SWAMP
Surface Water Ambient Monitoring Program

SWAMP Assessment Framework

B. Bernstein

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List of Acronyms

CEAP	Canadian Environmental Assessment Program
CEDEN	California Environmental Data Exchange Network
CEQ	Council on Environmental Quality
CRAM	California Rapid Assessment Method
CWQMC	California Water Quality Monitoring Council
DDT	Dichloro-diphenyl-trichloroethane (a synthetic insecticide)
DO	Dissolved Oxygen
EC	European Commission
NNE	Numeric Nutrient Endpoints
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint Source
NRC	National Research Council
OEHHA	Office of Environmental Health Hazard Assessment
PCB	Polychlorinated biphenyls
PHab	Physical Habitat
QAPrP	Quality Assurance Program Plan
QAPP	Quality Assurance Project Plan
SQO	Sediment Quality Objectives
SSO	Site-Specific Objective
SWAMP	Surface Water Ambient Monitoring Program
TDS	Total Dissolved Solids
TIE	Toxicity Identification Evaluation
TMDL	Total Maximum Daily Load
USEPA	U.S. Environmental Protection Agency
WER	Water-Effect Ratio

Introduction

This report is a companion document to the updated Surface Water Ambient Monitoring Program (SWAMP) *Comprehensive Monitoring and Assessment Strategy to Protect and Restore California's Water Quality* (Strategy). Its purpose is to present a framework for surface water monitoring and assessment for all Water Board programs (e.g., NPDES permitting, TMDL; see Strategy for a complete list) that will address the State Water Board's strategic goals through approaches that:

- Increase the amount of usable data and information regarding water quality and beneficial uses;
- Reliably and consistently translate data into useful information; and
- Coordinate the collection, assessment, and reporting of water quality information among Water Board programs, agencies, and stakeholders

The SWAMP was created in 2000 in response to the State Legislature's mandate to coordinate all ambient water quality monitoring conducted by the State and Regional Water Boards (Water Boards) to assess attainment of all core beneficial uses in all waterbody types. This broad mandate sought to address a set of fundamental problems undermining the overall effectiveness of ambient monitoring, including:

- A lack of standardized or comparable questions, indicators, methods (including field, laboratory, and quality assurance), assessment thresholds, data management procedures, and reporting processes for Water Board programs;
- Poor coordination among Water Board programs and among State and Regional Water Boards; and
- An inefficient and insufficiently rigorous process for developing statewide assessment reports required under the Clean Water Act sections 303(d) and 305(b).

The SWAMP has developed a number of standardized monitoring, assessment, quality assurance, and data management methods. These have contributed to an overarching infrastructure for organizing efforts to address the three fundamental problems listed above. While the SWAMP has assumed direct responsibility for several statewide assessments (e.g., perennial wadeable streams, sportfish tissue contamination), meeting the State Water Board's strategic goals will require focusing additional effort on integrating SWAMP policies and infrastructure into the larger context of other Water Board programs.

The audience for this report is Water Board management, the Water Board's program managers, the Executive Officers of the Regional Water Boards, and the caseworkers, that is, staff with the responsibility for fulfilling the Water Board's strategic goals and the management authority to ensure that the framework's procedures and recommendations are implemented. In particular, this report also speaks to SWAMP Coordinators at the Regional Water Boards who will have responsibility for implementing the principles of this Assessment

Framework at the regional level by fostering coordination of monitoring and assessment across Water Board programs.

Coordinating Water Board Monitoring

Water Board programs are structured around the protection of beneficial uses, with ambient water quality monitoring intended to assess the status of core beneficial uses for all waterbody types, as illustrated in the conceptual overview in Table 1. A primary SWAMP goal is to coordinate the collection and reporting of such monitoring information among Water Board programs. In support of this goal, the SWAMP has made great strides in developing the monitoring infrastructure (i.e., indicators, methods, standard operating procedures, quality assurance, data management) needed to assess beneficial uses in surface waters. These procedures are used by SWAMP staff at Regional Water Boards and by the SWAMP in its three statewide programs (Bioassessment, Stream Pollution Trends, and Bioaccumulation Monitoring Programs).

However, the SWAMP will never have the resources itself to monitor all of the state's water bodies for all core beneficial uses (i.e., all the cells in Table 1). Instead, there is a complex array of programs, both within the Water Boards and across multiple state and federal agencies, to protect and assess beneficial uses in various water bodies across the state at local, regional, and statewide scales. An evaluation of the major regional and statewide monitoring and assessment programs, using performance measures adapted from the U.S. Environmental Protection Agency's (USEPA's, 2003) *Elements of a State Water Monitoring and Assessment Program* (Appendix 3, CWQMC, 2008), identified significant problems related to the comparability of monitoring methods, the accessibility of data, the availability of consistent assessment approaches, coordination among programs (both within the Water Boards and across agencies), and the ability to readily access data for reporting. The California Water Quality Monitoring Council is addressing coordination with other state and federal programs to address these problems. Within this larger context, it is clear that the Water Boards could contribute substantially to resolving these problems and provide more information to managers and the general public by coordinating the monitoring and assessment activities of the various Water Board programs that deal with ambient water quality.

The SWAMP Assessment Framework presented here is an infrastructure for organizing key aspects of all Water Board monitoring and assessment for all beneficial uses and waterbody types (Table 1), even where they are not conducted by the SWAMP itself. In particular, it defines the SWAMP's role in supporting appropriate monitoring standardization and coordination across Water Board programs for all cells of Table 1. Each cell in Table 1 could be monitored, assessed, and reported on at a range of spatial scales, from local to regional and statewide. National efforts by federal agencies (e.g., USEPA, U.S. Geological Survey, U.S. Fish and Wildlife Service) may also provide information for specific cells.

Table 1. Water quality monitoring, assessment, and reporting planning matrix, illustrating the potential combinations of waterbody type and beneficial use categories that are or could be addressed by the Water Boards or its partners.

Waterbody Type	Core Beneficial Use			
	Aquatic Life	"Swimmable"	"Fishable"	"Drinkable"
Wadeable Streams				
Large Rivers				
Lakes				
Estuaries				
Ocean, Coastal, Bays				
Wetlands				

Assessment Framework Overview

Effective monitoring and assessment requires attention to several aspects of program design and implementation. Figure 1 illustrates which of these should be standardized at the statewide level (gray boxes) and which may use other, scale-dependent methods that are more appropriate to a particular region or locality (blue boxes). Within this overall context, the SWAMP's role is to ensure that standardized methods and/or relevant scale-dependent approaches are available for each beneficial use / waterbody type combination (Table 1):

- For the three statewide assessments it has primary responsibility for, the SWAMP will take the lead in developing such methods
- Where the SWAMP does not have primary responsibility, it should work in concert with the California Water Quality Monitoring Council and other Water Board programs to
    - Make such standardized approaches more readily available where they already exist
    - Help develop such standardized approaches where they do not yet exist

The role of Water Board managers, in both the State and Regional Water Boards, is then to implement needed standardization and coordination across all Water Board programs, with

SWAMP Coordinators in each Regional Water Board playing an organizing and facilitating role for such efforts at the regional level.

Figure 1 illustrates the main steps in the SWAMP's coordination function. Beneficial uses (Box 1) are defined in Basin Plans and these define a starting point for developing more program-specific questions for particular beneficial use / waterbody combinations (Box 2). Monitoring designs to address these more specific questions may differ depending on their scale and/or site-specific circumstances (Box 3). Even such site-specific monitoring designs, however, can often use standardized core indicators (Box 4) and standardized sampling, quality assurance, and data management methods (Boxes 5 and 7). The SWAMP has developed such standardized indicators and methods for the beneficial uses it has primary responsibility for, and will ensure that, where available, such standardized tools for all core beneficial uses (Table 1) are communicated to Water Board programs as needed. Even where site-specific assessment approaches (Box 8) are used, beneficial use status should be evaluated with respect to standardized thresholds and assessment endpoints (Box 6). Depending on the indicator, thresholds and endpoints may be strictly numeric, strictly narrative, or narrative statements supported by numeric thresholds. In several cases, the State Water Board is developing biological thresholds to assist programs in interpreting monitoring data. Finally, individual programs make the ultimate decision about how to use monitoring information and how it should be reported (Box 9).

Figure 1 also illustrates the critical importance of articulating assessment questions (Box 2). This piece of the monitoring and assessment puzzle provides the functional link between broader concerns about beneficial uses and the technical specifications of monitoring designs. Without clearly defined questions, monitoring programs can easily waste valuable resources collecting data that address the wrong question or no question at all. Thus, the development of a question-driven mindset throughout Water Board programs is an essential aspect of the SWAMP's assessment framework.

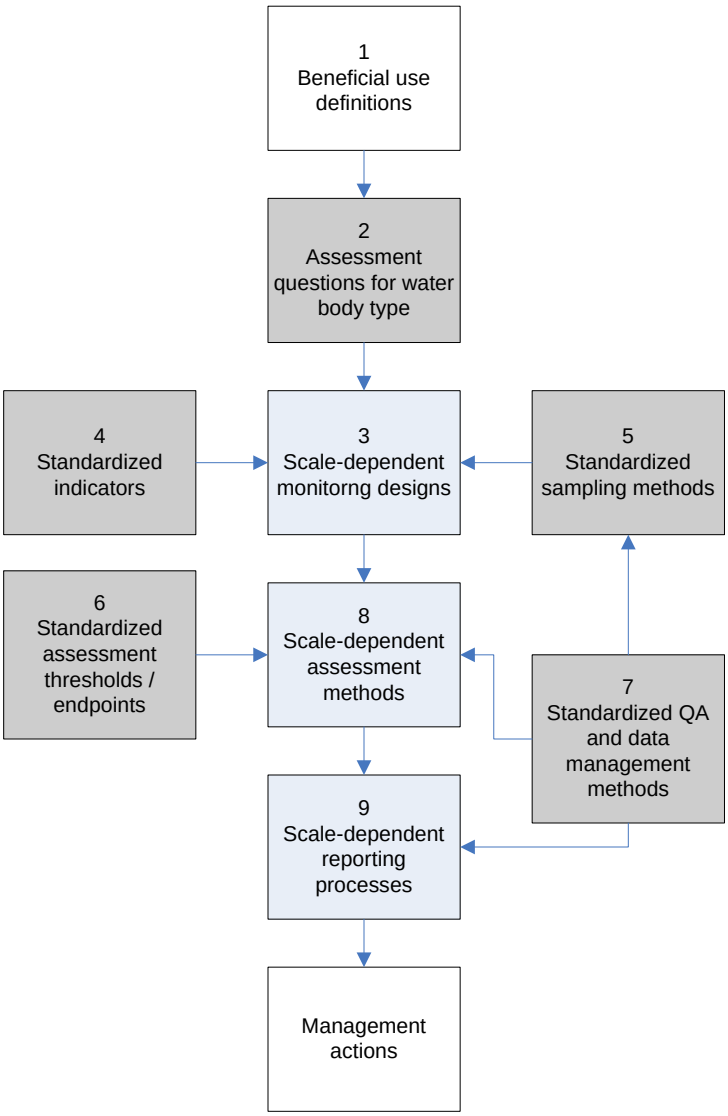

Figure 1. Key elements of monitoring design and assessment. Gray boxes are those elements for which SWAMP is responsible for ensuring the availability of standardized methods and/or approaches. Blue boxes are those elements that may use either standardized statewide methods or other methods that are more appropriate to a particular region or locality.

Question-Driven Monitoring

As Figure 1 illustrates, clearly stated assessment questions are an essential prerequisite for effective monitoring designs, something that is almost universally emphasized in guidance on monitoring and research design (e.g., CEAP, 2004; CEQ, 1997; EC, 2001; Gross, 2003; Hegmann et al., 1999; Henderson and O'Neil, 2004; Suter, 1996; USEPA, 1992, 1998; U.S.

Forest Service, 2005; Wood, 2002). Assessment questions can be framed at three levels of detail (Figure 2). At the highest level, the SWAMP and the California Water Quality Monitoring Council have adopted the following four questions associated with core beneficial uses (i.e., the top row of Table 1):

1. Is our water safe to drink?
2. Is it safe to swim in our waters?
3. Is it safe to eat fish and shellfish from our waters?
4. Are our aquatic ecosystems healthy?

For each of these questions there are is a second level of more specific assessment sub-questions about the status of beneficial uses that provide additional focus for monitoring design:

a. What is the quality of waters relative to beneficial uses (i.e., are uses impaired)?
b. To what extent are water quality conditions changing over time (i.e., are conditions getting better or worse)?
c. What are the areas needing protection and what is the magnitude and extent of problems where they exist?
d. What are the sources of stressors threatening uses (i.e. what's causing the problem)?
e. How effective are water quality improvement projects and programs at protecting or restoring beneficial uses (i.e., are solutions working)?

These two sets of broad assessment questions are universally applicable across all waterbody types and all spatial scales for each core beneficial use. They provide a common starting point and an important level of consistency across programs and regions.

However, there is one additional set of more detailed questions (Bernstein et al., 1993) that include the technical perspective needed to guide the design of monitoring programs to ensure they provide meaningful and useful information:

i. What is the management goal (e.g., no effects greater than X, no change from present condition, find problem areas, estimate percentage area in different conditions)?
ii. What monitoring strategy is suitable (e.g., measure one indicator, measure multiple indicators, track trends)?
iii. What degree of certainty and precision is required (e.g., qualitative information, minimal certainty/precision, extreme certainty/precision)?
iv. What reference conditions are appropriate (e.g., reference location, reference time, standards, model prediction)?
v. What spatial scale is appropriate (e.g. site-specific, regional, statewide)?

vi. What temporal scale is appropriate (e.g., immediate, months, year-to-year, years to decades)?

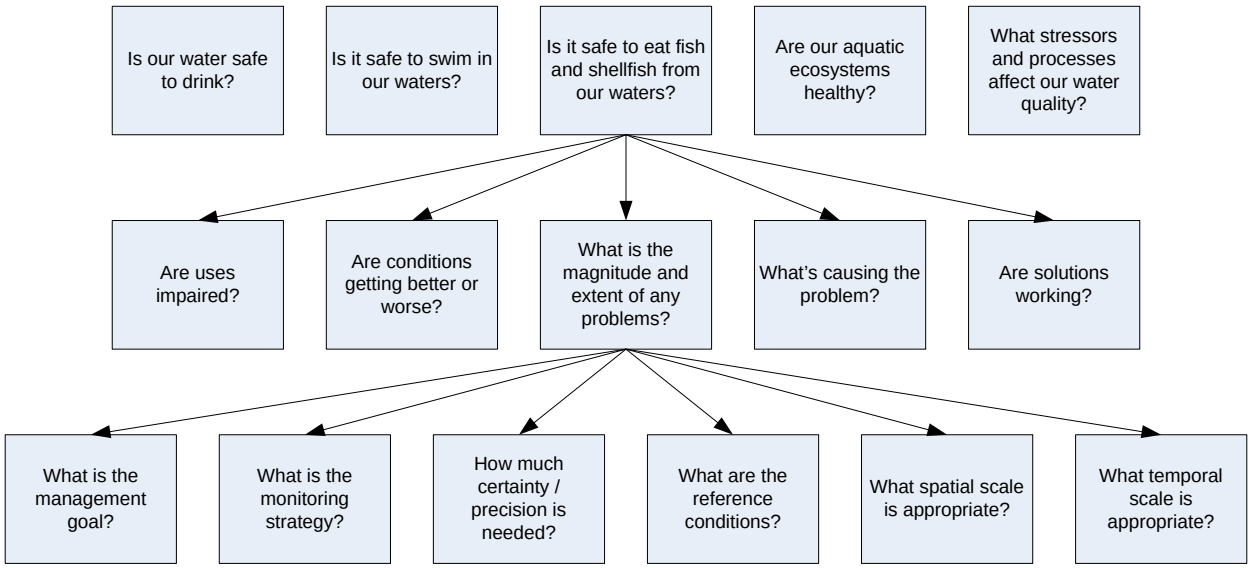

Figure 2. The three levels of questions needed to develop effective monitoring designs, showing how each question in a higher level must be addressed by all questions at the next lower level. The top two levels of questions are universally applicable to all waterbody types and all spatial scales. The lowest level of questions must be addressed separately for each monitoring design.

An example from a National Research Council (NRC) report on environmental monitoring (NRC, 1990) illustrates the difference between assessment questions at each of the three levels of detail, related to a planned dam development on a Canadian river:

1. What would be the impacts of a proposed dam on the fish resources of the river (equivalent to: Are our aquatic ecosystems healthy)?
2. Will spawning habitat be impacted (equivalent to: Are uses impaired)?
3. What percentage of the Arctic char spawning habitat would be lost given a 0.5 meter reduction in the water level of the river during the month of September? (partial detail needed for monitoring design)

Another example, from a different regulatory arena (offshore oil platform decommissioning), also illustrates the nested levels of management questions needed for effective monitoring design:

1. What is the impact of decommissioning on commercial fishing?
2. What is the impact of vessel traffic on commercial fishing operations in the immediate vicinity of the project?

3. Does vessel traffic associated with decommissioning reduce commercial fishing activity by more than 25% within five miles of the project during decommissioning?

By question-driven monitoring, the SWAMP thus means the integrated and systematic application of the three levels of questions described above. Monitoring programs at the statewide and regional scale are more likely to use standardized assessment questions and monitoring designs, and programs at more localized scales are more likely to add features tailored to their specific needs. A key part of the SWAMP's role is to work with Water Board programs, at statewide, regional, and local levels, to apply these questions to meet the specific needs of individual programs and their monitoring efforts (see Strategy for more detail.) A more consistent application of such question-driven monitoring design across Water Board programs will help ensure that data collected at certain sites and times can be used for more than one program. This will produce long-term logistical and cost benefits by reducing duplication of effort and enabling monitoring designs, indicators, and methods to be used more widely across programs and at different spatial scales (Figure 3). In addition, this will improve the value of assessments for decision making as programs at larger spatial scales provide needed context for interpreting monitoring results from those operating at smaller spatial scales. Conversely, more localized monitoring efforts should provide detail useful in understanding how broad patterns operating at statewide and regional scales play out at finer spatial scales.

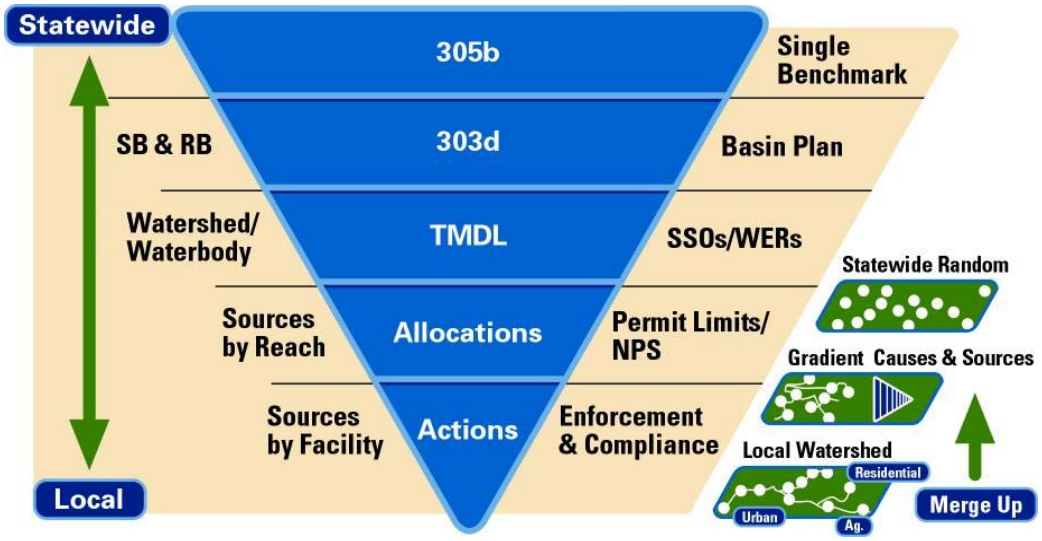

Figure 3. Water Board monitoring programs that use a question-driven approach to produce comparable data (i.e., based on standardized monitoring designs, indicators, and methods) can provide data that can serve the needs of multiple Water Board programs that operate at a range of spatial scales, from the local to statewide. SB and RB refer to State Water Board and Regional Water Boards, respectively; SSOs to site-specific objectives, WERs to water-effect ratios, and NPS to the Nonpoint Source.

Indicators, Methods, and Thresholds

One of the ultimate goals of the SWAMP assessment framework is to ensure the availability and use of standardized indicators, sampling methods, and assessment thresholds or endpoints (Figure 1) for each cell in Table 1. The SWAMP and other Water Board programs have made significant progress in defining indicators, methods, and assessment thresholds and in applying these to specific monitoring programs. For example, Table 2 (taken from Strategy) lists recommended water quality indicators for general designated use categories (see Strategy for more detail).

Standardized methods and assessment thresholds exist for many of these indicators. For example, the California Toxics Rule establishes thresholds for many chemical indicators for protecting aquatic and human health, the Office of Environmental Health Hazard Assessment (OEHHA) has developed fish contaminant goals and advisory tissue levels for protecting fish and shellfish consumption, and California Department of Public Health has developed standards to protect drinking water that are included in all Basin Plans. In addition, standardized monitoring approaches exist for the assessment of some categories of biological condition in some waterbody types. Some of these standardized monitoring and assessment elements have been developed by the SWAMP, some by other State Board programs and/or USEPA, and still others by broader collaborative efforts involving several state and federal agencies. Although such efforts include entities beyond the SWAMP, promoting their consistent use across all Water Board programs is a core responsibility of the SWAMP and the SWAMP Coordinators at the Regional Water Boards.

While indicators and assessment thresholds do exist for many of the beneficial use / waterbody combinations in Table 1, there are still important gaps to be filled:

- Not all indicators in Table 2 within a beneficial use category are equally applicable to all waterbody types.
- Indicators do not exist for all beneficial use / waterbody combinations.
- Some indicators do not yet have thresholds to guide the assessment of monitoring results.
- The minimum set of indicators needed to assess beneficial use protection for the integrated 303(d) / 305(b) report has not yet been identified.

Filling these gaps will be challenging. For example, in terms of aquatic life and wildlife, there are many kinds of ecosystems and populations within each waterbody type, with estuaries (as just one example) containing benthic infauna and macrofauna, a variety of fishes, birds (many threatened or endangered), and several habitats. Developing scientifically rigorous and practical assessment approaches that are applicable statewide is demanding. The State Water Board's ongoing efforts to develop consistent sediment quality objectives (SQO) for bays and estuaries, biological objectives for wadeable perennial streams, and numeric

nutrient endpoints (NNE) for estuaries and freshwater are representative of the type of multi-year commitment typically required.

Table 2. SWAMP recommended water quality indicators for general designated use categories (modified from USEPA, 2003).

Beneficial Use	Indicators	
	Core	**Supplemental/diagnostic**
Aquatic life and wildlife	**Conventionals** Temperature, conductivity, pH, DO, nutrients **Toxics** Metals, Bioaccumulative, Pesticides **Toxicity** Water and/or sediment **Biological conditions** Invertebrates (streams) Chlorophyll (lakes, streams, estuaries) Algae Wetlands **Physical habitat** PHab (streams) CRAM (wetlands)	 Other chemicals of concern in water column or sediment TIEs (water and/or sediment) Health of organisms Landscape/Land use Flow
Fish/shellfish consumption	**Chemical indicators** Mercury, chlordane, DDTs, PCBs **Fecal indicators (for shellfish)** Total and fecal coliform	Other chemicals of concern in water column or sediment Landscape/Land use
Recreation	**Fecal indicators** Enterococci, total and fecal coliform (seawater) *E. coli*, enterococci (freshwater) **Other** Secchi depth (lakes) Nuisance plant growth Chlorophyll *a* Microcystis/microcystin	Landscape/Land use Other chemicals of concern in water column or sediment Flow Nutrients
Drinking water	Trace metals Pathogens (Drinking Water Rule, Basin Plan language) Algae (microcystis) Nitrates Salinity Sediments/TDS	Other chemicals of concern in water column or sediment Flow Landscape/Land use

The SWAMP will play a range of roles in developing and applying standardized monitoring and assessment elements, including:

- Leading the development for those beneficial use / waterbody combinations that are the SWAMP's primary responsibility (e.g., biological objectives for wadeable perennial streams)
- Supporting the development of comprehensive monitoring and assessment approaches, and related permit requirements, for other Water Board programs (e.g., stormwater)
- Providing technical support to development efforts led by other agencies (e.g., wetlands monitoring and assessment)

In addition to these means of improving coordination and consistency across regions and programs, the SWAMP should use its role in reviewing quality assurance program plans to foster a more rigorous approach to the design of monitoring and assessment programs. Quality assurance is too often assumed to include only issues narrowly related to sampling and sample processing (e.g., laboratory methods, detection limits). Modern quality assurance and quality control approaches, however, focus more broadly on all aspects of the process that can affect the overall quality of the final product, the assessments that answer key management questions. Thus, if laboratory procedures follow standard methods but the wrong assessment threshold is used, the assessment is of poor quality. Or, if standard sampling methods are used but the monitoring design is unsuited to the question(s) that motivated the monitoring effort, the assessment is of poor quality. The SWAMP, along with Water Board managers, should emphasize that quality assurance encompasses all aspects of monitoring and assessment programs, and should be judged by the utility of the final assessment product.

The State Water Board has developed a Quality Management Plan that describes the Water Boards' quality assurance philosophy along with management policies and procedures. These will apply to programs (e.g., NPDES, Nonpoint Source) within the State Water Board and nine Regional Water Boards, as well as any contractors, other state or local agencies working as partners with the State or Regional Water Boards, grantees or contractors working for any of these organizations. All data collection activities, including biological, physical habitat, and chemical monitoring; the selection and use of data from secondary sources; and data analysis and modeling efforts, are to be guided by the principles of this overarching Quality Management Plan:

- The intended use of environmental data and the level of data quality necessary to support decisions made using that data will be established by State and Regional Water Board staff prior to the design and initiation of all data collection activities
- All State and Regional Water Board programs generating, using, or receiving environmental data will adhere to the policies outlined in the Quality Management Plan

- All data generated by or for the State and Regional Water Boards, include those produced by other agencies, contractors, grant recipients and regulated parties, will be of documented quality (with "quality" broadly defined as above)
- Adequate resources and staff will be provided by the Water Boards to meet the quality assurance and quality control requirements of the Quality Management Plan

Individual programs must develop specific Program Plans that implement the policies of the State Water Board's Quality Management Plan and that define quality objectives, decisions or goals, and measurement quality objectives that apply to all data generated under the program. The SWAMP has developed its Quality Assurance Program Plan (QAPrP, SWAMP 2008) and other State Water Board programs collecting ambient surface water data may use elements of the SWAMP QAPrP that are appropriate to their needs. Finally, individual projects may develop Quality Assurance Project Plans (QAPPs) that define details at the level of individual projects.

Data Management and Access

The SWAMP has developed a set of standardized formats and tables for storing and transmitting ambient monitoring data. Tables have been developed for chemical constituents (water, sediment, and tissue), toxicity results (water and sediment), biological communities (fish and macroinvertebrates), and habitat measures (grain size, physical habitat). These are used internally by the program and by those wishing to meet SWAMP comparability requirements.

The SWAMP has also developed the California Environmental Data Exchange Network (CEDEN) to support the storage of and access to surface water monitoring and assessment data for all Water Board programs across the state. CEDEN will enable Water Boards, permittees, and other data sources to upload their data to one of several regional data centers linked as a statewide data network. Users will then be able to use CEDEN to readily find and obtain data based on a variety of search criteria such as location, program, or constituent. In addition, an important part of the SWAMP's Strategy is to provide technical support to users through staff at the regional data centers. CEDEN is a critical prerequisite for the reporting element of the assessment framework described in the next section.

Reporting

As Figure 1 illustrates, monitoring and assessment activities report on information that will answer key management questions and assist in making decisions to protect water quality. Recognition of this ultimate use of monitoring data underlies all of the SWAMP's efforts at improving the designs, indicators, and assessment thresholds used in Water Board programs. At the statewide level, the integrated 305(b) / 303(d) report is the state's primary means of addressing needs for statewide assessment and for tracking trends in environmental condition over time. At regional and local scales, a variety of other reporting

processes are used to address scale-depending assessment and decision needs. For all such processes, ready availability of high-quality and consistent monitoring data and assessment results at a range of spatial scales is key to improving their efficiency, rigor, and credibility and for identifying, prioritizing, and managing risks to water quality and associated beneficial uses.

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