February 22, 2000

Staff Report by the
Division of Water Quality

MODEL FOR DEVELOPING SPECIFIC SURFACE WATER MONITORING OBJECTIVES

Introduction

At every stage of environmental management, good monitoring programs provide the feedback needed to ensure that the programs implemented to improve the environment are effective and that progress is being made to meeting the established goals. It is important to clearly define the information most useful to resource agencies to better protect water quality and safeguard resources. Clear monitoring objectives are essential if the ambient monitoring program is to produce meaningful and useful information.

One of the most difficult steps in developing an ambient monitoring program is the establishment of the program's objectives. No monitoring program can answer all monitoring questions. For programs to effectively provide the information needed for environmental management decisions it is necessary for clear and specific monitoring objectives.

The report presents a model that the State Water Resources Control Board (SWRCB) staff propose to use in the development of objectives for the State's Surface Water Ambient Monitoring Program (SWAMP).

Model for Developing Monitoring Objectives

In developing the SWAMP monitoring objectives we will use a modified version of the model for developing clear monitoring objectives proposed by Bernstein et al. (1993). This model is valuable in developing SWAMP in several ways. First, it makes explicit the assumptions and/or expectations that are often embedded in less detailed statements of objectives (as presented in Figure 1 [from SWRCB, 2000]). The model clearly identifies the most important issues (from both management and scientific perspectives) that must be considered, defined, and resolved. Second, the explicit nature of the model makes possible the systematic creation of a variety of alternative objectives and ensures that important issues will not be overlooked. The model also presents key issues in a way that is accessible to both managers and scientists. The model is a series of questions that focus the development of specific monitoring objectives (Table 1).

The following paragraphs briefly discuss the kinds of issues that must be considered in making choices among the characteristics in each category. The categories affect each other. For example, a management need for more precise information will necessarily influence the choice of monitoring strategy.

1. Management Goal—Management goal refers to the guiding policy focused on managing a beneficial use. The choice here depends on numeric and narrative water quality objectives, availability of guidelines for interpreting monitoring information in terms of beneficial use impact, the nature of the impact and the ecosystem's response to it, and what is practical. It also depends on balancing related management goals among several beneficial uses when these overlap, interact or conflict.

   The management goal will be used to establish the focus of the monitoring objective. The management goal can come from the basin plans, Statewide plans, water quality control policies, and other agency standards or guidelines (e.g., promulgated EPA criteria, FDA advisory levels, etc.). The management goal should be used as the basis for answering specific questions about the condition of locations, areas or whether conditions are getting better or worse.

2. Monitoring Strategy—Monitoring strategy refers to the approach taken to monitor an impact or change. The choice here depends on the nature of the impact, natural ecosystem characteristics, and available scientific and technical knowledge. The strategy is primarily a scientific question but managers may have an opinion or reason for selecting a particular monitoring strategy.

   For extremely variable beneficial uses or valued ecosystem components (e.g., water column fish populations), it may be more advantageous to qualitatively identify the system condition rather than quantitatively measure parameters with little information content or predictive value. In some instances, an indicator species or an important rate such as reproductive output furnishes better information than a broader range of measurements. In other instances, risk assessment models may have to be used when it is not possible to measure such effects as illness rates.

3. Degree of Measurement Certainty—Certainty is a statement of whether the measurements are right or wrong. The choice here depends on the need for information of a particular quality.

   In some instances, simple qualitative information about whether something has occurred or not may be sufficient. In the case of wastewater outfall impacts on the soft bottom benthos it might be important to know with a high degree of certainty whether the impacted areas are continuing to shrink. It may also be important to measure with a high degree of certainty whether an impact at a site or in an area persists over time.

   Accuracy or certainty is the difference between a measured value and the true or expected value. Measurement accuracy is determined by comparing a sample to a known value for a standard reference material). Some important measures of animal response or impact may not have standard references (e.g., toxicity tests).

Low certainty—qualitative measures
Moderate certainty—quantitative measures with replication.
High certainty—quantitative measures with replication and comparison to standard reference material or collections.

4. Degree of Measurement Precision—Precision is the degree of agreement among repeated measurements of the same characteristic (is the answer within 2% or 10%?). The choice here depends both on the need for information of a particular quality and the limitations of scientific knowledge and technique.

   Low precision—qualitative measurements or if measurements are quantitative, non-professional personnel, simple test procedures that do not require controlled laboratory conditions or controlled measurements in the field.
   Moderate precision—quantitative measurements, written procedures with quantified measures of precision (stated measurement quality objectives), trained personnel.
   High precision— quantitative measurements, written procedures with quantified measures of precision (replicated measurements within a test, stated measurement quality objectives), professional personnel, controlled laboratory conditions and controlled measurements in the field, repeated measurements over time.

5. Reference Conditions—Reference conditions refer to comparisons that are made to determine if impacts or changes are getting larger, smaller, or staying the same. The choice here depends on the structure of the ecosystem and the availability of comparisons as well as on the monitoring strategy selected.

   Where monitoring is focused on identifying trends, the best reference might be to conditions at a previous time. Previous times are also often the best references for water body-wide changes or resources, since there may be no reference locations. When there is natural variability among locations, several reference locations may be needed to protect against mistaking a natural change for a human impact. Where it is not possible to measure the expected impact, such as with many health effects, model estimates of baseline conditions must be used as the reference for predicted illnesses.

6. Spatial Scale—Spatial scale refers to the spatial extent of both management concerns and the monitoring strategy. The choice here depends on the management goal and on the spatial scale of impacts, ecological processes, and natural variability.

For example, a site-specific scale is appropriate for monitoring the effects of a local dredge disposal site or a particular storm drain. As another example, a combination of spatial scales is needed for monitoring the effects of pollution or contamination due to wastewater outfalls. This is because sediment transport and biological uptake into fish spread contaminants beyond the immediate area of the outfalls.

Site-specific—refers to a point at a discharge or other high pollution-risk location.
Local area—refers to an area that may be influenced by pollutants. This area is relatively small compared to the water body.
Water body area—refers to areal estimates of the impacts or pollutant concentrations within whole water bodies.
Statewide—refers to areal comparisons between water bodies.

7. Temporal Scale—Temporal scale refers to the temporal extent of both management concerns and the monitoring strategy. The choice here depends on the management goal and on the temporal range of impacts, ecological processes, and natural variability.

   For example, focusing on trends requires a time scale long enough to see meaningful changes. In another situation, periodic processes such as reproduction may need to be monitored several times in a row to detect important changes. Some impacts occur immediately and, in these cases, monitoring can provide answers quickly. In other cases, impacts only become apparent after a lag time and monitoring must stretch over a longer period before information is available.

Using the Model: Examples

Table 2 presents a summary of the results of using the model to develop more specific questions for assessing (1) the quality of swimming areas, (2) the quality of surface drinking water, and (3) the impacts on aquatic life in fine-grained sediments.

References

Bernstein, B.B., B.E. Thompson, and R.W. Smith. 1993. A combined science and management framework for developing regional monitoring objectives. Coastal Management. 21: 185-195.

SWRCB. 2000. Plan for implementing a comprehensive program for monitoring ambient surface and groundwater quality. Report to the California Legislature by the State Water Resources Control Board (1/2000). 49 pp.

TABLE 1: MODEL FOR DEVELOPING SPECIFIC MONITORING OBJECTIVES.

1. What is the management goal?
• No pollutant greater than a set amount
• No effects from activity or source
• No change from present conditions
• No change greater than natural variability
• Return to pristine conditions
• Conditions show a steady trend of improvement
• Resource or ecosystem remains in a particular condition
• Resource or ecosystem returns to a particular condition after disturbance
2. What monitoring strategy is suitable?
• Measure actual effect
• Use one indicator to represent change or effect
• Use a suite of indicators together to represent change or effect
• Use model predictions or estimates of effects
• Qualitatively identify the resource or ecosystem condition
• Quantitatively measure resource or ecosystem parameters
• Measure key processes or rates
• Focus on key events or disturbances that are of overriding importance
3. What degree of measurement certainty is possible or required?
• Qualitative information only
• Minimal certainty
• Moderate certainty
• High certainty
4. What degree of measurement precision is possible or required?
• Qualitative information only
• Minimal precision
• Moderate precision
• High precision
5. What reference conditions are appropriate?
• Reference location(s)
• Reference time(s)
• Reference tests(s)
• Model prediction
• Compliance standards (a kind of model prediction)
• Other populations of the same species
• Similar species or communities
• Analogous situations

6. What spatial scale is appropriate?
▪ Site specific
▪ Local (area)
▪ Entire waterbody (area)
▪ Statewide (area)
7. What temporal scale is appropriate?
▪ Immediate
▪ Months
▪ Year-to-year
▪ Long-term (several years-decades)
Specific Question:

TABLE 2: EXAMPLE APPLICATION OF THE MONITORING OBJECTIVES MODEL.

Steps	Is it safe to swim?[1]	Is it safe to drink the water?[2]	Is aquatic life protected?[3]
Management goal	• No pollution greater than a set amount • No effects from activity or source	• No contamination above a set amount • Resource remains in a particular condition	• No change greater than natural variation • Resource or ecosystem remains in a particular condition
Monitoring strategy	Quantitatively identify the resource parameters	Use a suite of indicators together to represent change or effect	• Use a suite of indicators together to represent change or effect • Quantitatively measure resource or ecosystem parameters
Accuracy or certainty	Moderate	High	Moderate-High
Precision	Moderate	High	High
Reference conditions	Compliance standards	Compliance standards	• Locations • Tests
Spatial Scale	Site-Specific or local area	Entire waterbody	Entire waterbody
Temporal scale	Immediate	Month-to-month	Immediate

Specific Questions

[1]At storm drains, publicly owned treatment works, and sites influenced by other sources of bacterial contaminants, estimate the concentration of bacterial contaminants above health standards or adopted water quality objectives.

[2]Throughout waterbodies that are used as a source of drinking water, estimate the concentration of bacterial or chemical contaminants from month-to-month above drinking water standards or adopted water quality objectives to protect drinking water quality.

[3]Identify the areal extent of degraded fined-grained sediment in rivers, lakes, nearshore waters, enclosed bays and estuaries using several critical threshold values of toxicity, benthic community analysis, and chemical concentration.

FIGURE 1: AMBIENT SURFACE WATER MONITORING QUESTIONS

Are Beneficial Uses protected?

Focus on specific beneficial use …

- Is it safe to swim?
- Is it safe to drink the water?
- Is it safe to eat fish and other aquatic resources?
- Is water safe for agricultural use?
- Is water safe for industrial use?
- Are aesthetic conditions of the water protected?
- Is water flow sufficient to protect fisheries?
- Are aquatic populations and communities protected?

Focus each question further…

What percentage of area has problems?

Where are specific locations with problems?

Are conditions getting worse or better?