United States Environmental Protection Agency

Office of the Administrator
Science Advisory Board
Washington, D.C. 20460

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December, 1987

EPA

Report of the Environmental Effects, Transport and Fate Committee

Review of a Framework for Improving Surface Water Monitoring Support for Decision-Making

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D C 20460

OFFICE OF
THE ADMINISTRATOR

December 1, 1987

The Honorable Lee M. Thomas
Administrator
U.S. Environmental Protection Agency
401 M. Street, S.W.
Washington, D.C. 20460

Dear Mr. Thomas:

The Surface Water Monitoring Subcommittee of the Science Advisory Board's Environmental Effects, Transport and Fate Committee has completed its review of a study prepared by the Office of Water and the Office of Policy, Planning and Evaluation entitled **Improving Surface Water Monitoring Support for Decision-Making: A Framework for Change.** The review was requested by the Office of Water, and was conducted on February 23 and 24, 1987 at North Texas State University in Denton, Texas.

The Subcommittee believes that the study provides a strong conceptual framework for a sound monitoring program, but recommends certain refinements to further strengthen both the study and the monitoring program. The study's strength is its recognition of the need for change and the underlying concept to create that change. In addition, the planning and development approach used in the study solicits input from diverse sources and assesses that input, identifying both obstacles and challenges, to provide a useful framework for action. A major weakness results from the study's relatively narrow base of information.

The Subcommittee identified several areas in this study that need further consideration or additional emphasis including the need for: precisely defining the purpose or objective for monitoring before programs are designed or implemented; considering the source of water quality problems when designing monitoring strategies such as point source, non-point source, and the more likely combination of both sources; and coordinating monitoring efforts in different media, such as air, sediment, and living organisms, to contribute towards an ecosystem level understanding of changes due to pollution. The study should also

emphasize the importance of: incorporating new analytical techniques and physical, chemical, and biological methods to insure that the best scientific results are obtained from existing resources; coordinating EPA's surface water monitoring programs with those of other Federal and international agencies; and developing technical guidance to promote data consistency and comparability. Finally, the study should stress the importance of data analysis, since proper analysis of collected data is essential to decision-making. These and other issues are discussed in the attached report.

The Subcommittee appreciates the opportunity to conduct this scientific review. We request that the Agency formally respond to the scientific advice transmitted in the attached report.

Sincerely,

Norton Nelson, Chairman
Executive Committee
Science Advisory Board

Rolf Hartung, Chairman
Environmental Effects, Transport
and Fate Committee

Kenneth Dickson, Chairman
Surface Water Monitoring
Subcommittee

Enclosure

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Science Advisory Board
U.S. Environmental Protection Agency

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Appendices

1.0 EXECUTIVE SUMMARY

The Surface Water Monitoring Subcommittee concludes that the study prepared by the Office of Water entitled "Improving Surface Water Monitoring Support for Decision-Making: A Framework for Change" provides the conceptual framework for a sound monitoring program. The Subcommittee encourages the Agency to refine the study further in light of the ideas and suggestions offered in this critique. Specific conclusions and recommendations include:

- The study of surface water monitoring is a long needed step toward integrating disparate activities within the Agency. The questions and needs of the Agency that are related to surface water monitoring are appropriately addressed by the study.

- A sound concept is provided defining the necessary elements for a successful monitoring program, such as assessing the reasons for monitoring, organizing monitoring efforts to address identified needs, and managing and analyzing data to support decision-making.

- The planning approach used to develop the study merits recognition because it solicits input from a variety of sources at Federal and State levels, assesses input, identifies obstacles and challenges and produces a framework for action.

- The study should place more emphasis on the importance of precisely defining the purposes (objectives) of a monitoring program before design and implementation begin. The basic purpose of many monitoring programs is to characterize the aquatic resource. This function of monitoring has many specific applications, such as providing data for background characterization, information on use attainability, ecoregion analysis, and site specific criteria development. Before monitoring programs are initiated, a clear understanding of the purpose for the data collection must be acknowledged, and possible applications should be considered to guide both collection and analysis portions of the monitoring program.

- The study should avoid the simplistic concept that water quality problems are either point or non-point source in origin. Most water quality problems have elements of both, and monitoring should be conducted with this perspective.

- Surface water monitoring programs should be coordinated with the monitoring programs for other media (e.g., air, sediment, fish tissue, and groundwater). This integration is needed to fully understand the origins or sources, fate, and consequences of pollutants in the environment. Coordinated, multimedia approaches will be more effective than single medium approaches.

- Monitoring programs need to incorporate state-of-the-art physical, chemical, and biological methods. The study should

propose a procedure for identifying and incorporating emerging methods, such as toxicity testing and real-time monitoring.

- The study should emphasize the importance of coordinating surface water monitoring programs at EPA with those of other Federal and international agencies. This coordination will facilitate the generation of a more uniform set of data with broad applicability and will contribute to both cost effectiveness and superior data quality. Plans for such coordination should be specified as part of the study.

- The Subcommittee recommends that the "Technical Support Document for Water Quality-Based Toxics Control" [1] be used as a model to develop technical guidance on surface water monitoring for use by the states. The study should point out the need for technical guidance at the State level to promote consistency and comparability between data.

- For monitoring data to be useful in decision-making, the data must be analyzed. The study should recommend that analysts be employed and charged with developing computerized data management systems to aggregate, analyze and summarize monitoring data for use by Agency decision-makers. This may require modifying existing systems, such as STORET, or creating new systems. Such analysis will also assist in identifying and prioritizing environmental problems, and may give clues to appropriate solutions.

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[1] USEPA, Office of Water Enforcement and Permits, and Office of Water Regulations and Standards, September 1985. **Technical Support Document for Water Quality-Based Toxics Control.** EPA-440/4-85-032.

2.0 INTRODUCTION

2.1 Origin of the Review

EPA's Office of Water requested that the Science Advisory Board (SAB) of the Environmental Protection Agency review the Surface Water Monitoring study. SAB reviews are conducted under the auspices of its Executive Committee, which agreed to conduct the review and delegated responsibility to the Environmental Effects, Transport and Fate Committee. On January 14, 1987, this Committee met and received a preliminary briefing on the Surface Water Monitoring Study, given by Ms. Mary Blakeslee, Senior Program Analyst, Office of Water. The Committee established the Surface Water Monitoring Subcommittee to conduct the review and appointed Dr. Kenneth L. Dickson as chairman of the Subcommittee.

2.2 Purpose of the Review

The Subcommittee received a document entitled, "Improving Surface Water Monitoring Support for Decision-Making: A Framework for Change," authored by EPA's Office of Water, and the Office of Policy, Planning and Evaluation (with assistance from American Management Systems, Inc.). The study describes current surface water monitoring efforts, identifies the inadequacies of the current programs, and discusses changes that should be made to improve future programs. The Executive Summary of this document is included as Appendix A.

The purpose of the review is to provide an independent, peer assessment of the scientific adequacy of the objectives, conclusions and recommendations of the surface water monitoring study, and to evaluating the concepts underlying the approach.

2.3 Review Procedure

The Subcommittee met in public session on February 23 and 24, 1987, at North Texas State University, in Denton, Texas. Ms. Mary Blakeslee, Office of Water, and Mr. Paul Campanella, Office of Policy, Planning and Evaluation presented a detailed briefing on the study at that time. Following this briefing, the Subcommittee discussed the underlying principles of the study, its conduct, and the recommendations it provides. These discussions formed the basis for recommendations, suggestions, and comments on the study.

2.4 Description of This Report

The Subcommittee's report provides general conclusions with regard to the study's fundamental concepts, documenting their strengths and weaknesses. In addition, the report provides a discussion of specific issues that were identified during the review process, issues that have a significant impact on the study itself and the field of surface water monitoring as a

whole. Finally, the report presents specific conclusions and recommendations on current and future issues addressed in this review.

3.0 GENERAL COMMENTS

The Subcommittee lauds the Office of Water and the Office of Policy Planning and Evaluation for addressing the questions and needs related to surface water monitoring as they concern the Environmental Protection Agency. The study under review is a long needed step toward integrating what currently appear to be disparate activities in the Agency.

It is important for the Agency to assess its reasons for monitoring, organize its monitoring efforts to address identified needs, and implement a program of data management and analysis which will facilitate informed decision-making. The report reflects such an effort but, as in all such reports, it has both strengths and weaknesses. Although this critique may highlight weaknesses, the Subcommittee emphasizes that this review is intended to "fine tune" a study that is sound in concept.

3.1 Strengths

The Agency recognizes the need for change. This study is evidence of that recognition and will serve to initiate needed changes. The Subcommittee sees this factor, the underlying concept, as one of its greatest strengths. The planning approach used in developing this study also merits recognition because it elicits input from a variety of sources at Federal and State levels, assesses that input, identifies obstacles and challenges, and produces a framework for action. This document is a useful synthesis of ideas that can assist in developing a strong monitoring program.

3.2 Weaknesses

A major weakness of the study results from its relatively narrow base of information. Although a variety of sources at Federal and State levels were interviewed, they appear to be primarily administrators and managers within EPA. These people are often not familiar with the details of Federal or State monitoring programs, and deficiencies range from a lack of understanding of the reasons for monitoring to lack of knowledge of the uses of data. More of the technical staff directly responsible for monitoring programs and/or data management and analysis should have been interviewed. This would have resulted in interviews with several individuals in an agency because different types of monitoring, such as routine, intensive, and compliance monitoring, are the responsibilities of different people. Specifically, the opinions of scientists within the EPA Office of Research and Development, particularly at Environmental Research Laboratories, should have been solicited. The

scientific community within EPA routinely collects and uses monitoring data, and their opinions would have given more balance to the study.

The States are also under represented in the study. State monitoring programs vary widely. The reasons for this variability include political climate, scope of environmental problems, size, available resources, and expertise of staff. Some State programs illustrate technical competence while others do not. This diversity is not reflected in the study document. Instead, the report simply concludes that State programs are inadequate to meet emerging needs and that changes are needed. The lack of monetary resources needs to be recognized as a major factor limiting nearly all State monitoring programs.

The report consolidates Federal and State monitoring programs throughout much of its discussion. This distorts the fact that Federal and State monitoring programs often have very different purposes and functions. The report should acknowledge that EPA is better equipped to conduct some types of monitoring, such as monitoring beyond State borders for acid deposition effects, whereas States have different roles and capabilities, such as compliance monitoring.

While it is understood that the source of information for the study was personal interviews, many statements made in the report are not supported and should be qualified. For example, statements concerning statistically based conclusions about water quality over wide areas need to be documented.

The study adequately explores the breadth of the monitoring issue, but this breadth is not completely reflected in the recommendations. The six main recommendations are: 1) issue guidance on cost-effective approaches to problem identification and trend assessment; 2) accelerate development and application of promising biological monitoring techniques; 3) continue and expand efforts to improve information on National Progress in Water Pollution Control; 4) analyze the feasibility of requiring National Pollutant Discharge Elimination System (NPDES) permittees to conduct ambient follow-up monitoring studies; 5) improve EPA and State knowledge about sources and uses of existing water-related data; and 6) establish central coordination of EPA activities to integrate water-related data. In general, these recommendations seem too narrowly focused. The specific issues and suggestions to follow can be applied to expand the recommendations presented in the study.

4.0 SPECIFIC ISSUES

4.1 Purposes of Monitoring

4.1.1 Functions of Monitoring

The study places appropriate emphasis on the utility of monitoring data in decision-making for water pollution control

programs. However, the organization of this section of the study is confusing and detracts from more basic issues. The authors introduce four reasons for using monitoring data in surface water programs. These four reasons are to: 1) identify water quality problems and trends; 2) develop water quality controls and management actions; 3) determine compliance and effectiveness of control; and 4) develop priorities and plans. Further description of these reasons can be found in Appendix A page A-5.

This section can be improved by beginning with the development of priorities and plans, then demonstrating how the three remaining functions support the development aspect. The information in the remaining three functions should be expanded to better reflect the breadth of issues that can be addressed with monitoring data.

4.1.2 Challenges

Another section of the study addresses the challenges facing water quality managers. Some of the challenges identified focus on the issues of assessing ecological effects as a means to define problem areas, establish criteria, and evaluate the effectiveness of current practice. As stated in the study document, these are: 1) assessing the ecological effects of toxic discharges and instituting controls; 2) increasing use of intensive surveys to collect data used in setting water quality based permit limits; and 3) demonstrating the environmental results of pollution control investments.

Other challenges identified in the study address shifting priorities at the Agency in terms of both point and non-point sources and areas affected (e.g., rivers, lakes, and estuaries). These are stated as follows in the study: 1) identifying and characterizing non-point sources of toxic and conventional pollutants, and 2) expanding efforts to identify and control pollution problems in near-coastal and ocean waters. The challenges described are presented in more detail in Appendix A, page A-12.

The Subcommittee recommends restructuring this section to reflect the issues pointed out above (assessing ecological effects and shifting Agency priorities regarding point and non-point sources), and to clarify the source of challenge, such as problems for water quality managers or problems caused by shifting Agency priorities. This restructuring will help to define the challenges and develop options for meeting them. The specific discussions under several of the challenges need amplification. For example, challenge 1 represents a shift in focus from a chemical by chemical approach to an integrated monitoring program. This is a basic change in the philosophy of monitoring and deserves more emphasis.

4.1.3 Obstacles

The discussion of obstacles (Appendix A, page A-13) overlooks a major problem implicit in many monitoring programs - the lack of clear definition of the question(s) addressed by monitoring. Before a monitoring program is begun, both the broad purpose (e.g., compliance with NPDES permits) and specific needs should be carefully defined. A set of questions would aid in developing the monitoring design, identifying the types and forms of data to be collected, and interpreting the trends. The study does list examples of key questions that water quality managers will face in the next decade, such as what pollution problems pose the greatest threat to human health, and what environmental benefits are gained from specific control activities. However, these questions are broadly stated and need an expanded supporting rationale.

4.1.4 Characterization of Aquatic Systems

The study needs to recognize that an understanding of the natural or expected characteristics of the resource to be managed is basic to the needs of any water quality management program. Water programs under the Clean Water Act have progressed nationally in areas where adequate information on attainable uses is available and where national criteria are accurate. However, the geographical diversity of the Nation precludes the uniform application of criteria and standards.

A valid purpose of the surface water monitoring program is to provide data in support of ecoregion characterization or development of baseline conditions for subsequent assessment of aquatic alteration. The development of ecoregion characterization - a concept that assesses regional variation in water quality characteristics and aquatic communities due to climate, surface geology, soils, vegetation, and land use patterns - has shown promise as a tool for helping States and regional offices define regional goals for attainable water quality.

The establishment of base-line conditions is important to understanding system variability and resiliency and to assessing alterations, either improvement or deterioration. Information of this nature may be used to align the entire water quality management system to achieve valid and accurate goals for maintaining the integrity of the Nation's waters.

4.1.5 Trend Monitoring

The study does not place sufficient stress on the importance of monitoring to identify water quality trends. Monitoring for trends can help to answer questions when it is used in context and with regard for the differences between systems. In particular, trend monitoring can aid in evaluating:

- compliance or control in a permit-regulated system,

- progress in water quality control efforts, and
- background condition and changes induced by nonanthropogenic activities.

Data needs for trend analysis should be distinguished clearly from those of problem screening and identification. For example, data from short-term, intensive studies are not applicable for trend analysis unless certain elements of uniformity, repetition, and time sequencing are maintained.

If questions calling for trend analysis are stated precisely, trend monitoring can be accomplished efficiently. Such focus may be on indicators, such as frequency of violating standards, or on changes in mean, seasonal, or annual concentration of particular contaminants.

Section 305(B) of the Clean Water Act requires that EPA submit a report to Congress assessing the condition of the Nation's waters. This report is used to communicate information to both Congress and the public, but also serves as a tool for assessing problem areas and establishing priorities for control programs. EPA currently requires that the States prepare reports using a uniform format to facilitate the development of the national report to Congress. States use the format differently. Some supply more information than required to aid in developing in-state assessments and programs, while others provide the minimum information required by the format. EPA should continue to evaluate this reporting form. It should serve as a tool for developing the national report and for assessment and program prioritization by the states. The form should promote efficiency, consistency, and the capture of more relevant information for assessing water quality conditions.

4.1.6 Differentiating Between Point and Non-point Sources

Non-point source monitoring introduces a specific set of questions and concerns that differ from point source monitoring. Combining the two in a nondescript "ambient" monitoring program obscures the distinction and limits the usefulness of the data. Clear formulation of the questions can help determine whether the monitoring should seek to integrate the effects of all sources or isolate certain sources or groups of sources. Generally, monitoring non-point sources requires a commitment to fixed stations, monitoring for long durations, and capturing related data such as hydrologic, meteorologic, land use activities, and demographic data. The commitment to fixed stations, in particular, implies a demand that the Agency formulate its questions precisely.

Evaluations of non-point source program effectiveness may introduce further demands on a monitoring program such as estimating mass loadings or quantifying spatial inputs. There is a need for consistent, uniform sampling strategies that account for influences from storm events and seasonal factors, and avoid

bias. Careful formulation of questions is very important because a commitment to long-term monitoring can be substantial in both manpower and monetary resources.

4.1.7 Multimedia Monitoring

The study implies that water quality decisions in the 1990s will be made based on multimedia risk management (see Appendix A, page A-10), yet the body of the study does not address this issue. Multimedia assessments and their implications for monitoring should be incorporated into both the objectives and the recommendations. The importance of coordinating monitoring programs for various media should be stressed to ensure compatibility between station location, frequency of collection and data types. It is also important to consider the interfaces between functional subdivisions (e.g., air/water interface, marine microlayer) of media.

4.2 Data Needs

4.2.1 Chemical Specific Monitoring

Considering the myriad of chemicals that can be present in surface waters, it is not practical to rely solely on a chemical specific monitoring approach. The Agency should continue to develop monitoring techniques that integrate the effects of chemicals. Use of ambient toxicity testing approaches that assess the combined effects of all stressors should be an integral part of monitoring programs.

4.2.2 Biological Monitoring Techniques

Biological monitoring techniques can provide valuable information on water quality. Since organisms respond to their total environment, they offer an integrated alternative to chemical-by-chemical monitoring. The study identifies several ambient toxicity testing techniques and advocates their use in monitoring programs. The Subcommittee encourages the Agency to keep abreast of new physiological, biochemical, and genetic techniques that can indicate sublethal stress caused by chemicals. It is important to develop and use screening tests based on new techiques to improve the efficiency and sensitivity of the ambient toxicity tests currently available. The Agency should continue to foster the development of biological monitoring techniques for use in both inland and marine systems.

Analyses of sediments and biota from many aquatic areas around the country show hundreds of anthropogenic compounds. The study acknowledges that estimation of biological impact is more difficult than detection, since toxicity tests are usually performed with individual chemicals in "solution" rather than with the complex mixtures found in sediments.

The study recognizes that better indicators of biological damage are available. However, more tests than those mentioned

are available for application. Recently published studies have shown that tests derived from research on mammals are useful when applied to aquatic systems. Investigation of the impacts of in-place contaminants on aquatic biota with histopathological and immunological techniques are now possible. The detection of tumors in fish from Puget Sound, the finding of lesions and depressed immune systems in fish from the Elizabeth River, Virginia, and the determination of elevations in metallothionein concentrations in fish from Prickley Pear Creek, Montana are examples of the use of such technologies. The Subcommittee recommends that EPA begin to implement such technologies into programs for monitoring.

4.2.3 Real-Time Monitoring

A need exists for the development of real-time (i.e., continuous) chemical, physical, and biological monitoring technologies. With the exception of temperature, discharge, and conductivity, and the limited monitoring of dissolved oxygen and pH, there are few examples of real-time monitoring of water quality. Real-time monitoring would allow rapid detection of emerging problems and should promote efficient corrective actions to be implemented. The Agency should foster the development of chemical, physical, and biological techniques for real-time monitoring of water quality.

4.2.4 Watershed Monitoring

Comprehensive monitoring programs must be based on thorough analysis of the source of waters and characteristics of the watersheds. Ambient trend data are most appropriate if the influence of upstream effects are considered. Intensive survey data must include analysis of the entire watershed or drainage basin.

4.2.5 Responsibility for Monitoring

The Subcommittee recognizes the importance of defining the roles and responsibilities of various agencies for monitoring ambient waters. The study recommends that NPDES permittees conduct follow-up monitoring. This approach by itself may not meet the need for knowing how well water quality is protected. Current regulatory practices require individual dischargers to meet effluent limitations following the chemical-by-chemical and toxicological characterization approaches outlined in the **Technical Support Document for Water Quality-Based Toxics Control**. This is intended to assure that no single discharger adversely affects water quality. However, no mechanism exists to monitor the effect of overlapping zones of impact or the additive effect of chemicals on the ecosystem.

In developing its surface water monitoring program, the Agency needs to coordinate with other Federal agencies. Several agencies besides EPA collect surface water monitoring data for a variety of reasons: the United States Geological Survey (USGS)

collects chemical, physical, and biological data; the United States Fish and Wildlife Service (USFWS) monitors fish and shellfish tissue residues; the National Oceanic and Atmospheric Administration (NOAA) monitors marine systems through the status and trends program; and the United States Department of Agriculture (USDA) supports several water quality monitoring programs. While these programs have purposes that differ from the primary interests of the EPA, they may provide useful data and, if effectively coordinated with the Agency's monitoring activities, could result in more comprehensive data for analysis of the quality of the nation's waters.

The study does not indicate consideration to harmonize the Agency's surface water monitoring with related programs throughout the world. Acid rain is but one example of the global problem requiring coordinated monitoring between countries. How does the proposed surface water monitoring program relate to monitoring activities in Canada or Mexico? Can European experiences in surface water monitoring be of value to the Agency in developing its strategy? It is the opinion of the Subcommittee that monitoring programs should be harmonized with international monitoring activities to provide data that can be readily compared and analyzed.

4.2.6 Monitoring Based on Knowledge of Chemical Fate

Many toxic substances remain in the water column for very short periods of time. Generally, these substances have an affinity for sediment particles that may be sampled and analyzed. Ambient monitoring is ineffective for detecting the elevated levels of these substances which result in fish tissue contamination, even when undetected in the water column. Intensive surveys are more effective, yet are extremely limited in scope. Other environmental programs (Superfund Amendments and Reauthorization Act, Resource Conservation and Recovery Act, Toxic Substances Control Act, Safe Drinking Water Act) are also developing toxics' detection elements to provide the specific information required for decision-making. Coordinated efforts to develop toxic substance budgets would be more effective than any single approach. By evaluating the raw materials coming into an industry, or other chemical user, and considering the processes and the avenues of disposal, the fate of potential toxic elements could be estimated. Each specific environmental program could use this information to develop monitoring systems to evaluate the availability to the ecosystem.

4.2.7 Monitoring and the Technical Support Document for Water Quality-Based Toxics Control

A regulatory mechanism now exists for the NPDES in the form of the **Technical Support Document for Water Quality-Based Toxics Control**. Much energy and thought has gone into this approach which is now being implemented throughout the U.S. It is expected that this approach, which integrates chemical-by-chemical analysis and toxicological data with waste load

allocation, will provide greater protection of water quality. It was apparent to the Subcommittee that little integration exists between the proposed monitoring program and this document. An attempt should be made to coordinate these efforts.

4.2.8 Consistency in Monitoring

EPA's intent to strive for greater consistency among states in their monitoring is admirable if the objective is to achieve some acceptable minimal level. However, extreme caution should be employed so that monitoring entities that use "better" designs and techniques are not forced to operate at a less desirable level in order to achieve "consistency." A thorough survey of State monitoring programs is warranted.

4.2.9 Providing Monitoring Guidance

The study recognizes the need to develop technical guidance on developing monitoring programs. The Subcommittee recommends that the Agency develop technical support documents and technology transfer teams to communicate the state-of-the-art in monitoring program design. The Subcommittee further recommends that the Technical Support Document for Water Quality-Based Toxics Control be used as a model. A large body of literature exists on the design of monitoring programs that should be reviewed and integrated into the technical support document, and the Agency should solicit the practical experiences of other Federal and State agencies in their development.

4.3 Data Management and Assessment

4.3.1 Data Management Aggregation, Assessment and Analysis

The study appropriately addresses the problems of data management and provides suggestions for linking data bases and making data more accessible to promote their use by decision-makers. However, the study does not recognize the need for data aggregation and analysis by staff at a level between the decision-makers and the data managers. Staff should prepare frequent overviews and status reports as a basis for managerial actions or to revise and clarify the questions which drive the data gathering activities.

The study implies that automated computer equipment and complex, sophisticated software are sufficient to give top level administrators direct involvement in the data analysis process. This approach would substitute artificial intelligence for professional judgment, intuitive analysis, and report preparation. A better approach would be to view the hardware, the software, and the data management system as tools for technical analysts to use in preparing summaries and reports, which provide the basis for managerial decision-making.

The Subcommittee commends the authors of the document for recognizing that better labeling of data and better utilization

of STORET are important to optimizing data integration and facilitating the dissemination of environmental data. It should be recognized, however, that STORET was not designed to accept nonspecific or qualitative data such as the mass-spectra of unknown compounds in environmental samples. Therefore, while STORET is important and needed, it will require modification or other, parallel computerized information systems will be needed to address these limitations.

Analyses of monitoring data are dependent on three monitoring characteristics:

1) Time - Analyses are often needed urgently and time series data are needed to indicate changing trends.

2) Quantity - A sufficient sample set or number of data points is needed to gain an estimate of probability and to assess precision.

3) Quality - An assessment of the accuracy or correctness of the measurement including descriptive identifiers, such as time, place, and substance(s) being monitored.

Data analysis should be considered in developing a monitoring strategy. Monitoring data are collected for a variety of purposes. Variations in purpose may require different monitoring characteristics, e.g., time span, number of samples, and degree of accuracy. Careful problem formulation will lead to appropriately designed monitoring programs producing data that can be analyzed to give insight to appropriate control strategies.

Data management systems must be designed to allow flexibility, and formatted for accurate, comprehensive data entry and accessible retrieval of data. In addition, the assessment capability of the system, in terms of data quality and statistical capability, must be sufficient with regard to accuracy, pertinence, and clarity, to support decision-making. With these constraints, it is possible to develop a modular archiving system sensitive to both purpose and variability in characteristics that will allow an analyst to integrate data to assist decision-making.

STORET and BIOS are capable of such modularization and can be adapted to the concepts listed above. AQUIRE is a data base that exemplifies some of the characteristics mentioned above and can be used as a model.

4.3.2 Data Assessment

Data assessment is not identified as a component of water quality management. The Subcommittee believes this to be a deficiency in the study. Assessment is the analysis and

interpretation of data from the monitoring program. Such assessments provide answers to the questions that the monitoring program was designed to address, such as whether water quality is being adequately protected. The conceptual framework of assessment is to compare the physical, chemical, and biological data to established performance standards, such as water quality criteria, water quality advisories, health standards, permit compliance, and maintenance of intended uses. When performance standards are not met, assessment serves as a trigger for further controls.

An alternative situation can exist when the assessment indicates that additional data would be useful in resolving a particular problem. The types of additional information sought could include improvements in exposure data (by collecting more data, improving the quality of chemical data, or collecting chemical data over time to reveal a trend), better quantification of biological/ecological field data, and establishing new performance standards, i.e., site-specific water quality criteria. Collection and assessment of data can be an iterative process until the assessment results in a scientifically defensible decision to take a regulatory compliance or control action, or do nothing. The assessment aspect of water quality management is a valuable tool for setting priorities for wise use of limited resources. It is also a means of evaluating the effectiveness of control actions taken to reduce exposures.

The use of the assessment step in water quality management forces the issue of setting upper or lower limits on physical, chemical, and biological characteristics that, if exceeded, can justify an action. It will also foster a better understanding of the cause of the problems.

A current deficiency in conducting effective assessments is determining which, and how much, monitoring data are appropriate to conduct the first level assessment. A second problem is understanding what are acceptable performance standards for specific bodies of water. However, this should not prevent the use of the assessment step in water quality management to meet the needs in the 1990's. Much progress has been made in analytical chemistry, toxicological testing, chemical fate modeling, computerized data bases, and standards setting to facilitate assessments.

4.4 Control Feedback

The intent, and therefore the design, of most organic chemical analyses employed by monitoring organizations is to quantify a preselected set of compounds. There are advantages and disadvantages to this approach. One advantage is that the qualitative aspects of the analyses are simplified. Cleanup, fractionation, and detection can be selected or developed for specific compounds, decreasing the possibility of false identifications. Another advantage is that the quantitative outputs of the analyses are usually more accurate and precise

because the methodologies employed are optimized for the preselected compounds. Both of these advantages are particularly important if the intent of the monitoring is to determine compliance with some regulatory program.

A disadvantage is that only the preselected compounds will be qualified and quantified. This disadvantage is trivial if the preselected list of compounds is all-encompassing and contains all the compounds likely to be encountered. However, this is not likely to be the case. The study correctly points out that the existing "lists" of compounds are incomplete.

Another disadvantage of most existing approaches is that, even though compounds other than those sought are quantified, the data pertaining to them are ignored. In other words, valuable data are not being utilized because of the narrow focus of chemical specific monitoring.

Another way of describing most existing monitoring systems for toxic organic chemicals is to say that they are "feedback" programs. Such feedback programs are keyed by error signals. For example, if a NPDES permit allows a certain amount of a specific compound in an effluent, a concentration that exceeds the permitted level by an established margin constitutes an error. Detection of this error may initiate regulatory action. Compounds not specified in the permit, and therefore not analytically sought, cannot become an "error signal" even though they may be detrimental to the biological communities in the receiving waters.

Technologies and expertise now exist to minimize such oversight through better design of inorganic chemical monitoring programs. The major tools used in the organic qualitative and quantitative analyses are Gas Chromatography (GC) and Gas Chromatography-Mass Spectrometry (GC-MS). These instruments yield signals for all the compounds present that can be resolved and detected by the various detectors utilized. Even though many of these signals are not essential to a "feedback" system in the strictest sense, they can be collected, stored, and analyzed with the use of data systems. Utilizing retention markers in the analyses and calculating relative retention indices for compounds detected by both GC and GC-MS facilitates such investigations.

A further refinement to consider may be the sacrifice of some quantitative aspects of the analyses to maximize the qualitative outputs--in other words, to minimize the cleanup and fractionation to which the extracts are subjected in order to maximize the number of compounds left in the extract to be analyzed. The results may be less useful for compliance or feedback monitoring but more important for feed-forward monitoring. Feed-forward monitoring, in this case, is defined as monitoring designed to determine when new, unregulated or unselected compounds enter a system, or to determine the distribution of classes of compounds. Feed-forward monitoring has the advantage of determining many more compounds, which in turn

provides a much more realistic estimate of the total toxic burden to which organisms are subjected. EPA funded the development of such a system in its Chesapeake Bay Program and the system is now in use in the State of Virginia. The technology exists to support this effort. Widespread implementation of such a program will be costly, however; the benefits may outweigh the costs.

APPENDIX A

EXECUTIVE SUMMARY OF THE STUDY:

"Improving Surface Water Monitoring Support for Decision-making: A Framework for Change"

EPA Surface Water Monitoring Study

Improving Surface Water Monitoring Support for Decision-Making: A Framework for Change

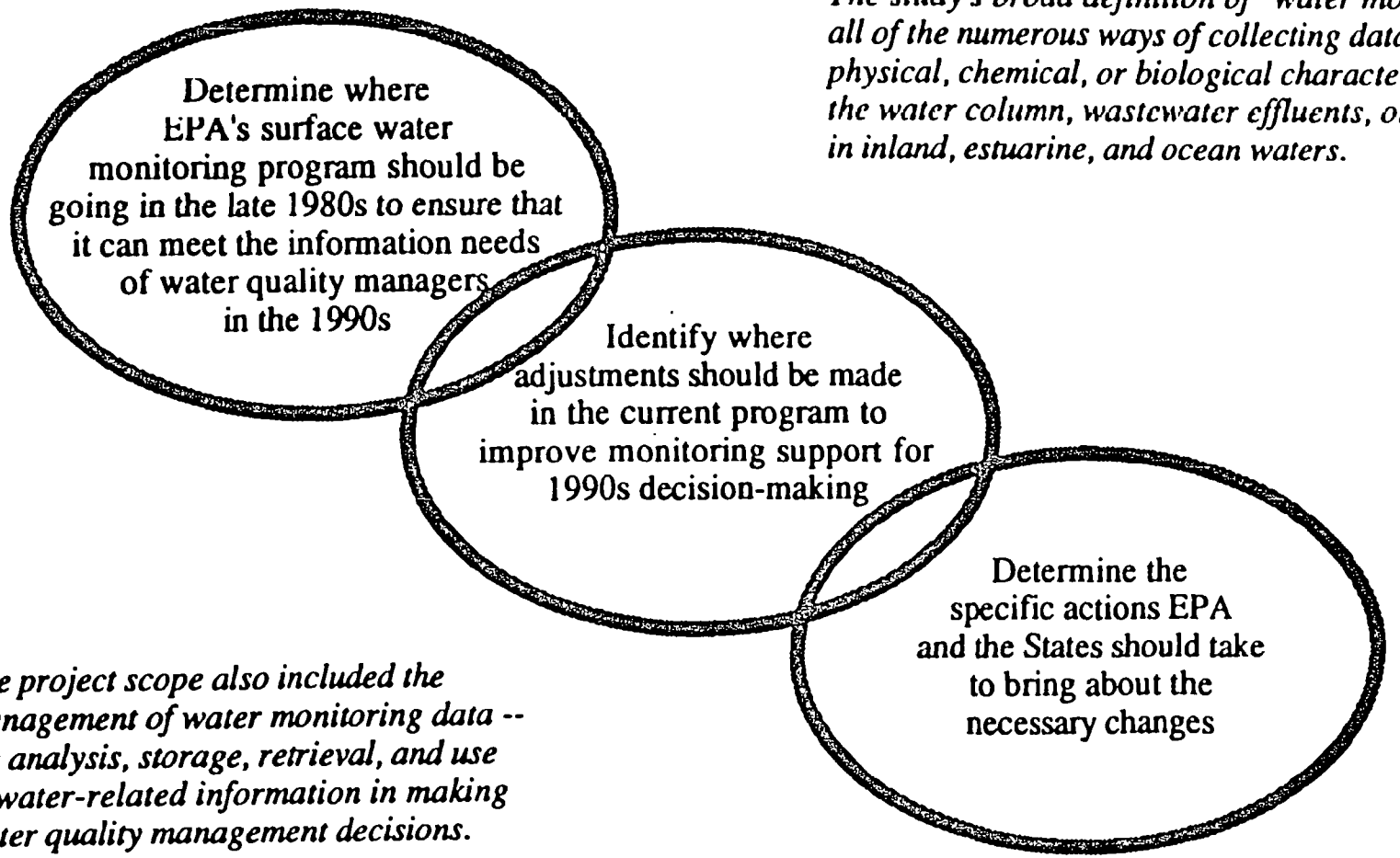
Draft
Executive Summary

Prepared by

the Office of Water,
the Office of Policy, Planning, and Evaluation,
and American Management Systems, Inc.

The 12-Month Study Had Three Inter-Related Objectives With Respect to a Broadly-Defined Scope

The study's broad definition of "water monitoring: all of the numerous ways of collecting data on the physical, chemical, or biological characteristics of the water column, wastewater effluents, or sediments in inland, estuarine, and ocean waters.



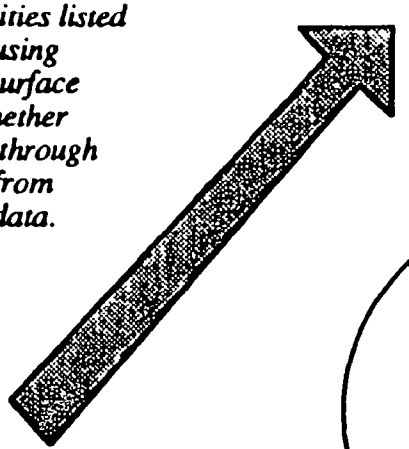
The project scope also included the management of water monitoring data -- the analysis, storage, retrieval, and use of water-related information in making water quality management decisions.

The Study Team Solicited Many Points of View -- From EPA, States, and Other Organizations

- Interviews with numerous key State and Federal managers
- Reviews of pertinent documents
- A series of working papers discussed with the study's Policy Committee and other advisors inside and outside EPA

Surface Water Monitoring is an Important Source of Information That Can Be Useful ...

The individual activities listed are the reasons for using monitoring data in surface water programs, whether the data is obtained through new monitoring or from sources of existing data.



I. Identify Water Quality Problems and Trends

- Identify water quality problems and trends on the National or Regional scale
- Identify water quality problems and trends on the State or areawide scale
- Characterize the nature, extent, and likely causes of a problem or set of problems
- Identify individual segments not meeting water quality standards

IV. Develop Priorities and Plans

- Develop priorities and plans for:
  - -- Control actions (e.g., permits, BMPs)
  - -- Corrective actions (e.g., enforcement)
  - -- Regulations (e.g., Effluent Guidelines)
  - -- Additional monitoring

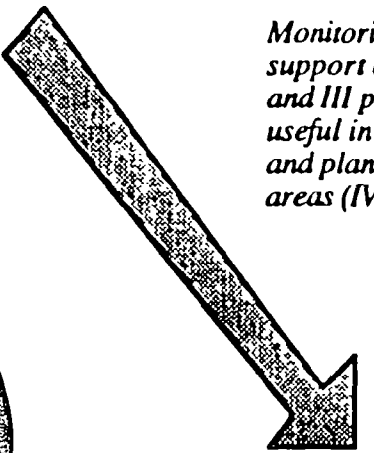
III. Determine Compliance and Effectiveness of Controls

- Determine compliance with permit conditions
- Evaluate the effectiveness of water quality management actions (point and nonpoint)

II. Develop Water Quality Controls and Management Actions

- Establish or revise water quality criteria and standards
- Develop permit conditions for industrial dischargers
- Determine permit conditions for municipal dischargers
- Develop and implement BMPs for nonpoint sources

... in Performing Four Essential Functions of Water Quality Management Programs



Monitoring conducted in support of functions I, II, and III provides information useful in developing priorities and plans for each of these areas (IV).

EPA and the States Use a Variety of Monitoring Approaches to Obtain Water Quality Information

Water quality monitoring approaches may be classified as either "ambient" or "source" monitoring.

- Ambient monitoring refers to all monitoring conducted beyond the immediate influence of a discharge pipe, including sampling of sediments and living resources.
  - States conduct most ambient monitoring in fresh waters
  - EPA provides guidance and technical support to States
- Source monitoring involves assessing the composition of industrial or municipal effluent discharged into waterways, and of the "mixing zone" where the wastewater and the receiving water merge.

Principal Ambient Monitoring Approaches

- Networks of "fixed stations" where water samples are repeatedly collected over time to provide an overview of water quality conditions and trends at each location and across the entire area covered by the network
- Intensive surveys of water column chemistry, sediments, or aquatic life at specific sites or in relatively well-defined geographic areas such as river basins and estuaries
- Professional judgment by experienced staff who can visually recognize changes in a waterbody or its biota that may indicate a change in water quality
- Statistically-designed special studies with a broad geographic coverage and often a single-pollutant focus (e.g., the National Dioxin Study)

Principal Source Monitoring Approaches

- Self-monitoring of effluent by industrial and municipal dischargers to check for compliance with permit conditions
- Compliance sampling inspections by States or EPA to provide a cross-check on discharger self-monitoring
- Effluent characterization studies by EPA to determine the constituents of the wastestream typically produced by a specific industrial class of discharger

While States Vary Widely in Their Methods and Priorities, the Current Approach to Surface Water Monitoring Nationwide Has Some Common Characteristics

Emphasis on "intensive survey" monitoring to support development of point source controls

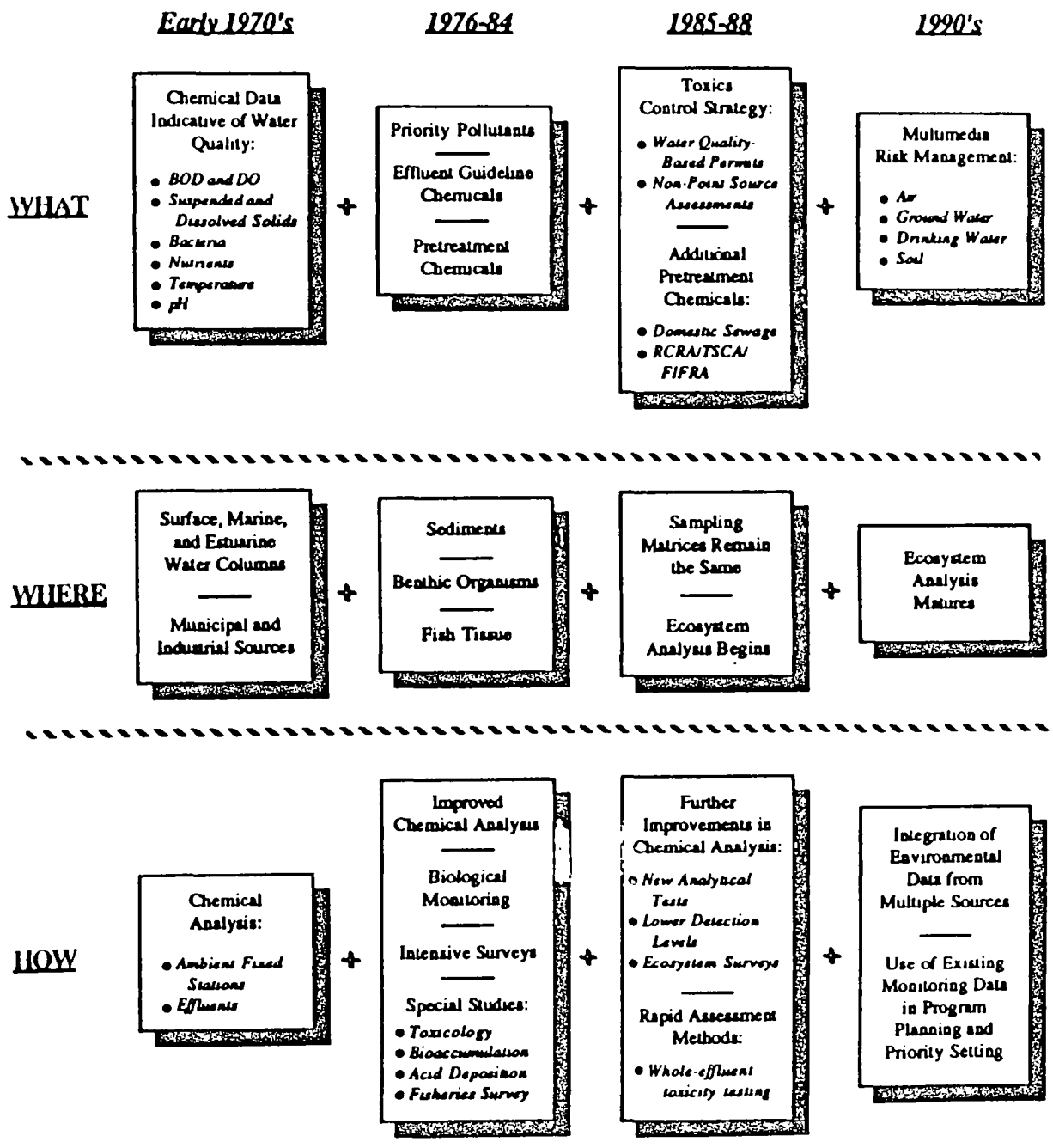
Heavy reliance on periodic watercolumn sampling at "fixed stations" to detect water quality problems and trends

Regular self-monitoring and reporting by NPDES permittees to determine compliance with permit conditions

Significantly increased EPA and state status-and-trend monitoring in near-coastal waters

Occasional large, statistically-designed surveys of specific problems, such as the National Dioxin Study

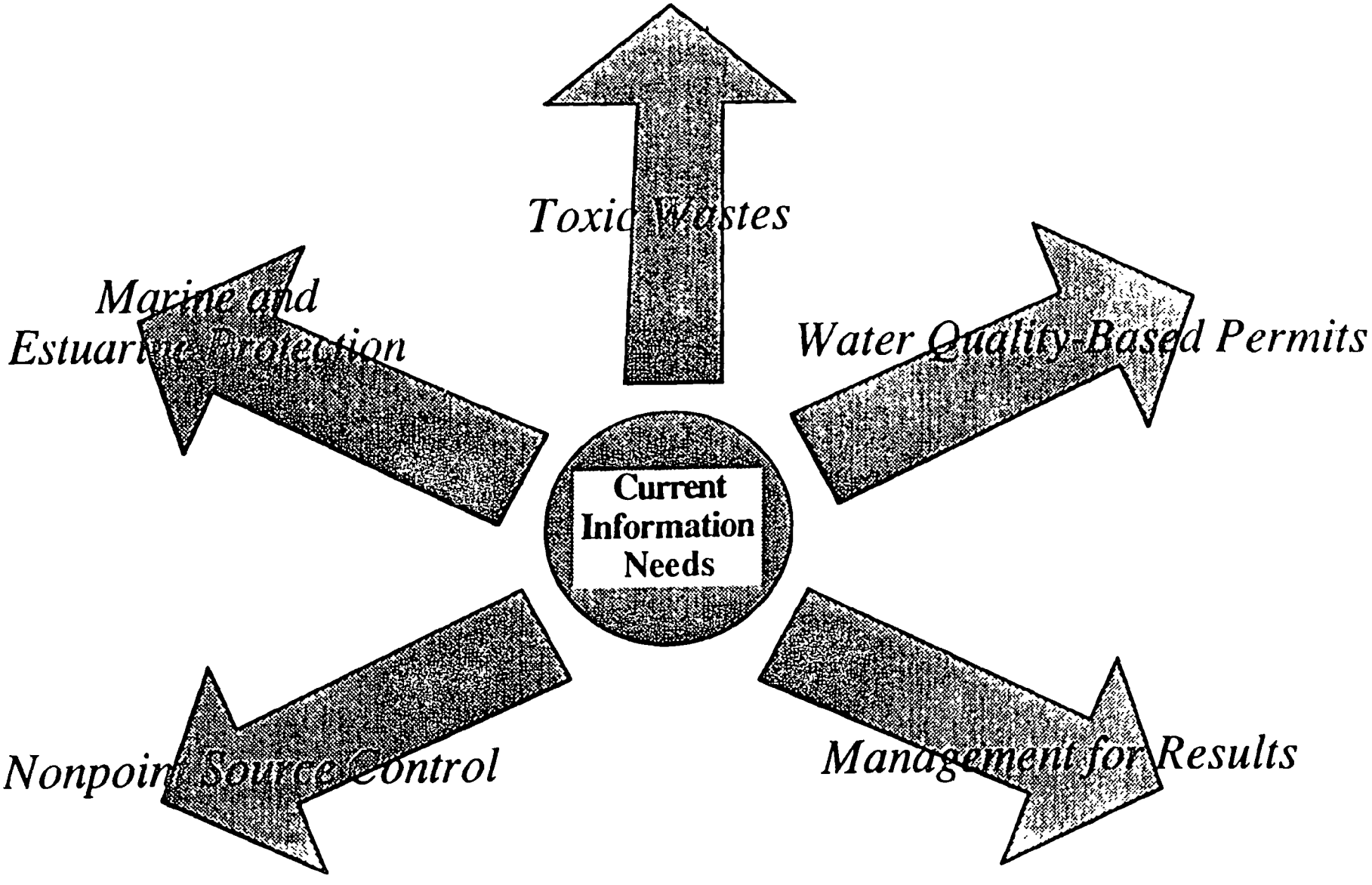
Summarization of State and national conditions and trends in the biennial "305(b) Report" and other publications



Surface Water Quality Management is an Increasingly Complex and Information-Intensive Task

The scope and complexity of water quality management are expanding rapidly. The task of pollution control and abatement is moving well beyond the focus on technology-based control of conventional point source pollutants that has been dominant since the early 1970s.

Emerging Challenges in Water Quality Management Are Creating New Information Needs for the Late 1980s and Early 1990s



Five Key Challenges for Surface Water Quality Managers

CHALLENGE 1:

Assessing the ecological effects of toxic discharges, and instituting controls

Toxic contamination from point and nonpoint sources is now recognized as a widespread and serious threat; more than 600 hazardous or toxic chemicals may require regulation.

Present analytic methods are not practical to monitor for a wide range of individual toxic contaminants, due to the high cost of analysis and the inability to detect many chemicals.

CHALLENGE 2:

Increasing use of intensive surveys to collect data used in setting water quality-based permit limits

Many dischargers must have "water quality-based" permit limits because technology-based limits do not sufficiently protect the quality of the receiving waters.

This approach requires States to determine which stream or near-coastal segments are "water quality limited," based on monitoring data and other factors.

CHALLENGE 3:

Identifying and characterizing nonpoint sources of toxic and conventional pollutants

In many of the Nation's waterways, urban and agricultural nonpoint sources are the principal cause of remaining water quality problems.

Nonpoint pollution of all kinds, from tributary and shoreline sources, contributes heavily to the degradation of estuaries and other near-coastal waters.

CHALLENGE 4:

Demonstrating the environmental results of pollution control investments

EPA senior management has stressed the need to strengthen the Agency's ability to "manage for environmental results."

In State surface water programs, the importance of follow-up information is growing with the advent of water quality-based permitting, the expanding focus on toxic pollution, and the increased attention to nonpoint sources.

CHALLENGE 5:

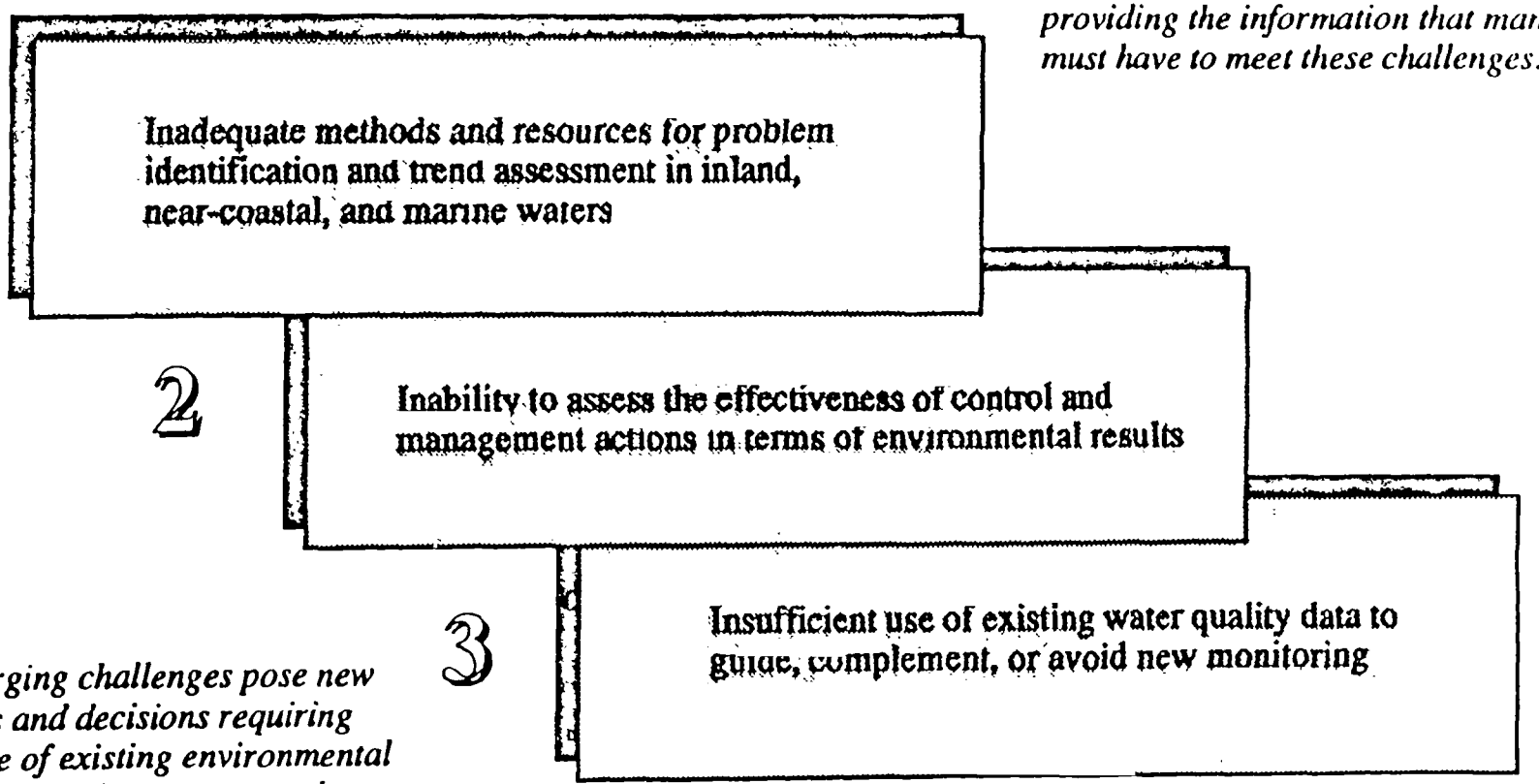
Expanding efforts to identify and control pollution problems in near-coastal and ocean waters

Bays, estuaries, and the open ocean are polluted by a variety of inland and shoreline sources.

Monitoring needs in these waters are expanding along with EPA and States efforts to assess environmental quality, identify pollution sources, and develop water quality management plans and programs.

The Present Approach to Surface Water Monitoring Cannot Fully Provide the Information That Managers Must Have to Meet the Challenges of the 1990s

The surface water monitoring program must overcome 3 major obstacles to providing the information that managers must have to meet these challenges.



The emerging challenges pose new questions and decisions requiring better use of existing environmental data as well as data not currently being collected.

Obstacle 1

Inadequate methods and resources for problem identification and trend assessment in inland, near-coastal, and marine waters

☞ Maintenance of ambient monitoring networks is expensive, and most existing networks are not adequate for current and future data needs.

- Fewer monitoring stations, sampled less frequently
- Water column sampling and analysis alone are not sufficient to detect all impacts of interest (e.g., bioaccumulation effects)
- Existing stations are not well-located to assess effects and trends of nonpoint pollution sources -- and some major point sources

☞ States have been slow to adopt new monitoring techniques.

- Newer methods require new skills and equipment
- Some new methods are perceived as experimental and expensive
- Most States are still struggling to solve known problems, which are themselves very complex

Obstacle 2

Inability to assess the effectiveness of point source control and nonpoint source management actions in terms of environmental results

☞ The need for EPA and State programs to use ambient monitoring to measure effectiveness is emerging and still not well-understood.

- The shift from a technology-based to a water quality-based approach is still recent
- States are concerned about making new investments before they have a better understanding of the evolving program impact

☞ EPA and States will have to develop new methods & approaches.

- Ambient monitoring has not regularly been used to determine water quality management program effectiveness
- Program effectiveness is usually measured in terms of continued compliance with permit limitations
- In developing new methods and approaches, States will face issues similar to those in Obstacle 1

Obstacle 3

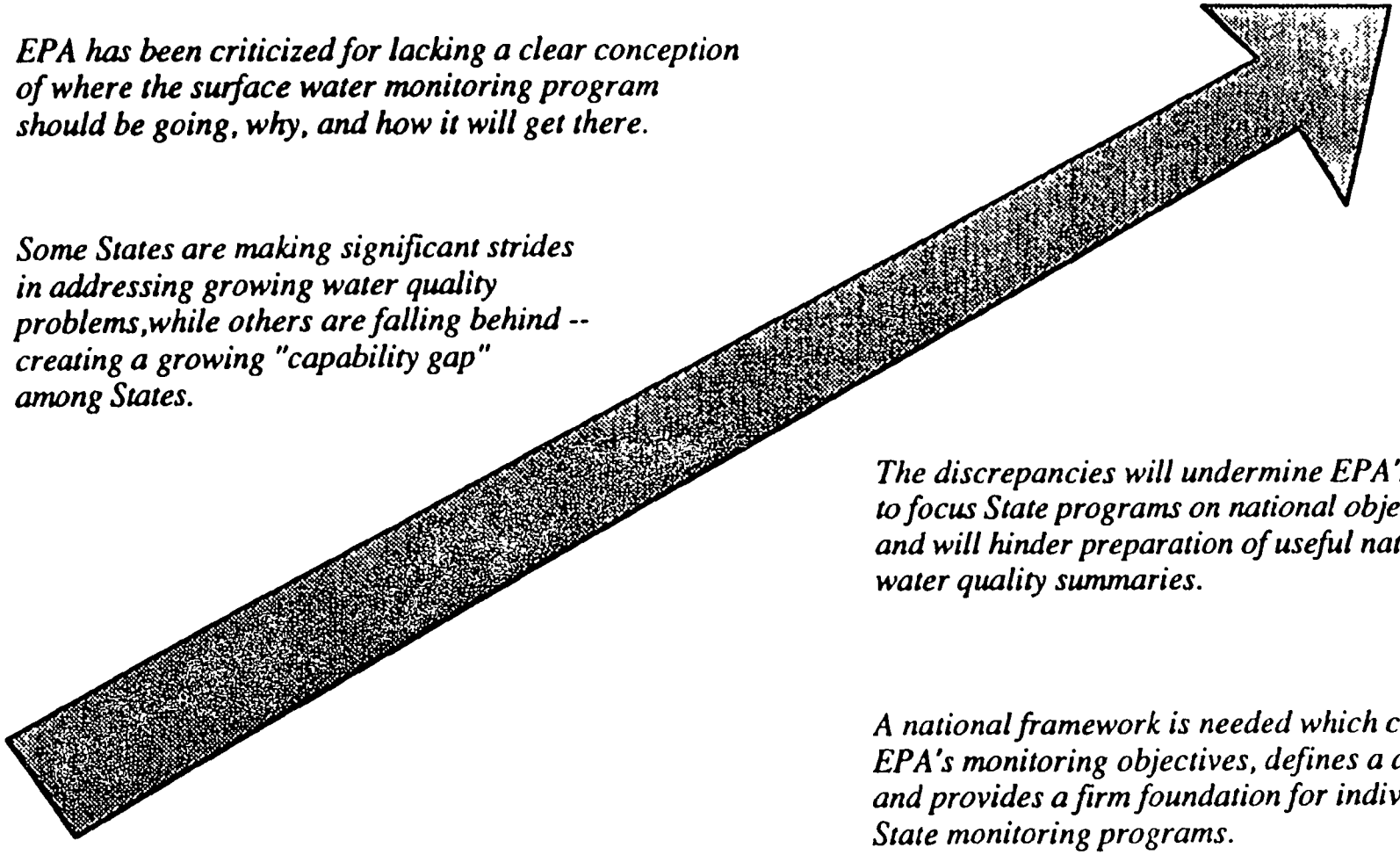
Insufficient use of existing water quality data to guide, complement, or avoid new monitoring

- Large historical data bases are not routinely used to look for potential problems or to assess the magnitude of existing ones.
  - Frequent mistrust of data collected elsewhere for other purposes
  - Managers find EPA's water-related data bases difficult to use
  - Low level of awareness about where data resides
- Potentially-useful data available through other Federal agencies is not being exploited.
  - USGS, NOAA, and numerous others
- EPA and the States need to expand and institutionalize their knowledge about potential sources and uses of existing data.
  - Some States and EPA offices are slowly gaining experience
  - Lack of leadership and coordination of diverse data management activities

The Office of Water Must Provide Leadership in Working With the States to Re-Orient Surface Water Monitoring Toward Future Information Needs

EPA has been criticized for lacking a clear conception of where the surface water monitoring program should be going, why, and how it will get there.

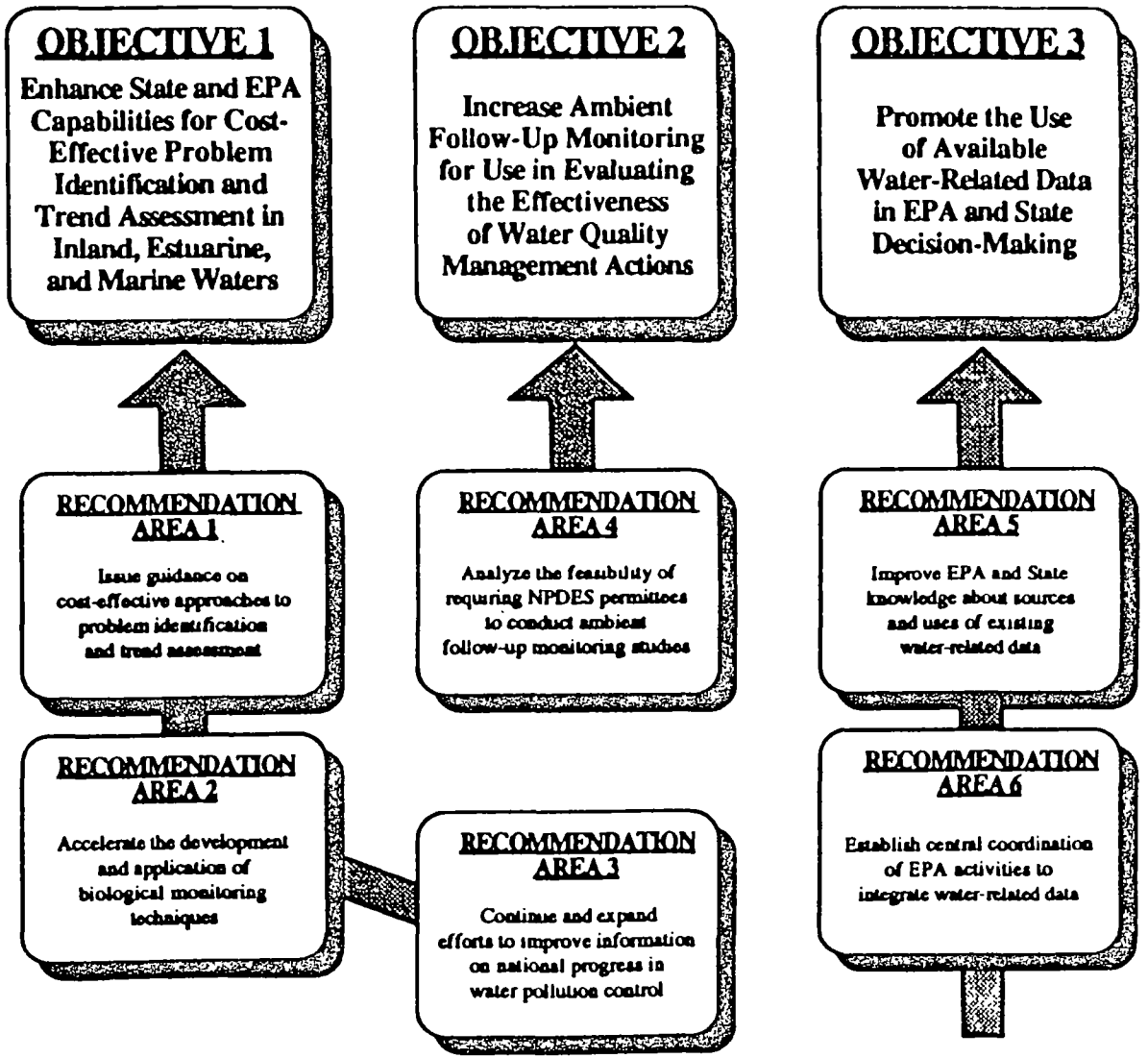
Some States are making significant strides in addressing growing water quality problems,while others are falling behind -- creating a growing "capability gap" among States.



The discrepancies will undermine EPA's efforts to focus State programs on national objectives and will hinder preparation of useful national water quality summaries.

A national framework is needed which clarifies EPA's monitoring objectives, defines a direction, and provides a firm foundation for individual State monitoring programs.

Action is Needed in Six Major Areas to Establish a National Framework for Surface Water Monitoring



The Study's Final Report Describes 21 Specific Actions That the Office of Water Should Take by the End of FY 1989

RECOMMENDATION AREA 1

Issue Guidance on Cost-Effective Approaches to Problem Identification and Trend Assessment

- Issue guidance to States on re-evaluating their surface water monitoring programs.
- Develop one or more technical reference manuals on basic design principles for water quality trend monitoring.
- Issue guidance on establishing and maintaining "citizens' watch" programs.

RECOMMENDATION AREA 2

Accelerate the Development and Application of Promising Biological Monitoring Techniques

- Thoroughly survey and evaluate the current situation with development and application of biological techniques in the United States and Canada.
- Determine the role that biological monitoring techniques should play in a systematic, cost-effective problem screening or trend monitoring program.
- Create a detailed action plan specifying the steps OW will take in FY 1988-90 to accelerate the development and application of biological methods.
- Fully support the implementation, refinement, and use of the BIOS subsystem of STORET, EPA's main water quality data system.

RECOMMENDATION AREA 3

Continue and Expand Efforts to Improve Information on National Progress in Water Pollution Control

- Provide detailed and unambiguous guidance to States on objectives, definitions, presentation formats, and recommended assessment methods.
- Proceed rapidly with development of a Water Quality Information Tracking System.
- Carefully examine the types of water quality monitoring performed by other Federal agencies, and develop an approach for systematically drawing on these sources, when appropriate, in the national assessment process.

RECOMMENDATION AREA 4

Analyze the Feasibility of Requiring NPDES Permittees to Conduct Ambient Follow-Up Monitoring Studies

- Specify the type and quantity of ambient effects information needed by State and/or EPA decision-makers.
- Clearly describe the characteristics of a technically-sound approach, or range of approaches, to ambient effects monitoring.
- Identify alternative methods by which the costs of ambient follow-up monitoring could be borne by the regulated community.
- Assess the advantages and disadvantages of each alternative method, and recommend how the Office of Water should proceed.

RECOMMENDATION AREA 5

Improve EPA and State Knowledge About Sources and Uses of Existing Water-Related Data

- Develop a standard for labelling of monitoring data sets.
- Issue guidance on sources and uses of existing water-related data.
- Improve STORET's usefulness as a decision support tool.

RECOMMENDATION AREA 6

Establish Central Coordination of EPA Activities to Integrate Water-Related Data

- Develop tools to make better use of DMR data, including linking of PCS, STORET, and other OW data files.
- Assess the feasibility of developing an automated data base of drinking water surveillance results.
- Ensure appropriate development and use of "geographic information systems."
- Promote awareness and use of data integration tools.

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