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Standard Guide for Planning and Implementing a Water Monitoring Program[1]

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INTRODUCTION

Water resource monitoring has taken place in many forms for scores of years. This monitoring has been sponsored and performed by a variety of federal, state, and local public agencies; and perhaps by an even wider variety of private, quasi-public and industrial entities. Historically, much of the early data dealt with quantities of flow, and drinking water quality was judged by the standards of the period.

During the past several years the problems related to point and nonpoint sources of pollution of water resources have become increasingly apparent. Technology has improved dramatically, as the need for monitoring data has improved. There is a necessity for information on marine beaches and estuarine areas, fresh water swamps, ground water, wetlands, streams, and sediment deposits, and to better understand the entire hydrologic cycle.

The need for more and varied water quality information has expanded as rapidly as our technological ability to generate the information. Further, it has become increasingly difficult and sometimes impossible to understand and resolve conflicts among the different data sets available. Much of the data have been collected at different times, in different geographic areas, and for different purposes. The data have been collected by persons with varied training, using different methods, and with vastly different analytical capabilities. As a consequence, we presently are at the stage where we may know more about a given situation than we understand and workers in the field who receive the data are unable to integrate the data available into a useful solution. The need for standardization of monitoring programs is evident. Standardization does not herein mean everyone doing everything exactly the same way. It does mean the use of methods and procedures, where applicable, that follow recognized and documented protocols as well as the accurate recording and storage of the data in accessible formats.

Realizing the difficulties in water monitoring, the Office of Management and Budget (OMB) of the federal government charged the Water Information Program (WICP), a program of the U.S. Geological Survey's Office of Water Data Coordination, with studying water quality monitoring in the United States and recommending improvements. The Intergovernmental Task Force on Monitoring Water Quality (ITFM), a federal, state, and tribal partnership, was established under the WICP's Interagency Advisory Committee on Water Data to carry out this study. The results of three years of work by about 200 contributors have been captured in a series of three annual reports (**1**, **2**, **3**).[2]

The following summarizes the conclusions from those reports:

(*1*) Monitoring programs shall keep pace with changing water-management programs.

(*2*) A collaborative strategy is needed to link the many separate monitoring programs.

(*3*) A genuine appreciation of the need for cooperation currently exists among monitoring agencies.

(*4*) Recent advances in technology provide opportunities for interaction and cooperation that previously were impossible.

[1] This guide is under the jurisdiction of ASTM Committee D19 on Water and is the direct responsibility of Subcommittee D19.02 on Quality Systems, Specification, and Statistics.

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[2] The boldface numbers in parentheses refer to a list of references at the end of this guide.

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Based upon those conclusions, the following recommendations were made:

(*1*) Implement an integrated, voluntary, nationwide strategy to improve water quality monitoring.

(*2*) Charter a permanent national body to guide the implementation of ITFM recommendations.

(*3*) Develop a framework for monitoring water quality that defines the components of a monitoring program.

(*4*) Develop criteria with which to select parameters that measure progress in achieving water quality goals.

(*5*) Recommend indicators to measure whether water quality uses designated by the state are being met.

(*6*) Charter a Methods and Data Comparability Council to foster the development and use of performance-based methods of collection and analysis.

(*7*) Use the ecoregions concept, reference conditions, and index calibration.

1. Scope

1.1 *Purpose*—This guide is generic in its application to surface or ground water, rivers, lakes, or estuaries (quantity and quality). It proposes a series of options that offer direction without recommending a definite course of action and discusses the major elements that are common to all purposes of water monitoring.

1.2 The elements described are applicable whether the monitoring is only for one location or integrates multiple measurement sites for the purpose of assessing a whole watershed, estuary, or aquifer system.

1.3 This guide is intended to outline for planners and administrators the components, process, and procedures which should be considered when proposing, planning, or implementing a monitoring program. The guide is not a substitute for obtaining specific technical advice. The reader is not assumed to be a technical practitioner in the water field; however, practitioners will find it a good summary of practice and a handy checklist. Other standard guides have or will be prepared that address the necessary detail.

1.4 *Monitoring Components*—A water monitoring program is composed of a set of activities, practices, and procedures designed to collect reliable information of known accuracy and precision concerning a particular water resource in order to achieve a specific goal or purpose. The purposes may range in scope from tracking status and trends on a regional or national basis to gathering data to determine the effects of a specific management practice or pollution incident such as a spill. This guide suggests and discusses the following process and components:

1.4.1 Establishment of program goals and objectives and recording of decisions in a written plan (see 6.1),

1.4.2 Developing background data and a conceptual model (see 6.1.12),

1.4.3 Establishment of data (quality, quantity, type) objectives (see 6.2),

1.4.4 Design of field measurement and sampling strategies and specification of laboratory analyses and data acceptance criteria (see 6.3),

1.4.5 Data storage and transfer (see 6.6),

1.4.6 Implementation of sampling and analysis strategies (see 6.4),

1.4.7 Data quality assessment (see 6.5),

1.4.8 Assessment of data (see 6.7),

1.4.9 Program evaluation (see 6.8), and

1.4.10 Reporting (see 6.9).

See also Fig. X1.1 in Appendix X1 and the condensed list of headings in Appendix X2.

1.5 *Monitoring Purposes*—Establishing goals defines the purpose for monitoring. Each purpose has some monitoring design needs specific to itself. There are six major purposes for water monitoring. They are as follows:

1.5.1 *Determining the Status and Trends of Water Conditions*—This can require long term, regular monitoring to determine how parameters change over time.

1.5.2 *Detecting Existing and Emerging Problems*—Determining if, how, or where a substance may move through an aquatic system, or if water quantities are changing.

1.5.3 *Developing and Implementing Management and Regulatory Programs*—Includes baseline and reconnaissance monitoring to characterize existing conditions such as to identify critical areas or hot spots; implementation monitoring to assess whether activities were carried out as planned; and compliance monitoring to determine if specific water quality or water use criteria were met.

1.5.4 *Responding to an Emergency*—Performed to provide information in the near term.

1.5.5 *Evaluating the Effectiveness of Water Monitoring Programs*—Is the monitoring able to achieve the stated goals? Also, monitoring to check on monitoring.

1.5.6 Supporting research objectives or validating of simulation models.

1.6 This guide is applicable to these purposes and provides guidance on some of the specific needs of each. After goals and objectives have been established, a specialist can define the type, frequency, and duration of sampling and measurements. The specialist also will be able to forecast the data analysis needed to meet the objectives.

1.7 There are related standards currently available or under development and several documents that prescribe protocols for water monitoring (**4–5**). See also Section 2.

1.8 This guide suggests that water monitoring programs use standardized documented protocols for all aspects of the program. Where they are not available or appropriate, the methods used should be documented.

1.9 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the*

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responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. Referenced Documents

2.1 *ASTM Standards:*[3]

D1129 Terminology Relating to Water

2.2 *Other Documents:*

Compilation of Scopes of ASTM Standards Relating to Environmental Monitoring, 1994, ASTM, Philadelphia, PA. PCN: 13-600003-16 (700 standards)[4]

ASTM Standards on Ground Water and Vadose Zone Investigations. PCN: 03-418094-38[4]

2.3 *EPA Documents:*

U.S. EPA 813/B-92-002 Definitions for the Minimum Set of Data Elements for Ground Water Quality[5]

U.S. EPA 910/9-91/001 Monitoring Guidelines to Evaluate Effects of Forestry Activities on Streams in the Pacific Northwest and Alaska[5]

3. Terminology

3.1 For definitions of terms used in this guide, refer to Terminology D1129.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *analyze*—to determine the relationship of parts or the value of a particular parameter.

3.2.2 *assess*—to determine importance of data.

3.2.3 *evaluate*—to determine significance or worth.

3.2.4 *measurement*—determining the values of a characteristic within a sample or in situ.

3.2.5 *metadata*—ancillary data that describe the natural conditions under which an environmental data value is measured, the purpose for collection, the methods and standards employed, and the organization responsible.

3.2.6 *sampling*—the removal of a portion of the water which may or may not be representative of the whole. This is not monitoring.

3.2.7 *water monitoring*—water monitoring consists of systematic activities conducted to characterize the quantity or quality, or both, of water.

4. Significance and Use

4.1 The user of this guide is not assumed to be a technical practitioner in the water field. This guide is an assembly of the components common to all aspects of water monitoring and fulfills a need in the development of a common framework for a better coordinated and more unified approach to monitoring water.

4.2 *Limitations*—This guide does not establish a standard procedure to follow in all cases and it does not cover the details necessary to meet a particular monitoring objective.

5. A Primer on Water Monitoring Programs

5.1 *The Problem*—Why is water monitoring difficult?

5.1.1 The movement of water through the hydrologic cycle dwarfs other material cycles operating on the earth's surface, such as the carbon and oxygen cycles. Water's chemical and physical properties enable it to dissolve many substances and physically remove and suspend others. Consequently, as water encounters various substances in the atmosphere, on land surfaces, and below ground, the water's chemical composition changes, and the composition of materials suspended in the water changes. Physical and chemical processes further change its composition as water moves through the hydrologic cycle.

5.1.2 Human activities using land and water have greatly altered the kind and amount of substances that water encounters as it moves through the hydrological cycle. Often, some substances, including those biological communities living within water, are present at concentrations that impair various water uses. These substances are regarded as pollutants. Much of our effort to manage water resources is directed at reducing the addition of pollutants in water. Other management efforts are directed toward altering local pathways of water flow and maintaining or enhancing aquatic and marine habitats.

5.1.3 Across the globe or across a county there are large spatial and temporal variations in water flows and volumes, in the natural features, which impact water resources, and in the nature and extent of human land and water uses. Consequently, there can be large spatial and temporal variations in the composition of water. The problem that must be addressed in water monitoring is how to spatially and temporally characterize the composition of water and the source of this composition with sufficient accuracy and precision to support local and regional water uses and management efforts. Monitoring water as it flows through the hydrologic cycle is not easy.

5.1.4 Reading through the following list of procedures and considerations will provide the administrator or planner with insight into the details of needed expertise, complexity, and work tasks in the design, implementation, and evaluation of a monitoring project.

6. Procedure

6.1 *Establish Program Goals and Objectives:*

6.1.1 Define goals and objectives using a multidisciplinary team. This requires a variety of professionals with special insights in order to prepare a sensible plan.

6.1.1.1 Review existing data.

6.1.2 Prepare a plan of work from the goals, objectives, and decisions. This will be an iterating process as progress is made developing the components. The plan can use a pilot approach or phased-in approach.

6.1.2.1 Coordinate activities with other relevant agencies, groups, and persons.

6.1.3 Develop a project schedule and budget.

6.1.3.1 Establish budgetary and personnel requirements.

6.1.4 Set timelines.

6.1.5 Set interim goals, checkpoints, and review periods.

[3] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[4] Available from ASTM Headquarters, 100 Barr Harbor Drive, West Conshohocken, PA 19428–2959.

[5] Available from Superintendent of Documents, Government Printing Office, Washington, DC 20402.

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