and precision estimates for measurements in bivalves and sediments, and of MDLs, should be described. If MDLs are based on the variance from repeated analyses of blanks taken through all the extraction and analysis procedures, the description should indicate whether ultra clean water or matrix (i.e., real bivalve tissue and sediment) blanks were used. For measured concentrations less than MDLs, it would be better to report the concentrations as whatever the analyst found. Users could then censor them as they wish.

- p. Derived values (e.g., shell cavity volume and weight) should be automatically (rather than manually) calculated from measured values. Dual entry from lab notebooks into spreadsheets is preferred over single entry, if resources permit.
- q. Annual reports need a publication date and location so they can be properly cited as the documentation for the RMP database. This will add credibility to the RMP's products.
- r. The titles of the *Monitoring Results* articles need to be carefully worded. The headline of one example (Is Bay Pollution on the Rise?) may be taken as leading and inflammatory.

5.0 ORGANIZATIONAL RELATIONSHIPS AND CAPACITIES

Summary: The authorities and relationships that structured the RMP were defined in the original documents that established the program. These provided sufficient guidance for the RMP's first five years, during which the program focused on implementing the initial five-year plan. During this period, the parties to the RMP have also established a cooperative, consensus-based management process. This has served to foster participation and commitment among a diverse group of interests. At the present time, however, this management system does not provide the structure and definition needed to guide the program through its next phase of development. The Review Panel strongly recommends that the RMP give serious attention to better defining the roles, responsibilities, and authorities of its members; develop more detailed and formal decision-making procedures; and increase its ability to address and resolve healthy conflict about the program's overall direction. The Review Panel believes that the development of a new five-year plan for the RMP provides an ideal opportunity to address these issues.

5.1 Introduction

The formal, legal relationships among the organizations involved in conducting the Regional Monitoring Plan (RMP) are described in Resolution No 92-043 of the California Regional Water Quality Control Board, San Francisco Bay Region (the Regional Board), and the MOUs between the Regional Board and the San Francisco Estuary Institute (SFEI; then named the Aquatic Habitat Institute [AHI]) dated 1992 and 1996. Resolution 92-043 stated the processes followed, and the authorities used, by the Regional Board in establishing the RMP as part of the Regional Monitoring Strategy under the umbrella of the San Francisco Estuary Project (SFEP). The original implementation plan for the RMP was charged to the Executive Officer of the Regional Board: "...the...Executive Officer shall work with the selected dischargers to prepare an implementation plan for the RMP including a schedule for submittal..." In a memorandum of understanding (MOU) the Regional Board and AHI (SFEI) agreed to establish a Steering Committee for the RMP comprising at least one member from each discharger category. The Steering Committee was charged with the responsibility to work on "... such issues as allocation of future program costs, selection criteria for contractors, participation in proposal review and selection, review of progress, technical review of program results, and evaluation of effectiveness of the program on a periodic basis." Resolution 92-043 and the text of the MOU make it clear that the Regional Board, SFEI, and the Steering Committee (representing the Participants) have authority to prepare the Study Plan for the core program. The study plan was described in the MOU as "... a detailed plan for implementing the baseline portion of the Program."

The Technical Review Committee (TRC) was established by action of the Regional Board, SFEI, and the Steering Committee as comprising a representative from SFEI, a representative from the Regional Board, and at least one member from each discharger category. The TRC was assigned the responsibility of assisting SFEI in "... developing annual work plans and five-year plans that are technically sound and consistent with the policy guidance of the Steering Committee and the Regional Board."

These original definitions of roles, responsibilities, and authorities served to initiate the RMP and provide broad guidance during its early years. However, this original authorizing language left the development of the details of day-to-day planning and decision making to the program's partici-

pants. While the processes that arose during the first five years were sufficient to accomplish the RMP's initial set of objectives, the Review Panel believes they do not provide an adequate basis to meet the challenges that currently confront the RMP. The following sections review the decision-making dynamics within the RMP and recommend ways these could be enhanced to help implement the recommendations listed in the other chapters in this report.

5.2 Consensus-Based Decision Making Within the RMP

In a formal sense, each organization participating in the RMP has a specified supporting role, defined in general terms, in the original Regional Board Resolution and Memoranda of Understanding (MOUs) and carried out under the Regional Board's overriding regulatory responsibility. While these founding documents outlined basic relationships and responsibilities, they left the day-to-day management approach of the RMP to be devised by the parties themselves. The parties to the RMP envision themselves as a coalition of organizations with a cooperative working relationship among "equals" with roughly equivalent influence and organizational authority. The Review Panel considers this a classical consensus management model and found that the program's participants in general concurred with this judgment.

Thus, the RMP developed from 1993 to 1997 without requiring detailed written policies and procedures that identify which parties have specific responsibility for recommending, reviewing, and approving programmatic content. Nor has there been an explicit process for resolving conflicts. In fact, the actual working relationships within the RMP are still developing and are not consistently perceived by representatives of different groups, a not unusual situation in a complex consensus-based program only five years old. The existing consensus management approach was appropriate early in the program because it allowed for widespread involvement in the development of the RMP and helped build commitment among the parties to the program. In addition, consensus management is most efficient when the dispersed power of the coalition is focused and exercised by a single spokesperson or small inner circle (Thompson, 1967). At the inception of the RMP, this role was played by Mr. Michael Carlin, whose vision for the RMP helped to bring it into being. Mr. Ritchie's (the Regional Board Executive Officer at the time) authority and Mr. Carlin's stature within the Regional Board staff made possible the effective management of the coalition as the scope and funding of the RMP evolved to its present level.

As such a program matures, however, consensus decision making may in fact limit the ability of the organization to move decisively and make needed changes. Where one member of the coalition actually has significant authority over the others, as the Regional Board does in the RMP, maintaining the consensus can become more important to the coalition than identifying and resolving differences of opinion. Members of the coalition may be concerned that bringing conflict into the open may force it to be resolved in ways that undermine the sense of equality and shared involvement among participants. Thus, conflict may not be acknowledged and addressed unless there is a procedure for doing so that helps preserve these important values. The Review Panel believes that this has, in fact, occurred within the RMP.

In addition, several circumstances now combine to lessen the effectiveness of this informal consensus approach even further. Both Mr. Carlin and Mr. Ritchie have left the Regional Board and their roles have been taken on by staff who were less involved in the initial development of the RMP. There seems to be broad sentiment that the Steering Committee should take a more active role in defining and directing the program, and SFEI staff, as appropriate, are pushing the scientific

envelope of the RMP. In addition, SFEI continues to take on more logistical and management responsibility for implementing the RMP. For the first time, in February 1991, the Steering Committee has not approved an expansion of the annual budget. Finally, as discussed in Chapter 2, it is time to reconsider whether the program's original objectives are still appropriate. While suggested modifications to the objectives have been proposed, the process for approving such suggested changes is not clear, nor is it clear where the authority lies for such approval. There does not seem to be consensus on this issue and there are unresolved conflicts within the RMP Steering Committee on appropriate alternatives to the existing objectives.

The Review Panel believes that the shortcomings of the RMP's consensus-based management system described above are not unusual. However, at this point in the program it is appropriate to evaluate existing interactions among the RMP's entities and formalize, replace, and/or add to them in ways that bring structure and predictability to decision making about the program. The recommendations at the end of this chapter suggest ways to accomplish this, although the Review Panel feels that specific details on how to accomplish this are best left to the RMP to develop. The Review Panel also believes, quite strongly, that addressing these shortcomings is essential if the RMP is to continue to flourish and provide the high-quality data that are essential to management of San Francisco Bay. In particular, the RMP's ability to redefine its objectives (see Chapter 2) and to articulate clear questions to guide study design and data analysis (see Chapter 3) rests on the willingness of the program's participants to come to grips with the decision-making issues outlined above. The Review Panel believes that the first step in this process should be the development of an explicit five-year plan for the years 1998 through 2002.

5.3 Organizational Roles

5.3.1 The Regional Board

The Regional Board's authority stems from its regulatory powers and region-wide perspective. The Regional Board created the RMP; clearly they are in the most powerful position among the parties to the RMP. However, the Regional Board has acted to moderate the power of their position by working through the Steering and Technical Review Committees, each of which is composed of representatives of the Participants. By establishing this working relationship the Regional Board acknowledges the importance of consensus among all parties in maintaining the RMP. In some cases, however, the direction of the RMP is dictated by the Regional Board, through the Executive Officer. In such cases there should be greater hands-on involvement of the Executive Officer to communicate conditions that must be implemented by the Steering Committee and SFEI.

The Regional Board's Executive Officer and staff told the Review Panel that the data generated by the RMP are useful in executing the Board's regulatory and planning responsibilities. Specific examples of how these data are used have not been provided. It is beyond the charge of the Review Panel to make an independent evaluation of how to improve this interface between the technical results of the RMP and the Regional Board's regulatory responsibility. However, it is apparent that the Regional Board is pleased with the information generated by RMP and the Board's objectives and goals for the Program are being met.

The Regional Board could strengthen the RMP by requiring its staff to provide SFEI and the Steering and Technical Review Committees with additional information on how data have been used and what specific kinds of data and/or analyses would support current and future decision making

(see Chapter 3 for additional discussion). This would initiate a dialogue that could improve the value of the data to the Regional Board. It would also provide input for the development of more specific objectives, enhance the planning process, and allow a sufficient planning horizon for developing special studies and pilot programs that more specifically address the Regional Board's needs.

The Regional Board could also strengthen the RMP by joining in discussions aimed at clear definition of the roles of all parties involved in the RMP.

5.3.2 The San Francisco Estuary Institute

SFEI's authority at the start of the RMP was derived from the Regional Board's power to "create" the funding to empower SFEI. In the first five years, SFEI has administered the RMP through a primary contractor, Applied Marine Sciences (AMS). As the RMP attains its goals and successfully completes each Annual Report, SFEI has taken on more direct responsibility to administer the program and has developed independent technical authority based upon its leadership and scientific expertise. *This continuing transition toward increased responsibility for SFEI will be effected more easily and quickly as SFEI develops substantial additional funding from other sources that will enable it develop a stronger and more diverse technical role in the region.*

The transition of responsibility from a primary contractor (AMS) to SFEI was foreshadowed in the Regional Board's Resolution Implementing the RMP and in the MOUs between SFEI and the Regional Board. In those documents the Regional Board delegated to SFEI the responsibility to implement the Regional Monitoring Strategy (RMS) for the Bay, the first element of which was the RMP. In the course of the last five years, SFEI has developed the staff and expertise necessary to assume increasing responsibility in the technical execution and contracting for services needed by the program.

There is some confusion about SFEI's desire to expand the RMP to include a more "ecosystem" based approach (see further discussion in Chapters 2 and 3). SFEI's efforts to gain approval for new, broader objectives conflict with the positions of the Regional Board and the Participants. With regard to the Regional Board, establishing new objectives that include measurement of additional end-points relevant to beneficial uses and impact assessment could place Regional Board Staff in the position of making management decisions with RMP data unsuited for the task. It should be noted, however, that EPA has recognized the value of using biologically based yardsticks (biocriteria) such as those suggested by SFEI to evaluate water quality criteria. Thus, SFEI's advocacy in promoting habitat evaluation in the RMP is clearly in step with these federal initiatives (EPA 1990) (see recommendation *ia* in Chapter 2 regarding potential expansion of the RMP).

With regard to the Participants, there is an understandable desire to hold the line on the content of the RMP and its budget. The Participants are comfortable with the program when it is defined as "monitoring related to pollution," but are less comfortable with extending the monitoring concept to habitat evaluation. The cause of concern may be purely financial for some Participants; however, others seem to be concerned about setting inappropriate precedents by stretching regulatory yardsticks to include habitat measures in addition to the classic numerical pollution criteria.

The Review Panel believes that SFEI is fulfilling its responsibilities by recommending program elements and objectives that move the RMP into new territory. Without constant scientific overview and reevaluation, the RMP could fall behind scientifically and technologically. Thus, in stimulating

discussion about modified objectives for the RMP, SFEI is performing an appropriate function. The wetlands monitoring study is an example of how the RMP can support the development of the RMS. Preliminary funding was provided by the RMP special studies budget. The wetlands studies were developed under the auspices of the RMP and, having demonstrated its value, SFEI has received independent funding for this element. In this example, the RMP served well as an "incubator" for a program that contributes to the RMS.

The success of SFEI's advocacy for expanding and adjusting the program, and its objectives, may have been limited by SFEI's financial dependence upon RMP during the first five years. Clearly, it was in SFEI's best interest to "push the envelope" of the RMP. It has been, and may still be true that the **perception** of conflict between its role as RMP manager and its own self interest limits SFEI's success as an advocate for expanding funding for the program. Recent successes in obtaining funding from other sources, if continued and expanded in the future, will almost certainly remove this impediment as SFEI exercises its proper role in developing the next five-year plan for the RMP.

The authority exerted by SFEI derives from a combination of science and policy. Some of SFEI's technical authority rests with key academic subcontractors and this has contributed to producing an excellent technical product. However, in the long run, it is difficult to exert strong technical authority and leadership without more direct responsibility for contracting, program management, data management, and analysis and interpretation. The Review Panel therefore considers it a healthy transition for SFEI to continue taking on additional responsibility for these aspects of the program. This will speed SFEI's development from an extension of the Regional Board that gets a program going to an independent technical presence in the program.

5.3.3 The Participants

The RMP Participants comprise the permitted dischargers and dredged material disposers in the San Francisco Bay area. Their authority in the RMP derives from their role as the financial support of the RMP. Resolution 92-043 of the Regional Board and the MOU between the Regional Board and AHI (SFEI) placed broad power in the hands of the Participants in the areas of: collaboration in writing the Study Plan, financial and technical review, and evaluating the effectiveness of the RMP.

Participant representatives occupy seats on the Steering Committee and the Program Technical Review Committee; they are, therefore, in the position of both recommending and authorizing certain aspects of the Program.

Participants cooperation in the RMP has been outstanding. To the best of our knowledge virtually all Participants have lived up to their financial responsibilities to support the RMP, and Participant attendance at critical meetings (Steering Committee and Technical Review Committee) has been laudable. Beyond the recommendation stated below, that the Steering Committee take a greater hand in RMP matters, the Review Panel sees no way in which the Participants need to improve their participation in the RMP.

The Participants are a diverse group with a wide range of backgrounds and expectations for the RMP and vastly different financial resources. As a group, they express support for the RMP, appreciation for its unique aspects, and a desire to see the RMP continued for a long period of time in its present form. This includes both the base program and the special and pilot studies. Most Participants indicated that by supporting the RMP, they expected to be able to reduce the cost of

other aspects of their regulatory requirements. This expectation has been met in some cases but not in others. The dredging community, for example, has been disappointed in their expectation that the RMP will reduce dredged material testing requirements. The Participants' success in using RMP data to reduce other aspects of their compliance programs seems directly related to their ability to interpret, and then use, those data themselves. Smaller participants with restricted budgets and limited in-house technical expertise are not able to use the data effectively. Increasing the RMP's ability to respond to these and other Participant needs will be improved to the extent the program improves its ability to focus on more specific and relevant scientific questions (see Chapter 3 for more discussion).

5.3.4 The Committees

The MOU defines the make-up of the Steering Committee and directs it to "work on" cost allocation, selection criteria, progress reviews, and the overall effectiveness of the program. However, no processes are defined whereby the Committee can execute these responsibilities. With the exception that the Regional Board, alone, has the authority to make changes in the Core Program, the Steering Committee appears to have a wide latitude to evaluate or to approve financial and technical elements of the RMP.

At present, the Steering Committee meets quarterly. This schedule does not provide for sufficient attention to a project as complex as the RMP if the Committee expects to provide strong direction to the RMP. The Steering Committee (or perhaps a duly constituted subcommittee) needs to take a more active role in defining what it expects to review versus what it expects to approve. This would clarify SFEI's responsibilities and authorities and would allow SFEI to develop a needs-based meeting schedule for the Committee. Timely review and approval of program elements and contractor selections are essential if SFEI is to successfully take on the responsibility for direct contracting of laboratory services.

The Technical Review Committee's responsibilities are to periodically review program design and program results. The manner in which the Technical Review Committee should report the results of that review to the Steering Committee is not defined. More importantly, it is unclear as to whether the Steering Committee has authority to decide, on its own, to accept suggestions from the Technical Review Committee.

5.4 Recommendations

- a. The Regional Board should clarify which authorities it retains for itself (or its staff), which are the responsibility of the Steering Committee and the Technical Review Committee, and which are responsibility of SFEI. This should include a definition of the responsibilities for recommending and approving changes to program objectives. It should also include a definition of processes and responsibilities related to soliciting, evaluating, and approving special and pilot studies.
- b. The Executive Officer of the Regional Board should direct SFEI to develop a five-year plan that will be presented to the Steering Committee no later than the end of the third quarter of 1997 and, following the Committee's review, to the Regional Board no later than December of 1997. *This schedule will result in an "approved" second five-year plan by mid 1998. It is not feasible to complete*

the plan in time to implement revisions to the annual program for 1998. Thus, the Review Panel recommends that the 1998 program be conducted in accord with the objectives stated for the first five-year plan.

- c. The Regional Board needs to communicate its needs and objectives for the new five-year plan, and for each of its component annual program plans, to SFEI in a formal fashion. This should include a clear description with examples of how the previous years' data have been used by the Regional Board staff to successfully attain regional water quality objectives.
- d. The Steering Committee should require SFEI to prepare an implementation plan for the new five-year plan, with sufficient detail to assure that SFEI will be properly staffed with technical and administrative personnel to undertake full responsibility for contracting the various elements of the program. The additional responsibilities to be assumed by SFEI in each year should be clearly identified.
- e. The Regional Board should require the Steering Committee to put into place a process that compares the results of each annual plan with the objectives of the program and that presents that comparison to the Regional Board. This is so that it can make any additional requirements known to SFEI at least three months prior to the implementation of the next annual program.
- f. SFEI should continue to take greater responsibility for the technical and contractual execution of the RMP.
- g. SFEI and the Regional Board staff should provide the Regional Board Members with information on the unique nature and accomplishments of the program. Newsletters, as a means of conveying RMP findings to a broad audience, are an important element. This unique program deserves wider recognition.

6.0 MANAGEMENT

Summary: The day-to-day operation of the RMP is administered smoothly by SFEI, with no problems apparent in any of the financial or contracting functions. To date, each year's program has been accomplished successfully with a minimum of problems. However, the Review Panel identified a series of issues that could create problems in the future and that deserve attention. First, there is no clear distinction between services that are charged directly to the RMP by SFEI and those that are covered by overhead. The Review Panel believes that this could create confusion in the future, particularly as SFEI obtains additional sources of funding for monitoring and research. Second, the existing multi-layered program structure, with nesting of subcontractors, results in several layers of project management and administration. This may result in higher than needed administrative costs and should be examined. Third, the very short planning horizon for each year's work is unrealistic for a program that requires intensive, complex field and laboratory scheduling. This reduces the ability to review the implementation plan and often puts contractors in the position of having to begin work without formal contracts and budgets. Fourth, there is no definition of any interim products that would allow the Committees or SFEI to determine if the desired technical quality and schedule are being attained during the course of the year. This reduces the opportunity for making needed midcourse corrections. Finally, while the initial five-year plan guided the program through its start-up phase, the longer-term planning process seems to have been on automatic pilot since then. There is no strategic plan for the years beyond 1997, nor is there a process for developing one. The Review Panel strongly recommends development of a new five-year plan.

SFEI's responsibility is to execute the RMP's technical program as directed by the Regional Board and the Steering Committee. SFEI administers the RMP using funds collected from participants as well as in-kind contributions. Approximately \$800,000 is provided to SFEI for these activities. For the most part the field and laboratory services are directly provided by the prime contractor, Applied Marine Sciences of Livermore, CA (AMS). Work performed under subcontract is managed by AMS. SFEI is changing this nested management model as it takes on more responsibility for subcontracting, data management, data reduction, and program management.

Under the existing management structure (see Chapter 5 for further discussion), no single party to the RMP has the sole authority to remove and/or replace any of the subcontractors or a provider of in-kind services. When problems occur they are discussed in the Steering Committee to develop a consensus on an appropriate action.

SFEI is responsible for two different administrative functions:

1. Contracting and financial management, which includes collecting money from the Participants in accordance with instructions from the Regional Board, contracting for technical services, and paying for the technical work
2. Administering the technical program as approved by the Steering and Technical Review Committees for each year

6.1 The Financial/Contracting Function

The RMP has a specific administrative procedure that defines SFEI's contracting and finance function. Although not detailed enough to use as a formal procedures manual, the responsibilities of the various organizations are described in general terms and are consistent with the descriptions in the Regional Board's Resolution to implement the RMP. There are no real alternatives for each organization's role in the financial and contracting aspect of the RMP; thus, the boundaries are clear and there is little room for confusion or conflict.

SFEI has some policies or procedures that are applicable to all of its programs and which cover the RMP for Trace Substances. The contract procedure document, distributed via an inter-office memo in 1992, stipulates requirements for tracking contracts received and subcontracts let. Responsibilities for each element are defined by job title within SFEI. SFEI maintains few written materials such as technical and administrative procedure manuals; however, this is not unusual in a small, relatively young organization. There has not been time to develop extensive written material nor has the need for such documents been emphasized.

6.1.1 Collecting the Money

The system for invoicing the Participants is simple and there is little need for decision making by SFEI. Decisions on the total amount to be paid and the allocation among permittees are made by the Participants and the Regional Board. SFEI implements those decisions by preparing the bills, sending them to Participants, receiving and recording funds, and then distributing funds within SFEI and among RMP contractors.

Both SFEI and the Participants are flexible in the method of invoicing and collecting payments. Some Participants pay the entire invoice in one payment, others in installments. There have been no major problems with receiving payments. If serious problems were to arise, SFEI would notify the Regional Board and Participants, but would not be expected to take action to enforce payment. It would be helpful if a formal procedure were developed to address this and other administrative issues.

Records are kept in an interrelated spreadsheet format. Financial information is provided in quarterly reports, a sequence that is consistent with the billing cycle. Information is updated at least monthly, and reports could be provided more frequently if needed. The system is simple, but appropriate for the function and level of effort required to complete it each year.

Financial management and record-keeping for the RMP at SFEI is the responsibility of Gabrielle Marek. Ms. Marek appreciates the importance of careful documentation and good accounting practices, and she has incorporated both into the system. She has had professional help developing the system but operates it on her own. She also plays a role in administering the technical program. She maintains the Program Plan and related documents and has a good big-picture view of the RMP from the administrative perspective.

6.1.2 Paying the Bills

The disbursement element of the financial function relies on basic, good accounting practices. SFEI has a professional accountant on staff, and standard practices are used to verify and pay contrac-

torsí invoices. The approval process includes appropriate technical overview and payment is related to deliverables by policy.

The overview and approval process for RMP work done within SFEI is less well defined than that for work performed by subcontractors. SFEI charges defined portions of specific employees' time directly to the RMP. The salaries are marked up by the SFEI overhead factor. However, there is no written definition of what services are directly charged and what are provided by overhead. Once the program budget and time allocation for assigned staff are defined for the year, financial information is provided quarterly to the Steering Committee, which provides an external review and approval function. There is no indication of any problem with this set of procedures, but it is not conventional operating practice and could lead to mistrust and misunderstandings in the future. The Review Panel recommends developing a standard policy for reviewing SFEI functions related to RMP activities.

6.2 Administering the Technical Program

The RMP provides SFEI with a large portion of its funding (see Chapter 7 for more detail). Many of the SFEI staff work on the RMP in some capacity, charging their time either directly or through SFEI's overhead allocation. *The degree to which the RMP dominates SFEI's overall budget made it difficult for the Review Panel to differentiate between the program and the institution. Although the boundaries between the two are not clear, they will by necessity become clearer as SFEI develops additional support.*

6.2.1 Program Planning

6.2.1.1 Strategic or Long-Term Planning - The initial five year plan was developed by the Regional Board staff during the formation of the RMP. It included a definition of objectives and recommendations for annual increases in funding. However, the initial five-year plan did not include a formal strategy for increasing the budget, nor for evaluating how well the plan has been implemented or whether objectives for the technical program and the budget have been met. More frequent periodic reviews of the RMP are certainly called for.

The initial five-year plan guided the program through its start-up phase; however, the longer-term planning process seems to have been on automatic pilot since then. *There is no strategic plan for the years beyond 1997, nor is there a process for developing one.* Several key individuals interviewed by the Review Panel acknowledged the need for, and the value of, a long-term strategic plan for the RMP. As a start in this direction, SFEI has prepared working documents aimed at developing new objectives for the RMP. As discussed in Chapter 2, these provide a starting point for longer-term planning insofar as they begin to define new objectives and approaches. However, none of these preliminary documents consider the financial element of the RMP nor do they address how, or when certain existing program elements should be modified, or eliminated.

The issue of strategic planning for the RMP is complicated by the difficulty in drawing a clear-cut line between planning for the RMP and for SFEI (as an independent institution). SFEI has responsibility for developing San Francisco Bay ecosystem monitoring under the CCMP's larger Regional Monitoring Strategy. The documents proposing a new RMP Objectives Framework define several objectives that would expand the RMP in the direction of ecosystem monitoring and assessment, in line with the overall Regional Monitoring Strategy. As discussed at greater length in Chapter 2,

some RMP Participants and the Regional Board staff question whether such an expansion of the purview of the RMP is appropriate. To some extent these questions relate to the appropriate uses of RMP funds and concerns that the primary objective (long-term monitoring of trace substances) might not be met. They also reflect some lack of clarity about the relationship between the RMP and the Regional Monitoring Strategy and about whether and how SFEI should use the RMP to lay the groundwork for further development of the Regional Monitoring Strategy. Without a consensus on a suitable long-term strategic plan for the RMP and the role of the RMP in the larger Regional Monitoring Strategy, these issues are likely to remain unresolved. Further, it will be difficult to introduce any real improvements to the RMP without some guidance on long-term goals for both budget and program content. (See Chapters 2, 3, and 5 for further discussion of related issues.)

6.2.1.2 Annual Planning - The annual program plan describes the membership of the Steering and Technical Review Committees, a schedule for deliverables for their review, a variety of supporting and historical documents, funding information, and an implementation plan. The implementation plan defines the core components of the RMP for that sampling year, and additional studies that will be conducted if money becomes available (contingency projects). While the plan defines the budget for each component, it is more a definition of the program's content for the year than it is an actual implementation plan. The implementation plan does not address study design. It does not define how each component will be conducted, by whom, and on what schedule. *There is no definition of any interim products that would allow the Committees or SFEI to determine if the desired technical quality and schedule are being attained during the course of the year.*

The RMP schedule identifies SFEI's responsibilities for interactions with the Steering Committee and the Committee's quarterly meeting schedule. The resultant time horizon for planning the next year's work is very short. The Review Panel believes that the meeting schedules and the very short planning horizon are unrealistic for a program that requires intensive, complex field and laboratory scheduling. The lack of an adequate planning horizon reduces the efficiency of scheduling field work and cognate laboratory analysis and limits the possibility of changing a contractor or re-bidding the work during the work cycle. More importantly, it limits the ability to carefully consider and adjust the implementation plan if needed.

Contracts for field and laboratory work should be in place in time to prepare gear and schedule staff. In some years contracts have not been in place until the end of the first quarter. All parties have been willing to work in good faith, which reflects the good relationships that characterize the RMP. While good-faith efforts are laudable, and have greatly aided the RMP during the early years, a more efficient contracting mechanism should be devised and implemented. The fact that the scope of the primary contractor's (AMS) work is being reduced as SFEI takes on more responsibility creates an additional risk for the program. SFEI is performing more of the technical components of the work, including data and report preparation, and would like to take on the responsibility of contracting directly with the laboratories. AMS or another field contractor may be less willing to extend itself and work on good faith, without a contract, as its responsibilities are assimilated by SFEI.

6.2.1.3 Midcourse Corrections - There is no mechanism for midyear alterations in the technical or administrative elements of the project. Since all annual funds are allocated at the beginning of the year there are no funds set aside to be used for investigating any significant findings arising from studies in progress.

If problems arise with contractors, or if there is a decision to change contractors, there is no established procedure for making such a change. In the most recent case involving the shift of some analysis funds to the Bay Area Dischargers Authority's (BADA) laboratories, this was achieved in midyear but was a difficult transition. The responsibility for, and authority to make, such changes is obscure. In the case of past problems with obtaining timely data from a contractor, changes were made by committee in order to avoid confrontation. Unfortunately this did not result in obtaining the data.

6.2.2 Budgeting and Cost

None of the RMP-related work has been the usual competitive bid process, nor have there been any estimates made of comparative costs. It is difficult to make concrete cost comparisons because of differences between the RMP and other large regional monitoring programs. There are some indications that the overall costs for the program might be higher than necessary. The nesting of subcontractors results in several layers of project management and administration, with unwritten (at worst), or imprecise (at best), definitions of which institution is responsible for what part of the RMP program. This could lead to confusion. Costs per sample for laboratory analyses are equal to or higher than costs for similar analyses; however, the detection levels, credibility, and services provided are exceptional and thus the overall value achieved for the analysis dollar is very good.

It is difficult to judge the cost effectiveness of the program because there are several intangibles that give the RMP exceptional status, and that have great value to the Steering Committees and the Regional Board. SFEI's position as a scientific entity independent of the Regional Board and the involvement of academic institutions lend credibility and prestige to the program. These intangibles have significant value for the RMP that could be lost if too much focus is placed on the bottom line.

6.2.3 Staffing

Nearly every SFEI employee works on some aspect of the RMP for some portion of their time, although not all charge their time to the project. Margaret Johnston, for example, had no time allocated to the 1997 program budget although she is participating in the review and receives and approves financial information.

SFEI does not have a staff member with the experience that would be required should the Institute take over full control of the RMP. The logistics required to implement this complex field and laboratory program have been managed by AMS for five years. Margaret Johnston indicated that it would be necessary for SFEI to hire a logistics-oriented individual at some point in the future. However, she felt that the immediate priority was to acquire enough funding for a full-time contract manager, which she defined as meaning an individual with an administrative orientation. The Review Panel has concluded that SFEI staff include sufficient administrative personnel. It is the view of the Review Panel that SFEI would benefit most from hiring a hands-on project manager with experience in the logistics of field sampling efforts

6.3 Recommendations

- a. A procedure for reviewing and approving the direct charges for SFEI's work should be developed.

- b. The services provided by direct charges to the RMP versus the services provided via other means should be defined. SFEI provides support and services that are not billed to the RMP. These include time spent by the Executive Director on the program itself and on its behalf, time spent by other SFEI staff, and substantial unpaid overtime (see also Chapter 7). These valuable but often intangible services should be identified and acknowledged as in-kind support for the program.
- c. As SFEI takes responsibility for direct contracting of laboratory services, funds presently allocated to AMS for contract management should be allocated to a technical, logistics manager. This individual should report to the program manager or his designee and should be responsible for assuring that the contractors are fulfilling their obligations.
- d. Changes in contractors should be made at the beginning of each annual program, if necessary.
- e. Only those program elements that are readily available from several potential contractors should be considered for competitive bidding. Existing contractors for most program elements bring substantial, sometimes intangible, value to the program.
- f. The RMP should consider how SFEI's Committee of Science Advisors could assist the RMP in two areas: 1) defining the boundary between scientific interpretation of the RMP data and management and regulatory issues, and 2) preparing the second five-year plan. The CSA should perform an annual technical review and identify scientific issues that should be evaluated based upon the RMP data.
- g. The Steering Committee should require SFEI to develop and distribute an agenda at least one week before each meeting. The agenda should clearly identify those action items that must be decided by the Committee at the meeting. SFEI must assure that the agenda includes sufficient background material and attachments to allow Committee members to understand the issues and be prepared to make decisions. A report from the Technical Review Committee should be a standing agenda item at each Steering Committee meeting.

7.0 RESOURCES

Summary: There appear to be sufficient resources available to carry out the RMP in its current form. While the Review Panel has recommended that additional data integration, modeling, and analysis be performed, it also believes that other recommendations in Chapters 3, 5, and 6 regarding the study design and the management structure may result in a more streamlined program with attendant cost savings. A significant contribution to the RMP is the wide array of in-kind services provided by virtually all parties to the program, including contractors. These contributions stem in part from the cooperative nature of the RMP and add a great deal of value to the program, although they are difficult to actually measure in dollar terms. There are no current efforts to obtain additional state, federal, or grant funds and/or in-kind services to support the RMP. The Review Panel agrees with the several Steering Committee members who believe that there may be several possible ways to obtain such support and that efforts to identify these should be undertaken. The Review Panel found that the large body of data, both from historical studies of the Bay as well as from other ongoing monitoring and research programs, represent a valuable but under-utilized resource for the RMP. The Panel recommends that the RMP put additional effort into integrating the results of these studies with the RMP's findings.

This chapter summarizes information on resources available for conducting the RMP for Trace Substances in San Francisco Bay (RMP). "Resources" here will be loosely interpreted to include anything of value for carrying out or completing the RMP. Resources, therefore, include not only money but also the time and materials spent on projects related to and integrated into the RMP, such as other monitoring programs in the Bay, the estuary, and tributary streams. Resources also include in-kind services of time, materials and effort contributed to the RMP by parties to the RMP as well as other organizations, individuals, and institutions in and around the Bay Area.

7.1 Financial Resources

7.1.1 Contributed Funds

The majority of funds for the RMP come from cash contributions from dischargers to Bay waters: large and small POTWs, industry, stormwater management districts, and the dredging industry. Cash funds at RMP startup (1993) were \$1,150,000 and have increased steadily to \$ 2,840,094 for 1997 studies. Some funds (\$250,000 per year) that are listed as available to the RMP are not cash; rather, they are federal dollars passed from the U.S. Army Corps of Engineers to the U.S. Geological Survey and are used to support programs cognate to the RMP core program. The Steering Committee on January 27, 1997 agreed that there would be no increase in RMP funding for the 1998 study year.

RMP funds from dischargers are paid directly to SFEI. Approximately \$800,000 (1997-projected) of the RMP funds remain at SFEI and are used to support administrative activities, data management, quality control, data analysis, report writing and publication, newsletter writing and publication, annual meetings, and the electronic database (including the WWW site). The remainder of RMP contributed funds are disbursed to contractors retained for carrying out specific functions described in the annual RMP implementation plan. Pass-through funds from the Army Corps of Engineers to USGS are not under the control of SFEI or the Steering Committee other than the fact that there is a

gentleman's agreement that studies carried out with these funds will fit within the objectives of the RMP (See Chapter 2, Box 1).

It is not known at this time whether the Regional Board will increase the number of dischargers (and, presumably, the funding level) in the RMP in the near future. Discussions are underway aimed at changing the allocation of RMP costs among dredgers such that payments from small dredgers, large dredgers, and the Army Corps of Engineers are more consistent with agreed-upon payment formulae. If such changes occur, they are unlikely to change the total budget for the RMP; however, it may occur that a vehicle for payment of federal funds to the RMP can be activated, thereby increasing the budget managed by SFEI.

To the best of the Review Panel's knowledge, there are no ongoing activities to obtain additional cash funds to support the RMP. Interviews with Participants and with Steering Committee members revealed consternation that there have been no concerted efforts to obtain state or federal funds or to investigate grant funds that may be available. The Review Panel believes that there may be several possible ways in which additional funds and/or in-kind services may be obtained through grants, seed monies, or federal-local partnership arrangements.

7.1.2 Budget Plans

That portion of the annual implementation plan that is funded and executed is determined by the funding available to the RMP. RMP activities each year are determined according to a process whereby funding requests for the monitoring year are submitted to the Executive Officer of the Regional Board for approval. However, there is no annual budget plan based upon a systematic analysis of funding needs for individual components of the RMP that extend beyond the core program. The Steering Committee may comment to the Regional Board and the Executive Officer of the Regional Board as to the acceptability of the budget and its allocation among discharger groups. Changes to the Core program may be ordered by the Regional Board. To this point in time, however, the Regional Board has collaborated with SFEI, the Technical Review Committee, and the Steering Committee in seeking consensus on any desired changes to the program (see Chapter 5). During the planning process, SFEI staff work with the Technical Review Committee to include as many additional special and/or pilot studies as possible that meet program objectives.

As noted in Chapters 5 and 6, decision making in the RMP is by consensus and follows no formal process. *The Review Panel found that all Participants would prefer that formal decision-making processes, guidelines for project planning, and guidelines for budget planning be developed. In addition, all Participants agreed that formal processes for soliciting, evaluating, and selecting special and pilot studies would benefit the RMP by allowing a more realistic allocation of resources among core elements and other studies.* The Review Panel concluded that such processes and guidelines should be developed, and should include a specific definition of roles for the Steering and Technical Review Committees and Regional Board staff in the budget planning process.

7.2 Resources from Collaborative/Cooperative Efforts

7.2.1 Internal Resources: SFEI Core Support

RMP funds comprise a large fraction of SFEI financial resources. Information provided to the Review Panel shows that, for fiscal year 1997, RMP funds will provide about 58% of SFEI operating

funds. SFEI is actively seeking additional funds to support a variety of activities throughout the Bay and estuary, including funds related to the overall Regional Monitoring Strategy, and funds for wetlands monitoring. Any and all funds received by SFEI serve to buttress the RMP trace substances effort. Each dollar of additional support makes it possible to maintain, and build, SFEI staff with scientists who contribute to the RMP merely by their presence and their availability to consult on RMP matters.

7.2.2 Internal Resources: SFEI Real Property and Equipment

SFEI owns, leases, and maintains space, facilities, and electronic equipment used in support of the RMP. The actual annual value of this contribution has not been computed. Presumably such a computation would be possible; however, it is unclear what such a computation would provide for the purposes of this review.

7.2.3 In-Kind Services

RMP receives in-kind services from a number of sources, including SFEI, the prime contractor Applied Marine Sciences, the U.S. Geological Survey, the University of California at Santa Cruz, and the various contractors involved in the RMP. In-kind services here refer to contributions to the RMP in any of the following categories: 1) unbilled effort, 2) providing services of exceptional value (as in reduction or removal of overhead), 3) matching funds, and 4) -back efforts by some contractors with other sources of support. Significant contributions to the RMP also come from the Central Valley Regional Water Quality Control Board, the California Department of Water Resources, the Bay Area Dischargers' Association, and Texas A&M university. Whereas in-kind services cannot be counted on as a constant resource, they should be considered in the overall context of the RMP, its management, and its future plans. Some of the most important of these in-kind resources are listed below.

7.2.3.1 In-Kind Services: SFEI - In-kind services from SFEI comprise professional services provided to the RMP from individuals not supported by RMP funds and by personnel contributing hours to the RMP in excess of their budgeted limits. The greatest contributions in this regard are made by Dr. Bruce Thompson, Dr. Rainer Hoenicke, and Dr. Jay Davis. They contribute unpaid overtime on RMP issues, as well as service on a variety of committees (e.g., IEP, Central Valley Toxics Committee) that have no direct connection with RMP, but that benefit the program in the long term. The Executive Director of SFEI, Ms. Margaret Johnston, provides in-kind service to the overall management of the RMP.

7.2.3.2 In-Kind Services: U.S. Geological Survey - USGS contributes in-kind resources to the RMP in the form of Geological Survey funds that match the money passed through to USGS from the U.S. Army Corps of Engineers. In this regard, the studies of Dr. Dave Schoellhamer at USGS in Sacramento, while critical to the RMP, receive RMP funds that cover only about one-half the actual cost of the studies.

USGS also contributes in-kind services to the RMP under the San Francisco Bay Initiative, comprising studies conducted by Dr. Jim Cloern, Dr. Sam Luoma, and others. These include examinations of biological effects of metals on Bay organisms and routine hydrographic data gathering aboard

the R/V *Polaris*, all of which are available to, and useful for, interpretation of RMP data (see, for example, Studies reported in the 1995 Annual Report (SFEI 1997)).

7.2.3.3 In-Kind Services: University of California at Santa Cruz - UCSC provides in-kind services to the RMP in several ways. First, UCSC activities for the RMP are carried out at a much-reduced overhead rate, providing the RMP with exceptional data gathering value for the dollars paid to UCSC. Second, UCSC data collection, analysis, and interpretation are performed in measurable part by personnel paid from other funds (fellowships, assistantships, research grants) within the University. While this makes the UCSC work a bargain, it also results in an underestimate of the cost-per-sample for water-column metals analyses performed within the RMP.

7.3 Other Monitoring Programs in the San Francisco Estuary

Numerous other monitoring programs, initiatives, planning programs, and research studies are ongoing in San Francisco Bay, the estuary, the Sacramento-San Joaquin Delta, and the main tributaries to the Bay estuary complex (the Sacramento, San Joaquin, Napa, and Petaluma rivers, and Coyote Creek). The Review Panel paid close attention to other monitoring programs, not in terms of evaluating their designs and efficacy, but in terms of assessing the extent to which these other monitoring programs are, can be, or should be, integrated into the RMP. Integration of other monitoring programs was recommended as a key element in developing new RMP objectives (Chapter 2), analyzing and interpreting data (Chapters 3 and 4), and reevaluating the RMP's design (Chapter 3). Several of these monitoring programs have been discussed in RMP Annual Reports (SFEI 1995, 1996, 1997) for sampling years 1993, 1994, and 1995.

The Bay Protection and Toxics Clean-Up Program (BPTCP) was a preliminary monitoring program that provided the context for developing the RMP for Trace Substances. The BPTCP is up for re-authorization in the State Legislature this year and will, in all likelihood, cease to exist at the end of 1997. The form of the program that may replace BPTCP is not known at this time; however, the San Francisco Bay Regional Board intends to carry on with some of the programs initiated under the BPTCP. Foremost among these is a study to collect and analyze fish tissues for the presence of toxic and potentially toxic compounds. This program will likely be funded under the RMP.

The Sacramento River Coordinated Water Quality Monitoring Program (the CMP) is carried out under the auspices of the Sacramento Regional County Sanitation District, the City of Sacramento, the County of Sacramento, and the County of Sacramento Water Resources Division. The CMP will ultimately be incorporated into the Sacramento River Watershed Program monitoring effort scheduled for implementation in 1997. Foremost among the functions of the CMP is the Ambient Water Quality Monitoring Program (AMP) consisting of water quality monitoring in Folsom Lake and the American and Sacramento Rivers. The AMP analyzes water samples for trace elements, cyanide, and several conventional measures of water quality. The trace metal data from the AMP are of critical interest to the RMP because data of sufficiently high quality and sufficiently low detection limits from the CMP can provide input to mass loading estimates for trace elements to San Francisco Bay.

The Sacramento River Watershed Program (SWRP) is intended to address all water quality related issues within the Sacramento River watershed, including trace elements and organic pollutants. The

data from the SRWP will provide critical data for the RMP that will assist in developing loading estimates of trace elements and organics.

The Review Panel believes that the CMP and the SWRP should become more integrated with the RMP as all these programs mature and evolve toward effective watershed assessment.

The United States Geological Survey San Francisco Bay Initiative is a research/monitoring program maintained by the USGS's Menlo Park and Sacramento offices. In combination with USGS special studies on organic pollutants in the San Joaquin River, and USGS/RMP studies funded by pass-through moneys from the U.S. Army Corps of Engineers, the USGS sampling, analysis and interpretive presence in the Bay area is of critical importance to the RMP. It is essential that the integration of USGS sampling and analysis data into the RMP be continued and expanded (see, e.g., reports in the RMP 1995 Annual Report (SFEI 1997)). USGS data records form perhaps the most complete collection of studies related to San Francisco Bay and its biota from the perspective of environmental factors. This full collection of data and interpretive reports can, and should, provide a critical resource to RMP investigators in formulating study designs for future years of the RMP.

7.4 Professional Advisory Resources

The RMP benefits from the ready availability of the wisdom and experience of the entire cadre of scientists presently active in San Francisco Bay, the Sacramento/San Joaquin Delta, and the major tributary streams feeding the San Francisco Bay/Delta Estuary. These include scientists at the University of California (Santa Cruz, Berkeley, San Francisco, and Davis), San Francisco State University, the State University at Hayward, US EPA, U.S. Army Corps of Engineers, the San Francisco Bay Regional Water Quality Control Board, the U.S. Geological Survey, California Department of Fish and Game, California EPA, the State Water Resources Control Board, and others. For the most part these scientists have remained accessible to the RMP, and many have served actively, in one capacity or another, as members of the Technical Review Committee, peer-reviewers for portions of the annual report(s), contributors to the annual reports, or contributors to SFEI newsletters highlighting the accomplishments and structure of the RMP. For the most part, professionals in Bay/Delta Studies have contributed of their time with no compensation other than the reimbursement of travel expenses for some members of the Technical Review Committee.

7.5 Historical Databases

The Review Panel noted in several discussions that there exists a plethora of information on San Francisco Bay, its water quality, sediment quality, and biota in the form of published and unpublished reports from USGS, various university reports, discharger reports, dredged material testing reports, fisheries data, site-specific water quality investigations, wasteload allocation studies, State Mussel Watch data, local effects monitoring studies, geophysical data, hydrological data, and so on. It was noted more than once in the Review Panel's work that the RMP was proceeding in the absence of a full and complete review of these data. Review Panel members concluded that a synthesis of the available historical data could well help resolve some of the difficult problems associated with developing the next five-year plan for the RMP.

7.6 Recommendations

- a. Resources available for continuing the RMP as a high-quality monitoring program are adequate. Their impact can, perhaps, be expanded by ensuring that the next five-year plan addresses recommendations made in chapters dealing with study design (Chapter 3), organizational relationships (Chapter 5), and management (Chapter 6).
- b. The overall value of the RMP product (i.e., a valid, interpretive reporting of conditions in San Francisco Bay) can be greatly increased by integrating the results of other current monitoring programs and research efforts into the RMP. Of particular importance in this regard are the efforts of the Coordinated Monitoring Program in the Sacramento River, the Sacramento River Watershed Program, and the full scope of research/monitoring efforts of the U.S. Geological Survey offices in Menlo Park and Sacramento.
- c. The vast array of historical data on San Francisco Bay water quality, sediment quality, and biota are potentially extremely valuable in adding a historical context to the RMP's efforts at assessing trends. A special study should be focused on synthesizing relevant available data in a way that will support SFEI staff, the Steering and Technical Review Committees, and the Regional Board in developing the best possible study design for the next five years of the RMP.

8.0 CONCLUSIONS AND RECOMMENDATIONS FOR IMPLEMENTATION

Summary: The Review Panel outlined a large number of recommendations to improve both the short- and long-term performance of the RMP. Some of these recommendations require little if any additional funding and can be implemented relatively quickly. Others are larger in scope or more fundamental in nature and require more time and effort to implement. These include, for example, special studies to integrate data from other studies into the RMP and to begin developing mass-balance models to provide a context for interpreting RMP results. They also include efforts to clarify the roles and responsibilities of the parties to the RMP and to develop a revised set of program objectives. The Review Panel believes that this last set of recommendations Summarized in section 8.2.2) is of the utmost importance and should be given the highest priority.

One of the RMP's major strengths is that the technical and administrative personnel involved in the project believe very strongly in it. For example, SFEI has already begun to implement many of the more straightforward recommendations in the draft report of this review issued on 20 May, 1997. Other recommendations, however, are more difficult to implement. They may address more fundamental and potentially contentious issues (e.g., the development of new study objectives) or ones that require the full involvement of all parties to the RMP (e.g., clearer definition of roles, responsibilities, and authorities). In the final analysis, each recommendation will be evaluated and considered for its overall value to the program and only those considered necessary to the program will be implemented as interest, time, and money allow.

This chapter provides some guidance for this evaluation and for planning the implementation of high-priority recommendations. It documents the overall conclusions the Review Panel derived from interviews, analysis, and discussions with technical and administrative personnel associated with the RMP (Section 8.1). These in turn lead to a preliminary prioritization of the recommendations made in the body of the report (Section 8.2) and a suggested plan for implementing the most critical ones. The Review Panel understands, nevertheless, that it is the responsibility of the Regional Board, the Steering Committee, and SFEI to evaluate each recommendation and determine whether or not it should or can be implemented.

8.1. Overall Conclusions of the Review

- The Regional Monitoring Program for Trace Substances in San Francisco Bay is a valuable environmental monitoring program based on a unique partnership between regulatory agencies and dischargers that can serve as a model for others.
- The data from the RMP are of very high quality and reflect, in many cases, state-of-the-art analysis for environmental parameters that is unequaled in a monitoring program of this size.
- Participants in the RMP believe that the program is important and valuable to them and will, in the long run, be of benefit to regulators, dischargers, and the population of the Bay Area.
- The RMP has operated on a consensus management model to date. The quality of the program can best be preserved in the future by more specific description of the roles, responsibilities, and authorities of the parties involved as well as of key decision-making processes.
- Participants in the RMP agree that the program should be continued for at least another five

years; a strategic plan is needed to guide the development of the program through those years.

- The original objectives of the RMP served it well during its early years; however, they are diffuse and non-specific. Study design, field execution, data analysis, and reporting would benefit from development of more specific objectives based upon the needs of the Regional Board and the Participants.
- The overall value of the RMP can be improved by applying a greater degree of interpretation to the data being collected, as well as a more thorough integration into the RMP of the results from other monitoring and research programs in the Bay area, both past and present.

8.2 Prioritizing Recommendations

The Five Year Review compiled many recommendations to be considered for implementation. Whereas some of these can be implemented immediately and with little effort, many that focus on the objectives and design of the program are closely interrelated and should be implemented only following a careful consideration of their relationships.

8.2.1 Recommendations for Immediate Implementation

Table 8.1 summarizes those recommendations that the Review Panel believes can be incorporated rather easily into the RMP's operations. Since the Annual Report for the 1996 sampling year is being prepared at this time, those recommendations that relate to data (recommendations from Chapters 3 and 4) should be given high priority.

With two exceptions (recommendations 5a and 5b), implementation for all the recommendations in Table 8.1 fall to SFEI. Recommendation 5a calls for the Regional Board to clarify and define precisely what their responsibilities are in the RMP. This item should receive high priority within the Regional Board since a definition of the Regional Board's responsibilities affects the implementation of other recommendations that directly address the design and execution of the program.

Recommendation 5b calls for the Executive Officer of the Regional Board to request that parties to the RMP devise a new five-year plan for the program. That five-year plan would cover the years 1998 through 2002, and would be the primary vehicle for implementing the major recommendations made by the Review Panel (see below).

Most of the recommendations for immediate implementation would have a minor financial impact on the RMP budget. By and large they represent slight to moderate increases in labor at the technical level. The Review Panel believes that a different division of labor within SFEI would aid implementation and keep financial impact to a minimum. The Review Panel suggests that SFEI emphasize greater use of less highly trained personnel in the more routine data processing, analysis, and report-writing functions, leaving staff at the higher levels to concentrate on more conceptual evaluations.

Perhaps the most expensive of the recommendations in Table 8.1 is the expansion of the laboratory intercomparison program. This would require that SFEI contract with additional laboratories for chemical analysis of split samples taken from the routine sample stream. While additional QA/QC would not necessarily improve the overall quality of RMP data, it would improve its credibility. The relative value of this recommendation should be weighed against other claims on budget resources.

Table 8.1. Recommendations in the Five Year Review report that can be implemented simply and directly. The recommendations are numbered according to their appearance in each chapter of the report, i.e., number 2e corresponds to recommendation 1e1 at the end of Chapter 2. iResponsible Partyî is the organization the Review Panel saw as having the best opportunity to implement the recommendation. iImplementation Approachî indicates the steps the Review Panel believes are needed to implement the recommendation. Evaluations of iFinancial Impactî are subjective estimates by the Review Panel.

Recommendation	Responsible Party	Implementation Approach	Financial Impact
2e Make RMP Information more widely available	SFEI	WWW; publications; presentations	slight
3f Use more sophisticated data presentation	SFEI; Chapter authors	Evaluate presentation methods	slight
4b Document fully the data management system	SFEI; Subs	Descriptive writing	slight
4d Develop computer-assisted quality checks	SFEI	Software development	moderate
4e Conduct recommended lab intercomparisons	SFEI; Subs	Expand intercomparison program	moderate
4g Store data backups off site weekly	SFEI	Procure storage site	slight
4h Provide for development of data management staff	SFEI	Courses; workshops	moderate
4j Increase citation of contributions	SFEI	Descriptive writing	slight
4k Analyze citations of RMP data	SFEI	Accounting	slight
4l Analyze WWW site usage statistics	SFEI	Software added to WWW site	slight
4m Develop specific list of PCB congeners	SFEI	Evaluate data	slight
4n Describe laboratory analysis methods in more detail	SFEI; Subs	Descriptive writing	slight
4o Describe accuracy measurements in more detail	SFEI; Subs	Descriptive writing	slight
4p Automatically calculate derived values	SFEI	Software development	slight
4q Add citation information to RMP Annual Report	SFEI	None	slight
4r Word newsletter titles more judiciously	SFEI	None	none
5a Clarify Regional Board responsibilities	Regional Board	Policy statement	none
5b Request from Executive Officer for 5-year plan	Regional Board	Official letter	none
6a Review direct charges internal to SFEI	SFEI	Accounting	slight
6b Define in-kind contributions from staff and contractors	SFEI	Evaluations; interviews; accounting	slight
6c Create technical/logistics manager	SFEI	Talent search	substantial
6d Schedule changes in contractors when possible	SFEI	Planning	slight
6e Implement competitive bidding where possible	SFEI	Planning	slight
6g Prepare Steering Committee agendas early	SFEI	Done	none
7a Accept Five Year Review report and recommendations	Regional Board; S.C.	Done	none

8.2.2 Recommendations for Gradual Implementation

The remaining recommendations fall into two main categories. The first includes specific studies the Review Panel believes are needed to address important scientific and technical issues. These are summarized in Table 8.2 in a sequence that reflects the Review Panel's judgment of their relative importance. It is most essential to integrate data from both current and historical studies into the RMP. This will provide the context needed to assess sources, define impacts, and evaluate design issues such as the potential value of using TSS to define exceedances, defining the seasonality of the data, and estimating the rates of burial of contaminant-laden particles in the Bay ecosystem.

The other category consists of recommendations that go to the very heart of the program: the design of the sampling, analysis, and interpretive components of the RMP, and the formulation of new objectives for the RMP. *The Review Panel considers these developmental activities the most important part of the Five Year Review report. Failure to address and reach some reasonable resolution about these issues would likely lead the RMP into the monitoring trap (Chapter 2, Chapter 3) of collecting data for the sole purpose of collecting data. To avoid the regression of the RMP, therefore, the Review panel believes that all parties should give the highest priority to implementing the following recommendations (see also Table 8.3):*

- To undertake to define carefully the roles of the parties
- To define the real data needs and the uses to which the RMP data will be put
- To expand the program objectives in detail (the form of the questions asked) and scope (the conditions evaluated by the RMP and its geographic scope)
- To evaluate the design of the RMP so that it provides the data needed to answer the questions stated in the revised objective statement

Table 8.2. Recommendations in the Five Year Review report that suggest specific studies or activities to be undertaken by the RMP. Recommendations that overlap with those in other chapters are cross referenced.

Recommendation	Cross-Listing	Responsible Parties	Implementation Approach	Financial Impact
2a Integrate other data for holistic appraisal	2b, 3d, 4c, 7b, 7c	SFEI; RB; RMP Subs	Develop study plan/work plan by RMP workgroup; new subcontract or increased effort by SFEI.	substantial
2b Assess sources; develop mass balance inventory	2a, 3c	SFEI; RB	Develop work plan by RMP workgroup; subcontract or increased effort by SFEI.	substantial
2c Define impacts on resources and beneficial uses		SFEI; Steering Committee; RB.	Develop work plan by RMP workgroup; increased effort by SFEI, RB, and SC.	substantial
3g Use TSS measurements to define exceedances		SFEI; Subs	Develop study plan/work plan by RMP workgroup; new subcontract or increased effort by SFEI.	substantial
3i Test seasonality of RMP data		SFEI; Subs	Develop study plan/work plan by RMP workgroup; increased effort by SFEI and subcontractors.	substantial
3j Determine rates of particle burial	2.b	SFEI; Subs	Develop work plan by RMP workgroup; subcontract or increased effort by SFEI.	substantial

Table 8.3. Recommendations in the Five Year Review report that suggest more fundamental activities to be undertaken by the RMP. Recommendations that overlap with those in other chapters are cross referenced.

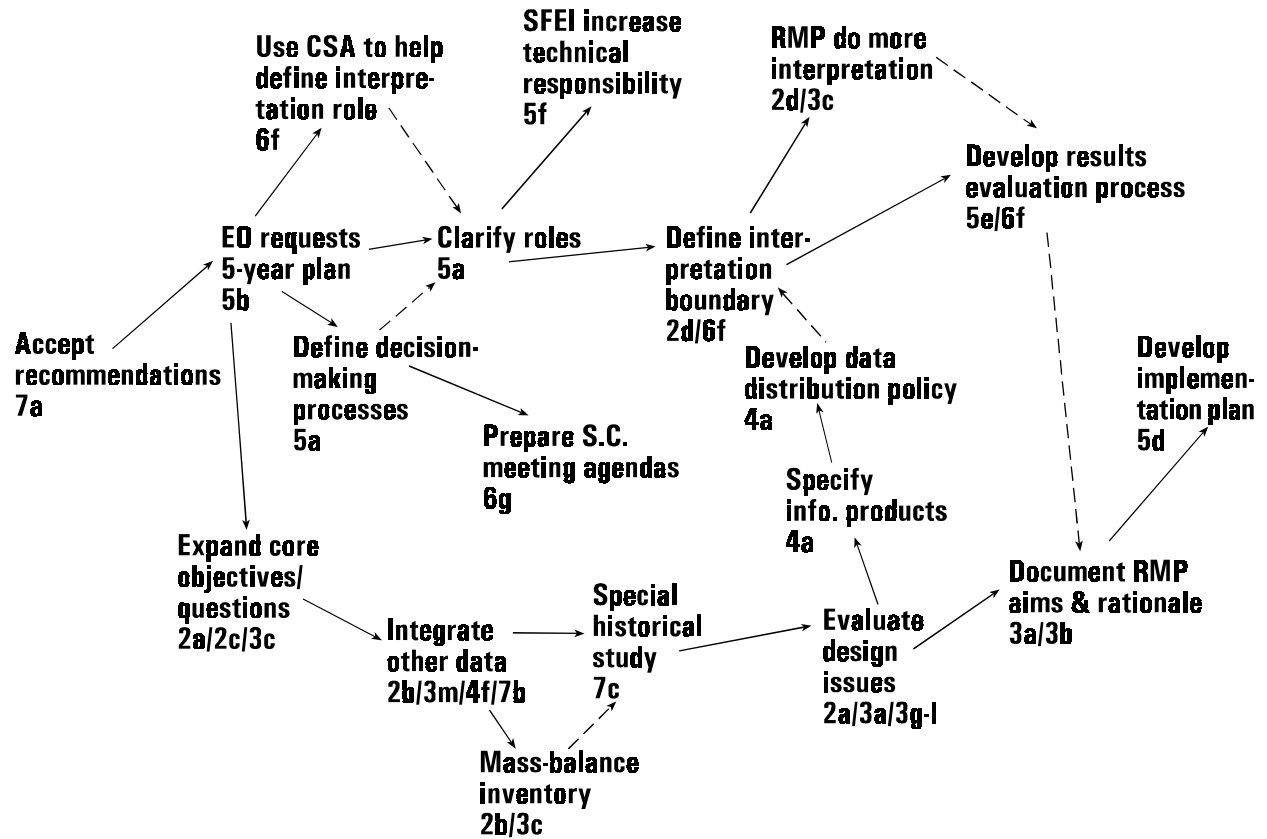
Recommendation	Cross-Listing	Responsible Parties	Implementation Approach	Financial Impact
3b Document aims of RMP	2c, 3a, 4a, 5c	All	Agreement on roles and responsibilities of parties; definition of data needs/usage by parties	?
3c Expand core objectives/questions	2b, 2c,	All	Agreement on scope and direction of RMP; develop five-year plan;	?
3a Evaluate design issues	3g, 3h, 3i, 3j, 3k, 3l	All	Definition of data needs/usage by parties; integration with other studies; statistical analyses.	?

Implementing the recommendations summarized in Tables 8.2 and 8.3 will require considerable effort from all parties to the RMP. They will involve additional committee and workgroup meetings for planning, discussion, and negotiation. Just as importantly, the studies listed in Table 8.2 will demand additional financial resources to support new subcontracts, or to enable SFEI to hire additional personnel to maintain their day-to-day scientific, administrative, and management activities as these additional studies are performed by the senior scientific staff. *The Review Panel believes that such additional funding should be made available to initiate implementation of these suggested studies in order of their prioritization (Table 8.2).*

The Review Panel also perceives different parties to the RMP as having primary responsibility for implementation of these recommendations. However, each will require collaboration among and between the Regional Board, the Steering Committee, and SFEI. Most will require that work plans be formulated, and that workgroups with representatives of the Technical Review Committee be convened to evaluate the topic and recommend actions to the Steering Committee.

Finally, it is important to note that the full suite of recommendations for gradual implementation (Tables 8.2 and 8.3) are interrelated. The Review Panel suggests that the first step in implementing these recommendations should be a critical path analysis that shows which actions must necessarily precede others (see Figure 8.1, following page, for an example). This will assist the parties to the RMP in analyzing the overall implications of each recommendation and in placing them in a logical sequence for implementation and for development of the new five-year plan.

Figure 1. Critical Path: RMP Recommendations



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