Overview

Fifty percent of the United States' drinking water comes from ground water, 75% of the nation's cities obtain all or part of their supplies from ground water, and the rural areas are 95% dependent upon ground water. Therefore, it is imperative that every possible precaution be taken to protect the purity of the ground water.

Because of the increasing interest in prevention of ground-water contamination and the need for nationally recognized methods for investigation of contamination, a Symposium on Field Methods for Ground-Water Contamination Studies and their Standardization was held 2–7 Feb. 1986, in Cocoa Beach, Florida. The symposium was sponsored and organized by ASTM Committees D-19 on Water and D-18 on Soil and Rock. Symposium Chairman was A. Gene Collins of the National Institute for Petroleum and Energy Research (NIPER), Bartlesville, Oklahoma, and Vice Chairman was Ivan Johnson, A. Ivan Johnson, Inc., Soil and Water Consulting, Arvada, Colorado.

The purposes of the symposium were to foster interdisciplinary communication and to develop information that can be used to prepare guidelines for ground-water contamination studies and also be used to develop field methods that can eventually become ASTM standard methods or practices. To move in a direction to meet these stated purposes, 51 papers were presented on methods related to quality assurance; geophysical exploration; well-drilling; construction, monitoring, and development of monitoring wells; ground-water sampling and sampling in unsaturated soils; soil permeability; nonpoint source investigations; and a variety of actual case histories. Of the presented papers, 37 have been peer reviewed and accepted for publication in this special technical publication.

A session was dedicated to U.S. Government efforts to improve field methods for ground-water contamination studies and federal needs for standards. The session was sponsored by the Ground-Water Subcommittee of the Interagency Advisory Committee on Water Data. Speakers from federal agencies, such as the Environmental Protection Agency, Agricultural Research Service, Geological Survey, and Nuclear Regulatory Commission, held panel discussions on the following topics: (1) Standardization of ground-water monitoring techniques—is it desirable? (2) Quality assurance/quality control of ground-water monitoring—can it be accomplished? and (3) Ground-water monitoring research—does it help? These papers also are included in this STP.

During another special session, representatives from ASTM Committees D-18 on Soil and Rock, D-19 on Water, and D-34 on Waste Disposal discussed the philosophical approach and standards development progress and plans of their respective committees. This session also provided discussion about activities of an ASTM Ground-Water Coordinating Subcommittee. A third special session presented a panel discussion on quality assurance through education and certification. Opinions and programs were discussed by representatives from the Association of Engineering Geologists, American Institute of Professional Geologists, National Water Well Association, American Institute of Hydrology, and the Interagency Advisory Committee on Water Data. None of the discussion from these special sessions is included in this STP, but the organizers appreciate the efforts of the speakers at these sessions to provide auxiliary information of interest to symposium attendees.

A field trip to the NASA Kennedy Space Center was provided in mid-week to tour the center and to witness a demonstration of construction of ground-water monitoring wells at the center and to observe logging and interpretation of borehole geophysical logging of a well. In association with the symposium, but held during the week preceding the symposium, were the semiannual meetings of the 30 standards-writing subcommittees of ASTM Committee D-18 on Soil and Rock.

The International Symposium on Geotechnical Applications of Remote Sensing and Remote Data Sensing and Data Transmission of the International Association of Hydrological Sciences was held on 31 Jan. 1986. These additional activities provided discussion of techniques that could be of interest to symposium attendees.

This STP has been divided into the following chapters: (1) Quality Assurance, (2) Geophysical Methods, (3) Well Drilling and Completion, (4) Water Sampling (Saturated and Unsaturated Zones), (5) Laboratory and Field Analyses, and (6) Case Studies. The chapter on quality assurance points up that today monitoring and protecting ground water are performed by industry and federal, state, and local government agencies and that the driving forces behind these efforts are regulations in the Clean Water Act (CWA), the Safe Drinking Water Act (SDWA), the Resource Conservation and Recovery Act (RCRA), and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund). Data are needed that can be compared against standards in a scientifically and defensible manner; however, the standards may not be available. Development of standard ground-water contamination investigatory procedures are needed to assure quality studies.

Barcelona and **Gibb** identify in their paper the essential elements of a comprehensive sampling protocol used in designing a ground-water quality investigation. This excellent paper points up many of the complex problems involved in a ground-water investigation. Standardized quality assurance guidelines would be helpful in meeting regulations.

The chapter on geophysical methods indicates that these methods are useful because of their relatively low cost and that with further development, subsurface three-dimensional plumes of pollutant ion species may be identifiable. The paper by **Tinlin et al.** describes the application of controlled source audio-frequency/magnetotellurics to locate anomalies resulting from the upward movement of formation brines through improperly plugged wells.

In the well drilling and completion chapter, an excellent overview of ground-water monitoring, well design, and installation technology is given in the paper by **Riggs** and **Hatheway.** Drilling and completion methods along with discussions of why certain materials are used in monitoring well construction also are found in this chapter.

In the chapter on water sampling, **Panko** discusses well purging as a prerequisite to obtaining a representative sample. **Everett et al.** discuss the applications of suction lysimeters in vadose zones to obtain representative samples containing volatile organics. The paper by **Gerba** addresses methods of obtaining samples containing viruses. **Torstensson** and **Petsonk** discuss a sealed pressurized sampling device which is useful for obtaining samples as well as measuring *in situ* pressures and hydraulic conductivity. **Barcelona et al.** discuss sampling verification methods, including purging methods, and the effects that well casing materials can have upon samples.

Oural et al. note the problems in obtaining representative samples for gross-alpha radiation analysis. **Ficken** discusses new downhole devices for obtaining samples containing organics. **Unwin and Maltby** discusses the effects that well purging have upon obtaining representative samples.

The laboratory and field method chapter discusses new methods such as remote fiber spectroscopy (RFS) employed by **Klainer et al.** to detect and monitor ground-water contaminants; this new technology with sufficient development should be viable and could be standardized. **Crocker** and **Marchin** describe their use of a dynamic fluid flowthrough core apparatus to determine chemical interaction between chemical pollutants and ground-water reservoir rock.

The paper by **Lindsay** and **Baedecker** describes a field method for determining sulfide in the concentration range of 0.3 to 1500 μm. An accurate standard field method for determining concentrations of sulfide would be useful and is needed.

Olsen et al. utilize a laboratory system to measure the effects of permeant composition on pore fluid movement in soil where the soil sample is mounted in a conventional triaxial cell. A specially designed triaxial cell was used by **Fang** and **Evans** to determine the long-term effect of landfill leachate upon compacted clayey liner material.

A direct method using a static trapping device emplaced in the soil to concentrate organic contaminants is described by **Voorhees et al.** The organics are determined with a mass spectrometer.

In the case studies chapter, **Urban** and **Gburek** find that ground-water quality distribution is portrayed in shallow and deep fracture systems, if the sampling design is based upon correct geologic and flow system controls. Flow system controls considered are recharge, lateral flow, and discharge zones.

The paper by **Kimball** describes a comprehensive monitoring and evaluation project conducted to determine nonpoint source pollution impacts from agricultural activities. The goals of the project included strict adherence to high-quality monitoring techniques. **Waller** and **Howie** describe site selection criteria for monitor well placement, monitoring well installation and completion, sampling procedures, quality assurance protocol, and initial results pertinent to a nonpoint-source contamination from agricultural chemicals conducted in an unconfined designated sole-source limestone aquifer. Ground-water contamination in the Karst area of Northeast Iowa was studied by **Stan et al.** The study involved geologic mapping, inventory of ground-water wells, potentiometric surface mapping, dye tracing, historic water quality and land management inventories, stream gaging, spring gaging, land use mapping, and land treatment and chemical use surveys. **Morin** and **Cherry** describe an iterative approach that they employed to obtain high-quality data in a field investigation of a small-diameter contaminated ground-water plume.

According to **Melville et al.,** tracer injection and observation experiments are the best available field methods for determining advection and dispersion in aquifers. To conduct 11 experiments, they designed, constructed, and operated multilevel observation wells.

Overall, the papers emphasize that regulations related to the prevention of ground-water contamination were formulated before methods fully adequate for meeting regulation requirements had been developed to the point where they could be easily converted into consensus standards. Furthermore, in some cases research and experimentation, along with actual practice, have been inadequate to define some methods, materials, and guidelines, especially as they apply to ground-water contamination. Many of the standards obviously needed for investigations of ground-water contamination, to some people, may be just as obviously needed for even wider use in investigations of ground-water availability and associated problems such as land subsidence, artificial recharge, irrigation, and urban and rural supply. Thus, the editors believe that this volume will be helpful in pointing the way for the fine-tuning needed to modify some existing methods for investigations of ground-water contamination or in pointing to research needed for new methods and materials for such investigations, keeping in mind that many methods also are needed, possibly with some modification, for the frequent investigations of ground-water supply. Such work can and should lead to eventual, and as early as possible, production of consensus standards that can be referenced in federal and state regulations. It is hoped that this volume will stimulate action of individuals and organizations in meeting the above-stated needs. ASTM Committees D-18 and D-19 will welcome assistance from those readers who are willing to assist in development of such standards.

The papers published herein received at least three peer reviews and were reviewed by the editors following revisions of papers by the authors. The editors express appreciation to the reviewers who assisted so much in assuring the quality of papers in this special technical publication. Appreciation also is expressed to the speakers at the symposium, the authors who prepared, revised, and provided final papers for publication, and the ASTM staff and officers of Committees D-18 and D-19 for their assistance and support in organizing and publishing the results of this symposium. Thanks also go to the following people who served as the Symposium Steering Committee for the development of the program: Dennis C. Erinakes, U.S. Soil Conservation Service, Fort Worth, Texas; Jack Keeley, U.S. Environmental Protection Agency, Ada, Oklahoma; Conwell C. McCune, Chevron Oil Field Research Company, La Habra, California; Les G. McMillion, U.S. Environmental Protection Agency, Las Vegas, Nevada; A. G. Ostroff, Ostroff Associates, Dallas, Texas; John B. Robertson, Weston Designers and Constructors, Rockville,

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