WATER RESOURCES ACTIVITIES OF THE USGS

1992

Ethan T. Smith, Compiler

U.S. Geological Survey

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U.S. DEPARTMENT OF THE INTERIOR
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Abstract

The Water Resources Division of the U.S. Geological Survey has the principal responsibility within the Federal Government for providing hydrologic information and appraising the Nation's water resources. The U.S. Geological Survey is unique among government organizations because it has neither regulatory nor developmental authority. Information that is made available to all interested parties is the primary product of the Water Resources Division.

The mission, organization, source of funds, and major programs of the Water Resources Division are discussed in this report. The following types of programs are described: (1) long-term programs that include the Federal-State Cooperative Program, the coordination of Federal water-data acquisition, the other Federal agency program, the national research program, the National Water Information System, the National Water-Use Information Program, the Hydrologic Data-Collection Program, the State Water Resources Research Institutes and National Water Resources Research Grants Programs, the ground-water investigations program, and international water-resources activities; (2) topical programs that include Nuclear-Waste Hydrology, Toxic Substances Hydrology, National Water-Quality Assessment, Regional Aquifer-System Analysis, Acid Rain, Volcano Hazards, the National Water Summary Program, wetlands, flood hazards, urban hydrology, nonpoint sources of pollution, erosion and sedimentation, estuaries, ice and snow, irrigation drainage, Indian water rights, global change hydrology, and lake hydrology; and (3) support programs that include the instrumentation program, the National Water-Quality Laboratory, and the National Training Center. Emphasis is on programs that will contribute to identifying, mitigating, or solving nationwide water-resources problems in the remaining years of the 20th century. Completing the report are discussions of how the hydrologic data and information are disseminated and an index.

INTRODUCTION

Effective management of water resources requires an understanding of hydrologic systems and factors that determine the distribution, availability, and quality of water. Within the Federal Government, the mission of the U.S. Geological Survey (USGS), Water Resources Division (WRD), is to provide hydrologic information and appraise the Nation's water resources. WRD activities are diverse and range from research investigations of specific aspects of the hydrologic cycle to large programs of regional water-resources investigations, such as the National Water-Quality Assessment Program.

In many cases, considerable overlap occurs in the topical descriptions of programs. Through the WRD water-resources research program, for example, investigations are conducted that are applicable to virtually all of the activities listed in this report. Similarly, projects in the Federal-State Cooperative Program cover multiple aspects of water resources. For these reasons, the sums associated with funding for each of the activities listed cannot be added to derive an accurate figure. The total WRD budget exceeds the WRD budget for water-resources activities.

This report describes the water-resources mission of the WRD and discusses the organization and principal sources of funds that support the activities conducted to meet this mission. Descriptions are given of the most significant water-resources activities, with a discussion of how the hydrologic data and information are disseminated.

Each description of a significant water-resources activity has the following parts:

- Introduction—Problem or issue addressed by the activity and a statement of purpose.
- Activities—Examples of ongoing or recently completed investigations.
- Recent accomplishments—Examples of findings or achievements.
- Funding—The size of the program in terms of funding; where possible, the funding of activities is given by source for fiscal years 1988 to 1992.

MISSION OF THE WATER RESOURCES DIVISION

The mission of the USGS, WRD, is to provide the hydrologic information needed by others to help manage the Nation's water resources. To accomplish this mission, the WRD, in cooperation with State and local governments, and other Federal agencies:

- Collects, on a systematic basis, data to determine the quantity, quality, and use of surface water and ground water, and the quality of precipitation.
- Conducts water-resources investigations and assessments at national, State, and local levels; characterizes water-resources conditions; and provides the capability to predict the effect of managerial actions, proposed development plans, and natural phenomena on the resource.
- Conducts basic and problem-oriented hydrologic and water-related research that could produce knowledge useful for the resolution of water-resources problems facing the States, regions, and Nation.
- Acquires information useful in predicting and delineating water-related natural hazards from flooding, volcanoes, mudflows, and land subsidence.
- Coordinates the activities of all Federal agencies in the acquisition of water data and operates water-information centers.
- Disseminates data and the results of investigations through reports, maps, and other forms of public release of information.
- Provides scientific and technical assistance in hydrology to other Federal agencies, to State and local agencies and governments, to licensees of the Federal Energy Regulatory Commission, and, on behalf of the U.S. Department of State, to international agencies.
- Administers the provisions of the Water Resources Research Act of 1984 (as amended), which includes the State Water Resources Research Institutes Program (Section 104) and the National Water Resources Research Grants Program (Section 105).

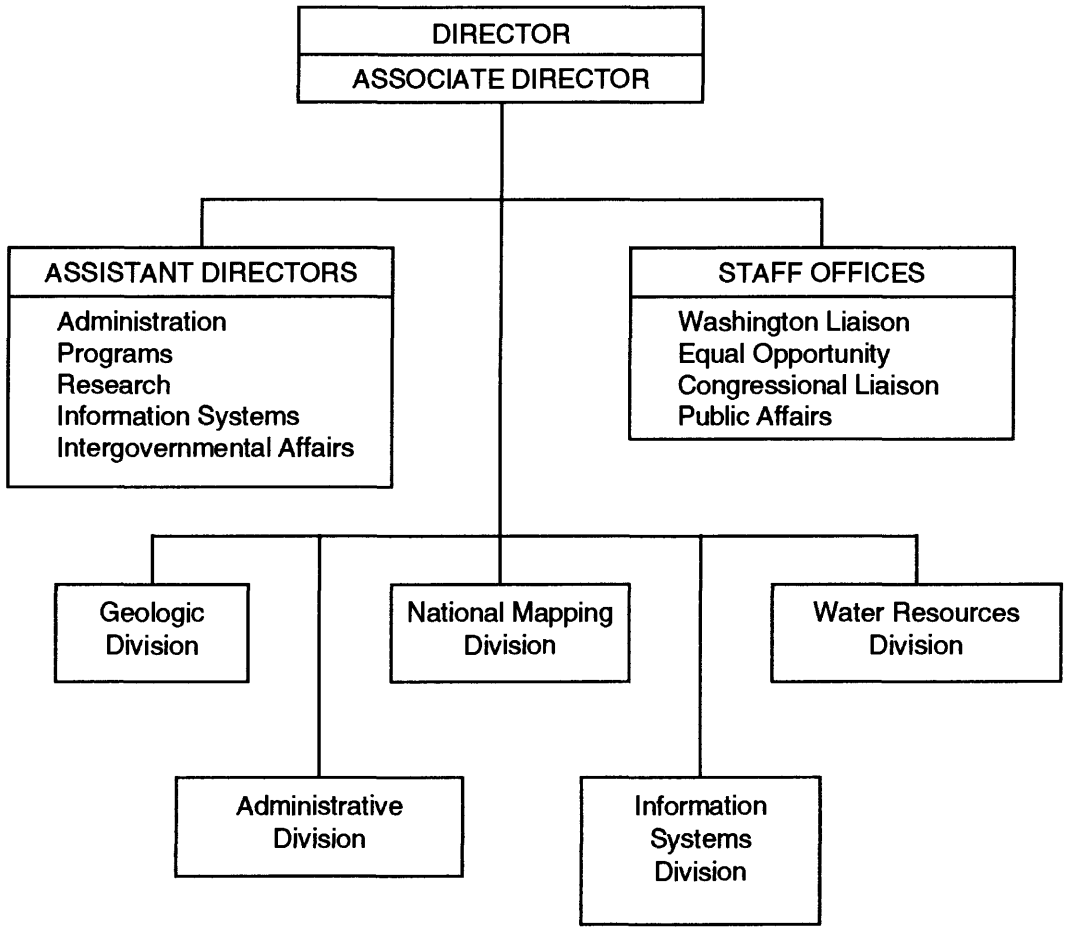
Authority for carrying out the USGS mission derives from legislation of 1879, which established the U.S. Geological Survey, and from legislation of 1888 and 1894, which authorized the survey of irrigable lands in arid regions and provided funds for gaging streams and determining the water supply of the Nation. Congressional appropriations have been made annually since 1894 for gaging streams and performing other functions that relate to water resources. In 1964, the mission was broadened to include the role of lead agency in the coordination of the activities of all Federal agencies in the acquisition of certain water data. This responsibility that was assigned to the U.S. Department of the Interior (DOI) by authorization of the Office of Management and Budget (OMB) was delegated to the USGS, WRD, by the DOI. In 1991, OMB Memorandum M-92-01 replaced earlier authority for water data coordination, and designated the USGS, WRD, as the lead agency for the Water Information Coordination Program. The DOI also designated the USGS as the administering agency for Title I of the Water Resources Research Act of 1984.

ORGANIZATION

U.S. Geological Survey

The USGS consists of three program Divisions and two support Divisions.

Organization of the U.S. Geological Survey



Water Resources Division

The WRD is one of the three USGS program Divisions. WRD headquarters is located at the USGS National Center in Reston, Virginia, and consists of the Office of the Chief Hydrologist and the Associate Chief Hydrologist and the Offices of the Assistant Chief Hydrologists for Operations, Program Coordination and Technical Support, Research and External Coordination, Scientific Information Management, and Water Assessment and Data Coordination.

The Chief Hydrologist, who is assisted by the Associate Chief Hydrologist, has overall responsibility for planning and managing the water-resources programs of the WRD. A Program Officer, who reports directly to the Chief Hydrologist, is responsible for annual budget preparation and program planning.

Management of the programs of the WRD are divided among the five Assistant Chief Hydrologists as follows:

Assistant Chief Hydrologist for Operations—

- Advises on the establishment of policy in budgetary, accounting, personnel, program status, and technical matters;
- Provides administrative and technical services to operational offices in support of their programs;
- Manages the Federal-State Cooperative Program and Technical Support Program budgets; and
- Directs the Federal Data Collection Program and instrumentation development efforts, including satellite data-relay activities.

Assistant Chief Hydrologist for Program Coordination and Technical Support—

- Advises on the planning and development of integrated national programs of hydrologic investigations;
- Provides technical advice and support to the WRD, including direction of quality-assurance efforts for scientific and data-collection activities, and the acquisition of information on the use of water in the Nation;
- Oversees the development of new approaches and methodologies;
- Provides oversight for hydrologic training programs; and
- Provides policy direction and guidance to the Offices of Atmospheric Deposition Analysis, Ground Water, Surface Water, and Water Quality.

Assistant Chief Hydrologist for Research and External Coordination—

- Advises on the planning and development of national research programs, both in-house and those required by the provisions of the Water Resources Research Act of 1984, as amended (Public Law 98-242);
- Directs the international aspects of research and investigative programs; and
- Provides direction and guidance to the Offices of External Research and Hydrologic Research.

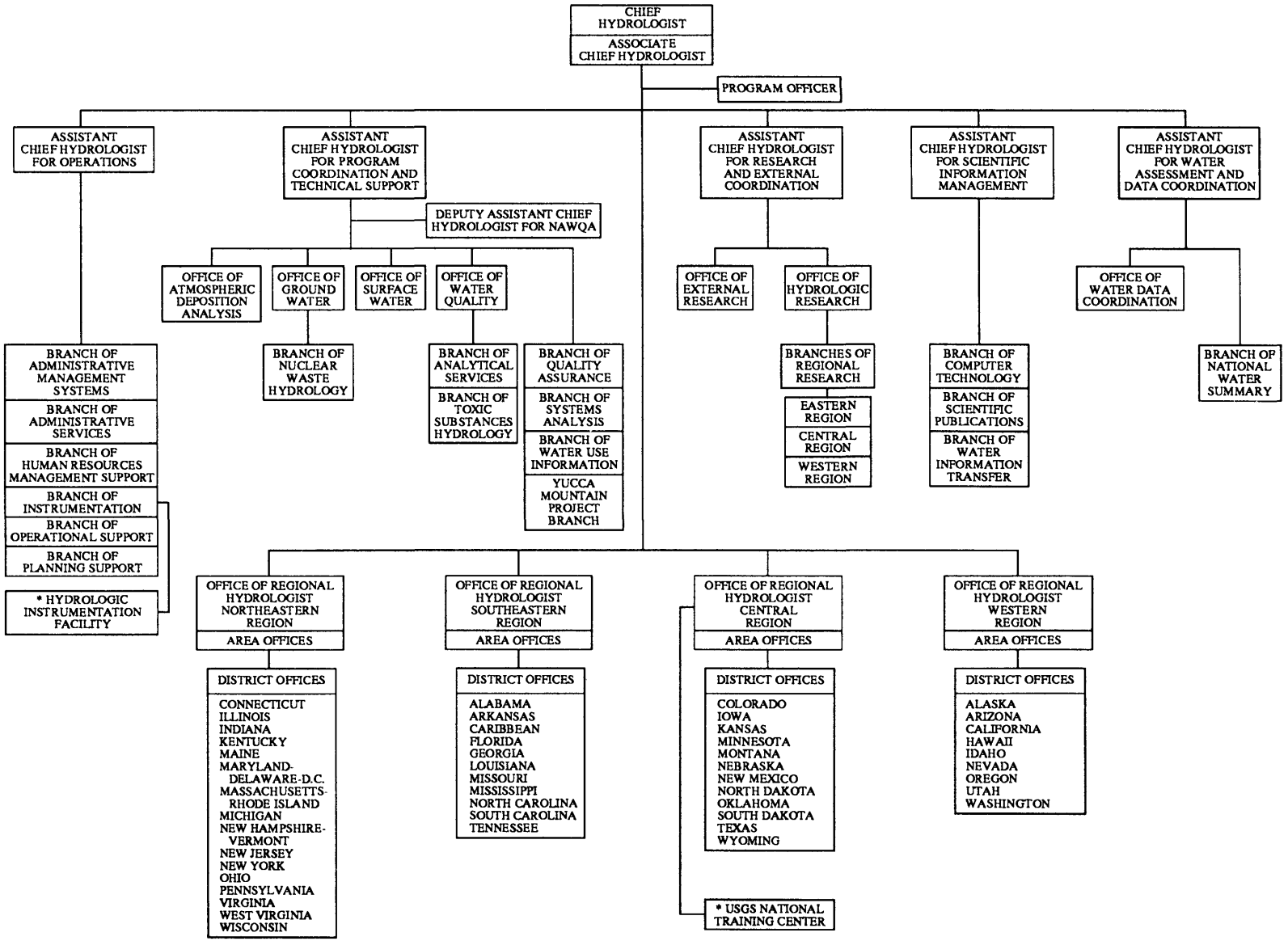
Assistant Chief Hydrologist for Scientific Information Management—

- Advises on the development of policy and programs related to the production and dissemination of scientific and general-interest publications;
- Advises on development of methods and procedures for processing, storing, retrieving, and disseminating water data collected by the WRD field organization in managing the computerized Distributed Information System and the National Water Data Storage and Retrieval System (WATSTORE);
- Directs the management and operation of the National Water Information System (NWIS) that documents the availability of water data and related information from the Federal Government;
- Oversees the programs that assist in information and technology transfer; and
- Provides policy direction and guidance to programs that are related to compliance with the National Environmental Policy Act and Superfund surveys.

Assistant Chief Hydrologist for Water Assessment and Data Coordination—

- Advises on the development and planning of activities to characterize water-resources conditions, trends, and variability at the national level and to provide overviews of specific water issues;
- Advises on policies and programs to promote interagency information-coordination activities as authorized by OMB;
- Facilitates the development of long-range plans and the review of proposed legislation; and
- Provides policy direction and guidance to the Office of Water Data Coordination and the National Water Summary program.

ORGANIZATION OF THE WATER RESOURCES DIVISION



* National facility administered by the office shown

December 1992

Field Offices

Region

The WRD field program is conducted through four Regional Hydrologists, each of whom is located at a regional center—Reston, Virginia (Northeastern Region); Norcross (Atlanta), Georgia (Southeastern Region); Lakewood (Denver), Colorado (Central Region); and Menlo Park, California (Western Region). Each region consists of several States. Each Regional Hydrologist, with authority from the Chief Hydrologist, is responsible for the water-resources programs and projects conducted by the District Offices within that region. The Regional Hydrologist represents the Chief Hydrologist in negotiations and dealings with other organizations and committees on matters of concern to the WRD.

Area

Area Hydrologists report to each Regional Hydrologist, and have delegated authority over groups of States within each Region. There are 15 area Hydrologists nationwide.

District

Field operations are conducted by 48 District Offices, each headed by a District Chief. These offices generally are located in State capitals, and their jurisdictional boundaries correspond to State boundaries. Each District typically has one or more subdistrict and field offices that report to the District Chief. Three multi-State Districts have offices that coordinate programs within each State and report to the District Office. Each District Chief is responsible for the planning, programming, and implementation of water-resources investigations within the District.

Research

Projects within the National Research Program (NRP) involve the study of physical, chemical, and biological processes that affect the movement of water and its constituents through the hydrologic system. NRP projects are located at centers in Reston, Virginia; Lakewood, Colorado; and Menlo Park, California; and at a few project offices in other sections of the country. A Chief, Branch of Regional Research in these locations, operating under the Office of Hydrologic Research, administers the NRP projects within their regions.

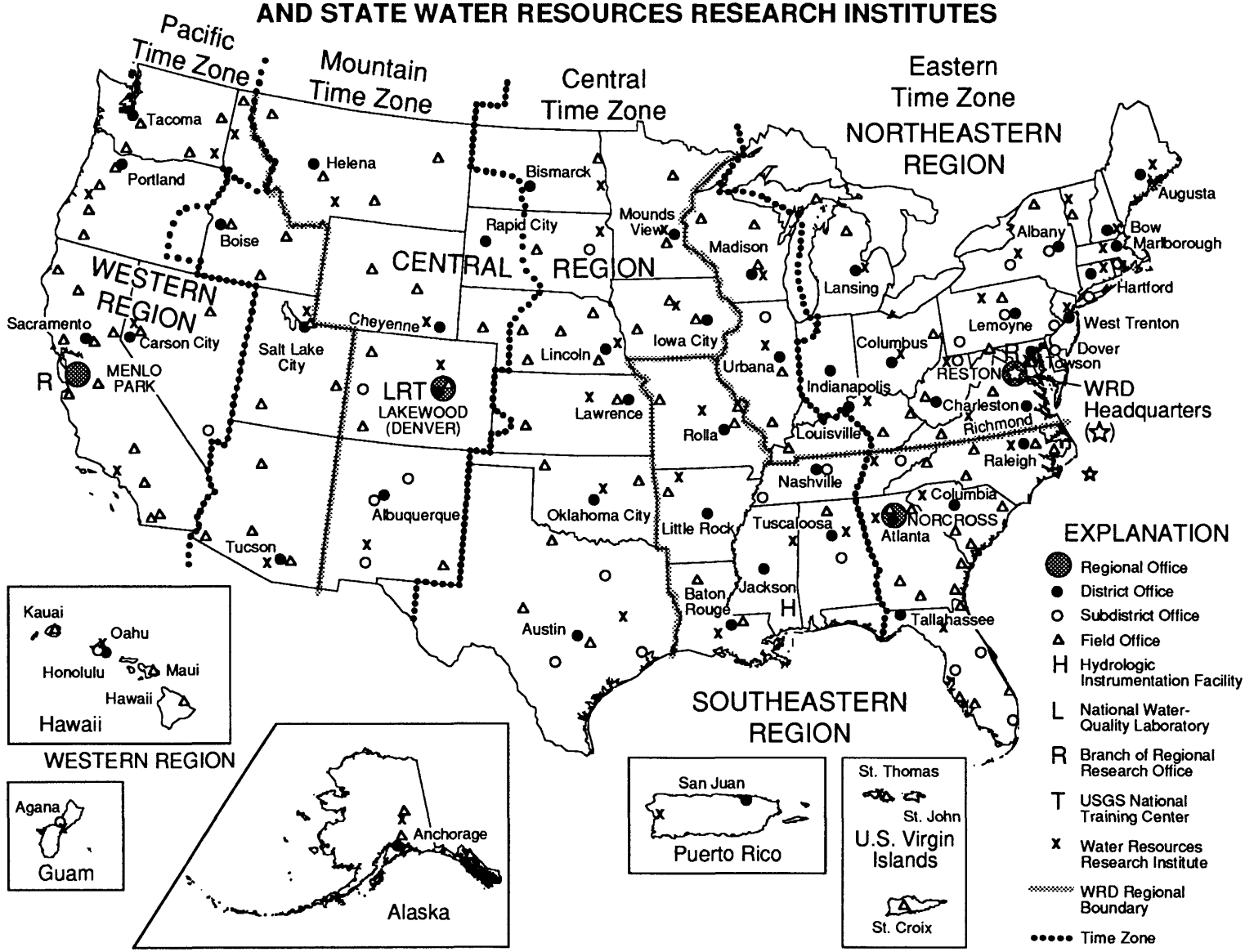
Support Functions

Support functions, such as data processing, processing of publications, instrumentation, and employee training programs, are provided at the USGS Headquarters (Reston, Virginia) and the regional centers. Analytical services for water-quality determinations are provided by a National Water-Quality Laboratory System that consists of a large, highly automated laboratory in Arvada (Denver area), Colorado, and by cooperator and contract laboratories at various locations, all working through the Branch of Analytical Services at Arvada.

The Branch of Instrumentation at Headquarters is responsible for all aspects of the application, testing, and use of equipment in support of WRD programs. The Satellite Data Relay Project is located at USGS Headquarters. All other instrumentation services (procurement, testing, supply, and maintenance) are provided by the Hydrologic Instrumentation Facility located at the John C. Stennis Space Center, Mississippi.

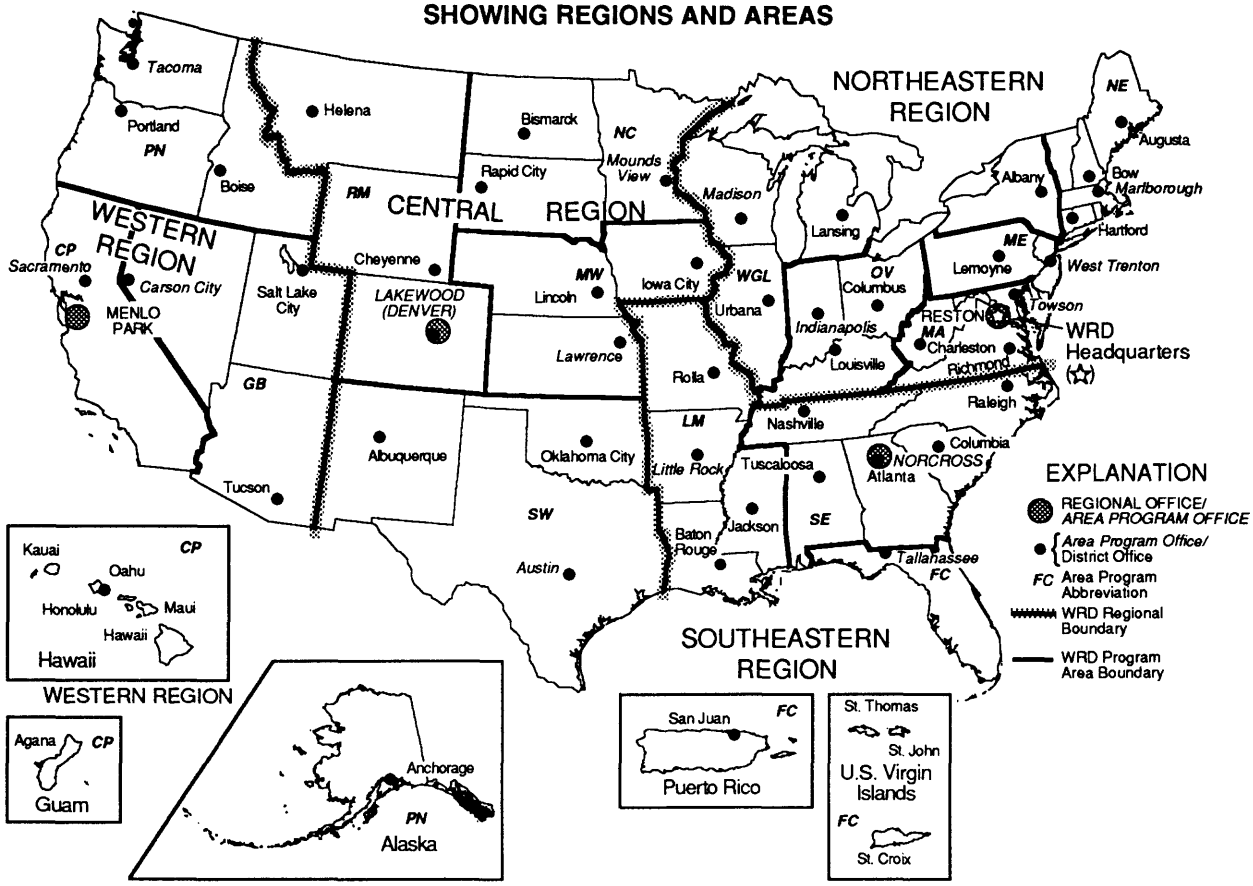
A training program in all aspects of WRD activities is carried out at the USGS National Training Center in Lakewood, Colorado. This center, administered by the WRD, also serves the needs of the other USGS Divisions.

U.S. GEOLOGICAL SURVEY WATER RESOURCES DIVISION OFFICES AND STATE WATER RESOURCES RESEARCH INSTITUTES



December 1992

U.S. GEOLOGICAL SURVEY WATER RESOURCES DIVISION OFFICES SHOWING REGIONS AND AREAS



CHIEF HYDROLOGIST

ASSOCIATE CHIEF HYDROLOGIST

REGIONAL HYDROLOGIST NORTHEASTERN REGION

AREA HYDROLOGISTS

District Chiefs

MID-ATLANTIC (MA) PROGRAM
- Maryland-Delaware-D.C.
- Virginia
- West Virginia

MID-EAST (ME) PROGRAM
- New Jersey
- Pennsylvania

NEW ENGLAND (NE) PROGRAM
- Massachusetts-Rhode Island
- Connecticut
- Maine
- New Hampshire-Vermont
- New York

OHIO VALLEY (OV) PROGRAM
- Indiana
- Kentucky
- Ohio

WESTERN GREAT LAKES (WGL) PROGRAM
- Wisconsin
- Illinois
- Michigan

REGIONAL HYDROLOGIST SOUTHEASTERN REGION

AREA HYDROLOGISTS

District Chiefs

FLORIDA-CARIBBEAN (FC) PROGRAM
- Florida
- Caribbean

LOWER MISSISSIPPI (LM) PROGRAM
- Arkansas
- Louisiana
- Missouri
- Mississippi

SOUTHEAST (SE) PROGRAM
- Georgia
- Alabama
- North Carolina
- South Carolina
- Tennessee

REGIONAL HYDROLOGIST CENTRAL REGION

AREA HYDROLOGISTS

District Chiefs

MIDWEST (MW) PROGRAM
- Kansas
- Iowa
- Nebraska

NORTH CENTRAL (NC) PROGRAM
- Minnesota
- North Dakota
- South Dakota

ROCKY MOUNTAIN (RM) PROGRAM
- Colorado
- Montana
- Wyoming

SOUTHWEST (SW) PROGRAM
- Texas
- New Mexico
- Oklahoma

REGIONAL HYDROLOGIST WESTERN REGION

AREA HYDROLOGISTS

District Chiefs

CALIFORNIA-PACIFIC (CP) PROGRAM
- California
- Hawaii

GREAT BASIN (GB) PROGRAM
- Nevada
- Arizona
- Utah

PACIFIC NORTHWEST (PN) PROGRAM
- Washington
- Alaska
- Idaho
- Oregon

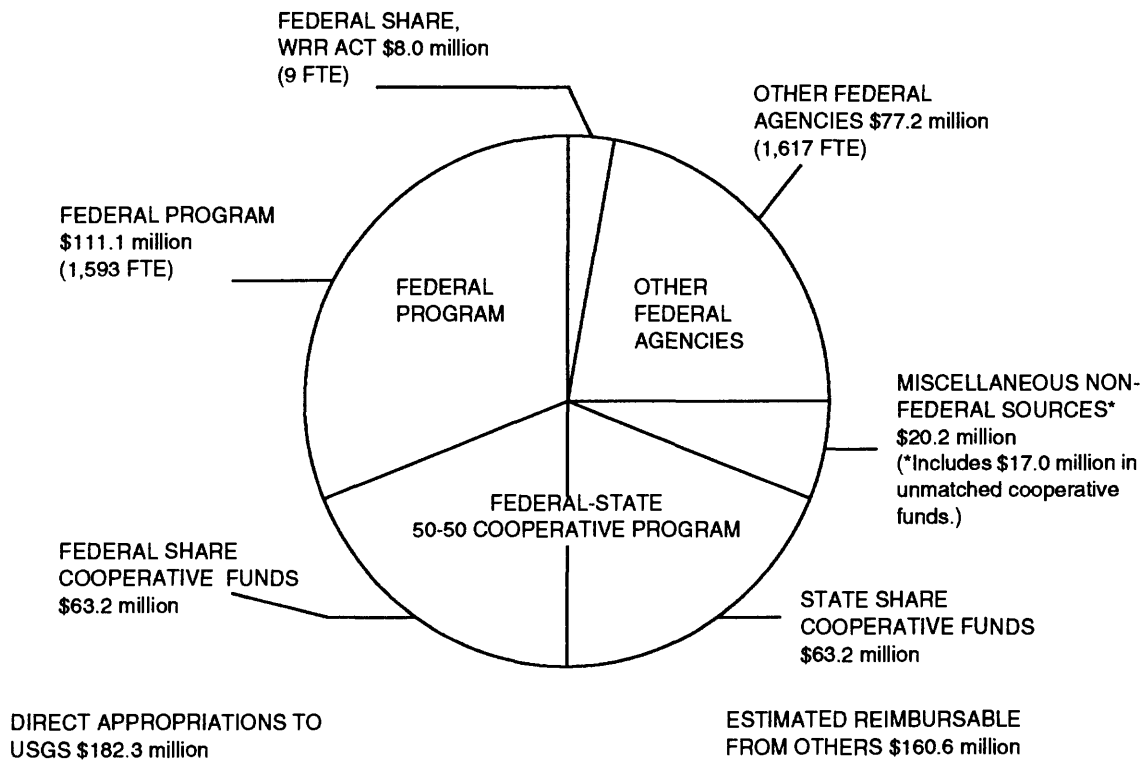
BUDGET AND SOURCES OF FUNDS

The total WRD budget for fiscal year 1992 was $342.9 million with funding coming from four principal sources:

- Federal Program—Funds are appropriated by the Congress and are specifically identified in the annual USGS budget. These funds are used to support research; data collection; high priority topical programs, including water-quality programs; the coordination of all Federal programs related to collection of water data; and internal support services.
- State Water Resources Research Institutes and National Water Resources Research Grants Programs—Funds are appropriated to the USGS to carry out extramural research activities, by employing grant mechanisms and to administer these programs as authorized by the Water Resources Research (WRR) Act of 1984.
- Federal-State Cooperative Program—Federal funds are appropriated by the Congress and are used to match funds furnished by State and other tax-supported agencies on a 50-50 basis. These funds are used for a variety of hydrologic data-collection activities and water-resources investigations in which the WRD represents the national responsibilities and the cooperating agencies represent State and local interests.
- Reimbursable Other Federal Agency Program—Funds are transferred to the USGS as reimbursement for work performed at the request of another Federal agency.

Another source of the WRD funding is unmatched, reimbursable funds from State and local government agencies, Federal Energy Regulatory Commission licensees, and other non-Federal sources. In the following diagram, FTE stands for full-time equivalent positions.

FISCAL YEAR 1992 FUNDING FOR USGS WATER PROGRAMS



FY 1992 TOTAL—$342.9 MILLION

PROGRAMS

Program development in the WRD is an evolving activity. Existing programs are reviewed regularly, and future National needs for water data and hydrologic investigations are projected. Water-related problems and data needs frequently are brought to the attention of the WRD by State and local agencies, Other Federal Agencies (OFA), and the public; thus, program development also is a grassroots effort. As data needs and water-related problems change, the programs are modified accordingly.

The programs of the WRD are of three major types—(1) data collection and dissemination, (2) problem-oriented water-resources investigations, and (3) research. Budgetary documents classify each WRD activity according to the source of funds: direct congressional appropriations (Federal Program); joint or shared funds (Federal-State Cooperative Program); and reimbursable funds from OFA.

Although this classification is helpful for budgetary and general discussion purposes, many of the programs are so interrelated that to explain each exclusively by sources of funds or type of activity would be difficult. For example, theories arising from research are the foundation of data collection and problem-oriented water-resources investigations; data collection is a major component of all water-resources investigations and most of the research studies.

In this report, WRD activities are discussed under three headings—"long-term programs," "topical programs," and "support functions." In reading the program descriptions, the reader should keep in mind that most WRD programs cross scientific and budgetary boundaries.

Long-term programs include:

- The Federal-State Cooperative Program,
- Coordination of Federal water-data acquisition,
- The OFA Program,
- The National Research Program,
- The National Water Information System,
- The National Water-Use Information Program,
- The Hydrologic Data-Collection Program including the National Stream-Quality Accounting Network and the National Hydrologic Bench-Mark Program,
- The State Water Resources Research Institutes and National Water Resources Research Grants Programs,
- Ground-water investigations, and
- International water-resources activities.

These programs provide the data and research needed for the topical programs.

Topical programs include:

- Nuclear-waste hydrology (high- and low-level radioactive wastes),
- Toxic substances hydrology,
- National water-quality assessment,
- Regional aquifer-system analysis,
- Acid rain,
- Volcano hazards,
- The National Water Summary Program,
- Wetlands,
- Flood hazards,
- Urban hydrology,
- Nonpoint sources of pollution,
- Erosion and sedimentation,
- Estuaries,
- Ice and snow,
- Irrigation drainage,

- Indian water rights,
- Global change hydrology, and
- Lake hydrology.

Topical programs are designed to provide critically needed information on issues of major and immediate concern to the Nation.

Support functions include:

- The instrumentation program,
- The National Water-Quality Laboratory, and
- The National Training Center.

These functions, which are mostly internal to the WRD (in contrast to the other programs discussed in this report that deal with other agencies and the public), contribute significantly to the success of the mission of the WRD.

Long-Term Programs

Federal-State Cooperative Program

The Federal-State Cooperative Program is a unique partnership for conducting water-resources investigations. The first cooperative program began in 1895 in Kansas. The Federal appropriations bill for fiscal year 1929 established the 50-50 cost-sharing principle that continues today.

State and local agencies contribute at least half the cost of WRD data collection and investigations of regional and local water-related problems and conditions. From these and other investigations, the WRD acquires much of the hydrologic information needed for planning, developing, and managing the Nation's water resources. More than 1,000 State and local agencies work together with the WRD in selecting investigations to produce a balanced program that recognizes the needs, priorities, and resources of all parties. Among the wide range of cooperating entities are State, county, and municipal governments; water-supply districts; drainage districts; flood-control districts; and interstate compact organizations. The Federal-State Cooperative Program comprises more than 40 percent of the water-resources activities of the WRD.

Activities

- Collects hydrologic data in every State, the District of Columbia, Guam, Puerto Rico, and several U.S. Territories to provide information essential to water-resources investigations, research, planning, development, and management. About two-thirds of the total number of data-collection sites operated by the WRD are supported by the Federal-State Cooperative Program.
- Conducts interpretive water-resources investigations at the request of cooperators.
- Conducts investigations of current water issues, such as ground-water contamination, effects of agricultural activities on water resources, droughts and floods, waste disposal, mineral and energy development, urban hydrology, river quality, and acid precipitation.

Recent Accomplishments

- Provided the background data and scientific research that serves as an early-warning system for the detection of emerging water problems.
- Demonstrated that sediment oxygen demand and oxidation of ammonia may be major factors in dissolved oxygen depletion in some Illinois streams.
- Collected information in the Iowa River basin, Iowa, on the distribution of selected pesticides in the soil and the movement of pesticides from the land surface to shallow ground water.
- Developed a three-dimensional flow model to simulate possible changes of ground-water levels in Salt Lake Valley, Utah, as the result of various scenarios of increased pumpage.
- Developed a geographic information system to store, manipulate, and analyze geohydrologic data for the Sacramento Valley area, California.

- Stimulated interest in legislation to protect aquifers that are the sole source of public water supplies through an investigation of the Edwards Limestone aquifer in Texas.
- Evaluated water quality in numerous streams and aquifers and assessed existing and potential effects of contamination from toxic wastes.
- Collected data (as part of the Cooperative Program in 1991) at about 9,000 stream, lake, and reservoir sites and about 29,000 wells and springs, and conducted about 550 interpretive and research investigations to help define, characterize, and evaluate the areal extent, quality, and availability of the Nation's surface- and ground-water resources.

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Funding

Source of funds	Fiscal year (dollars in millions)				
	1988	1989	1990	1991	1992
Federal-State Cooperative Program[1]	125.5	126.0	125.4	148.2	147.6

[1]Funds shown represent Federal and State shares.

Keywords

Cooperative activities, States, Cost-sharing, Special water districts

Water Information Coordination Program (WICP)

The U.S. Department of the Interior (DOI), through the U.S. Geological Survey (USGS) Water Resources Division (WRD), is responsible for the Water-Information Coordination Program (WICP) of the Federal Government. Originally, this responsibility was delegated to the DOI in Office of Management and Budget (OMB) Circular A-67, "Coordination of Federal activities in the acquisition of certain water data." In December 1991, the circular was updated and replaced by OMB Memorandum No. 92-01 (M-92-01). In 1964, when the original authorization was signed, the DOI established the Office of Water Data Coordination (OWDC), in the WRD, to implement the program. At the same time, the Secretary created two advisory committees: (1) the Interagency Advisory Committee on Water Data (IACWD), which is composed of 30 major Federal organizations, and (2) the Advisory Committee on Water Data for Public Use (ACWDPU), which is composed of major private section organizations representing States, Indian tribes, technical societies, universities, public interest groups, and industry. More than 200 individuals participate on more than 2 dozen committees, subcommittees, and working groups to meet the requirements of M-92-01. In 1992, the secretary established a subcabinet-level steering committee to oversee and guide the implementation of the WICP.

The WRD responsibilities for the WICP include national, regional, and State level activities. Primary responsibilities of the OWDC include providing management, administrative, and technical support to carry out the WICP at the national level. The OWDC provides support for water-data standards development. These and other responsibilities extend throughout the Federal Government and the non-Federal sector. Regional and district offices of the WRD are responsible for water-data coordination activities within their geographic areas. These offices have primary responsibility for operating the national water-information networks.

Activities

The WICP conducts activities to meet objectives defined by OMB, as follows:

- Evaluates the effectiveness of existing water-information programs and recommend improvements.
- Plans, designs, and operates a cost-effective national network for water-data collection and analysis.
- Coordinates funding, staffing, and the provision of other resources needed to support interagency water-information activities.
- Develops uniform standards, guidelines, and procedures for the collection, analysis, management, and dissemination of water-information.
- Establishes a National Water Information Clearinghouse to index and disseminate information.
- Coordinates new or expanding water-information program initiatives of Federal agencies.

Recent Accomplishments

- Established the Intergovernmental Task Force on Monitoring Water Quality to review water-quality monitoring nationwide and recommend improvements. It will continue through calendar year 1994.
- Prepared and distributed the Hydrologic Unit Map for the United States and Hydrologic Unit Maps for each State.
- Coordinated the relocation of the Federal Interagency Sedimentation Project to the U.S. Army Corps of Engineers' Waterways Experiment Station in Vicksburg, Mississippi.
- Sponsored and organized numerous conferences, symposia, and workshops on a variety of topics in cooperation with the IACWD and other major national organizations.
- Aided implementation of the National Water-Use Information Program, the National Stream-Quality Accounting Network, the National Water-Data Exchange, and the National Water Quality Assessment Program.
- Sponsored the Fifth Interagency Sedimentation Conference at which over 200 technical papers were presented. Over 400 individuals from the United States and 6 foreign countries participated in the conference.
- Accelerated the development of standards for ground-water monitoring and investigations in cooperation with the U.S. Environmental Protection Agency, the Department of the Navy, and the American Society of Testing and Materials.

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_____1989d, Proceedings of the Bridge Scour Symposium, McLean, Va., October 17-19, 1989: Subcommittee on Sedimentation, Interagency Advisory Committee on Water Data, 380 p.

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_____1989f, Partnerships for water-information coordination: Summary of the twenty-second meeting, Orlando, Fla., May 23-25, 1989, Advisory Committee on Water Data for Public Use, 25 p.

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_____1990b, Notes on sedimentation activities, calendar year 1989: Subcommittee on Sedimentation, Interagency Advisory Committee on Water Data, 194 p.

_____1990c, Water-resources information for confronting natural hazards: Summary of the twenty-third meeting, Portland, Ore., May 30-June 1, 1990, Advisory Committee on Water Data for Public Use, 30 p.

_____1991a, Federal Interagency Sedimentation Conference, 5th, Las Vegas, Nevada, March 18-21, 1991, Proceedings: Subcommittee on Sedimentation, Interagency Advisory Committee on Water Data, v. 1, 641 p.; v. 2, 634 p.

_____1991b, Notes on sedimentation activities, calendar year 1990: Subcommittee on Sedimentation, Interagency Advisory Committee on Water Data, 153 p.

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_____1989, History of the Federal interagency sedimentation project: International Symposium on Sediment Transport Modeling, August 14-18, 1989, Proceedings: American Society of Civil Engineers Hydraulics Division, 6 p.

Skinner, J.V., and Szalona, J.J., 1991, Gages for measuring fluvial-sediment concentration, *in* Federal Interagency Sedimentation Conference, 5th, Las Vegas, Nev., March 18-21, 1991, Proceedings: Subcommittee on Sedimentation, Interagency Advisory Committee on Water Data, v. 1, p. 2-1 to 2-8.

Funding

	Fiscal year (dollars in millions)				
Source of funds	1988	1989	1990	1991	1992
Federal Program	1.0	1.0	1.0	1.1	1.0

Keywords

Coordination, Organizations, Local governments, Interagency coordination, Data collection, Data coordination, Information transfer, Information retrieval, Hydrologic unit codes, Water-resources information, Water use, Indexing.

Other Federal Agency Program

The WRD frequently is requested to assist other Federal agencies by supplying hydrologic information or expertise pertinent to specific needs of those agencies. The agency requesting the work reimburses the WRD for services provided. In fiscal year 1992, about 50 agencies requested assistance as part of the WRD Other Federal Agency (OFA) Program.

Activities

The WRD provides hydrologic assistance to other Federal agencies in the following ways:

- U.S. Department of the Interior—For most of the Bureaus, collects hydrologic data, conducts various types of investigations of the availability and characteristics of ground water and surface water, and evaluates the current and potential effects of water-resources development and hazardous materials on water quality.
- U.S. Department of Agriculture—Investigates hydrology of small watersheds by studying sediment deposits, stream discharge, and quality of water.
- U.S. Department of Defense—For the U.S. Army Corps of Engineers, collects hydrologic data and investigates tidal flows in estuaries, subsidence, streamflow, ground water, sedimentation, and water quality; for military bases, conducts studies related to toxic waste, ground-water contamination, and water supply.
- U.S. Department of Energy—Studies hydrologic conditions and effects on the hydrologic environment of underground nuclear-explosion test sites and of existing and potential nuclear-waste storage sites, conducts research on the interaction between radioactive materials and various geohydrologic environments, and characterizes the hydrology and geology of the Nation's proposed high-level radioactive-waste repository at Yucca Mountain, Nevada.
- U.S. Environmental Protection Agency (USEPA)—Conducts environmentally related research and studies related to municipal waste-disposal sites, relation to ground-water hydrology; collects water-quality information; and provides hydrologic assistance for toxic-waste cleanup actions.

Recent Accomplishments

- Implemented Memorandums of Understanding (MOU) with the USEPA regarding related programs of the WRD, including coordination of information on hydrologic plans and technology transfer of data and information. Collaborated with the USEPA in developing the national ground-water-protection strategy.
- Participated in Superfund activities with the USEPA, U.S. Army Corps of Engineers, States, and some local agencies concerning cleanup of hazardous-waste-disposal sites.
- Provided the U.S. Army Corps of Engineers with technical evaluations of the effects of public works, such as the Cross Florida Barge Canal, on aquifer hydrology and water quality.
- Conducted hydrologic investigations in cooperation with the U.S. Department of Agriculture and USEPA to evaluate the effects of agricultural chemicals on ground water.
- Conducted studies of sediment, water quality, and hydraulics of the Colorado River in the Grand Canyon for the U.S. Bureau of Reclamation to help determine the consequences of river management at Glen Canyon Dam on the hydrology, channel form, and ecology of the Colorado River within the Grand Canyon.
- Conducted studies related to environmental contamination at more than 50 military installations. Studies are designed to aid in cleaning up of hazardous wastes on military installations as well as to address other aspects of environmental contamination.
- Conducted experiments on enhanced bioremediation of organic contaminants.

Funding

	Fiscal year (dollars in millions)				
Source of funds	1988	1989	1990	1991	1992
Other Federal agencies	63.1	74.4	72.1	90.9	97.4

Keywords

Federal agencies, Technical assistance, Ground water, Hazardous waste, Aquifer hydrology, Agricultural chemicals, Yucca Mountain, Nevada.

National Research Program

Hydrologic research increases knowledge and develops methodologies that are used to solve or mitigate critical water-related problems. The purpose of the National Research Program (NRP) is to improve the capability of WRD scientists to predict stress-induced changes in hydrologic systems and to understand more fully the movement of water, sediment, and chemical constituents through such systems. The NRP is one component of USGS-sponsored water-research activities. Other research is conducted in the District Offices and the State Water Resources Research Institutes and National Water Resources Research Grants Programs.

Activities

- Conducts research involving about 180 researchers working on an average of 110 projects in a year. The general areas of research are surface-water hydrology, ground-water hydrology, surface-water chemistry, ground-water chemistry, sediment transport and geomorphology, and ecology.
- The topics of 1992 research include hydrology of lakes and estuaries, sediment transport in streams, effects of acid precipitation on watershed chemistry, glacier and sea-ice dynamics, and movement of hazardous substances in surface and ground water.

Recent Accomplishments

Published more than 200 reports and abstracts covering a broad scientific spectrum in fiscal year 1992. Examples of recent research accomplishments include:

- Developed new methodology for field sampling and preserving ground water containing parts per trillion concentrations of chlorofluorocarbons (CFC's) and demonstrated the usefulness of using CFC's (freon) to identify waters that have been recharged in the last few decades and accurately determine the time when the recharge occurred. The concept of using dissolved freon in ground-water dating has been known; however, the method was developed so that it can be applied to real problems. The approach has many scientific and practical aspects including the identification of young ground water, which has implications regarding the potential for contamination (Basenberg and Plummer, 1992).
- Demonstrated through tracer-studies of intragranular porosity in sand-size material from an aquifer on Cape Cod, Massachusetts, that more reaction sites and greater porosity were present than were indicated by short-term laboratory tests and measurement techniques (Wood and others, 1989).
- Demonstrated that photoreduction of ferric iron results in a well-defined increase in dissolved ferrous iron during the day in a small mountain stream in Colorado that receives acidic mine drainage (McKnight and others, 1988).
- Determined a continuous record of oxygen-18 variations in the continental hydrosphere during the middle-to-late Pleistocene from a uranium-series-dated calcite vein in the southern Great Basin and showed that discrepancies and other differences in the timing of key climatic events between this record and the indirectly dated marine oxygen-18 chronology might mean that orbital forcing was not the principal cause of the Pleistocene ice ages (Winograd and others, 1988).
- Demonstrated the first example of an organism of any type that can oxidize an aromatic hydrocarbon anaerobically (Lovley and others, 1989).

Recent Reports:

Basenberg, E., and Plummer, L.N., 1992, Use of chlorofluorocarbons (CCl_3F and CCl_2F_2) as hydrologic tracers and age-dating tools: The alluvium and terrace system of central Oklahoma: Water Resources Research, v. 28, p. 2257-3283.

Lovley, D.R., Baedecker, M.J., Lonergan, D.J., Cozzarelli, I.M., Phillips, E.J.P., and Siegel, D.I., 1989, Oxidation of aromatic contaminants coupled to microbial iron reduction: Nature, v. 339, p. 297-300.

McKnight, D.M, Kimball, B.A., and Bencala, K.E., 1988, Iron photoreduction and oxidation in an acidic mountain stream: Science, v. 240, p. 637-640.

Winograd, I.J., Szabo, B.J., Coplen, T.B., and Riggs, A.C., 1988, A 250,000-year climatic record from Great Basin vein calcite—Implications for Milankovitch Theory: Science, v. 242, p. 1275-1280.

Wood, W.W., Kraemer, T.F., and Hearn, P., 1989, Intragranular diffusion—An important mechanism influencing solute transport in clastic aquifers: Science, v. 247, p. 1569-1572.

Funding

Source of funds	Fiscal year (dollars in millions)				
	1988	1989	1990	1991	1992
Federal Program	23.3	24.4	25.4	29.9	30.4
Other Federal Agencies	1.4	0.7	0.4	1.4	1.4
Total	24.7	25.1	25.8	31.3	31.8

Keywords

National Research Program, Surface water, Ground water, Chemistry, Geomorphology, Ecology, Lakes, Estuaries, Acid precipitation, Glaciers, Sea ice, Hazardous substances.

National Water Information System

The processing, storage, and retrieval of hydrologic data collected by the WRD is evolving from a system on a mainframe computer to a decentralized system composed of a network of microcomputers at many locations throughout the country. The National Water Data Storage and Retrieval System (WATSTORE) was established in 1971 as a single processing system for hydrologic data collected at thousands of sites in each State. This system is operated today as a national archive of hydrologic data; WATSTORE is supplemented by the National Water Information System I (NWIS I). NWIS I is a processing, storage, and retrieval system based on a network of 57 minicomputers located in the Districts and at other key sites. Data are processed and stored on each minicomputer and the data are uploaded periodically to WATSTORE.

The hydrologic data-management system currently (1991) is being re-evaluated to meet the needs of WRD in the 1990's. The new system, National Water Information System II (NWIS II), is designed as a decentralized system based on a network of microcomputers with UNIX operating systems. NWIS II will combine the data bases of WATSTORE and NWIS I into a single distributed-information processing and management system. The requirements of the new system were defined by eight user groups that represent a broad cross section of all current and potential users of the system.

Activities

- Maintains a nationwide network of minicomputers for processing and managing hydrologic information collected at hydrologic stations throughout the Nation.
- Maintains computer files on surface-water levels and flows, ground-water levels, water-quality characteristics, and water-use information.
- Provides water data to scientists, engineers, planners, and managers at all levels of government and in the private sector.

Recent Accomplishments

- Prepared a solicitation for bids to upgrade the WRD distributed information system from a network of 57 minicomputers to 2,000-4,000 UNIX-based microcomputers.
- Defined the functional requirements of the new NWIS II.
- Maintained hydrologic data bases containing more than 250 million values of streamflow, ground-water levels, chemical analyses of surface water and ground water, water use, and other hydrologic information.
- Continued to transfer data monthly to the Storage and Retrieval System (STORET) of the USEPA.
- Completed the requirements analysis of a new hydrologic data base management system and the design of the integrated data base that will allow entry and access to all types of hydrologic data in a single system.

Recent Reports:

Mathey, S.B., ed., 1991, System requirements specification for the U.S. Geological Survey's National Water Information System II: U.S. Geological Survey Open-File Report 91-525, 622 p.

Yorke, T.H., and Williams, O.O., 1991, Design of a National Water Information System by the U.S. Geological Survey, *in* International Conference on Interactive Information and Processing Systems for Meteorology, Hydrology, and Oceanography, 7th, New Orleans, Louisiana, January 14-18, 1991, Proceedings: American Meteorological Society, p. 284-288.

Funding

	Fiscal year (dollars in millions)				
Source of funds	1988	1989	1990	1991	1992
Federal Program	2.9	2.6	1.8	3.1	3.3

Keywords

Information retrieval, Computer systems, Data systems, WATSTORE, NWIS, Water-resources information, Distributed information system.

National Water-Use Information Program

The quantity and quality of water used in the Nation is of importance to a broad range of public and private interests including water policymakers, planners, managers, and water users. The WRD has compiled estimates of water use every 5 years since 1950. These estimates, derived from many sources, were based on different methods of collection and had a wide range of accuracy. In 1978, upon recommendation of the ACWDPU, the WRD established the National Water-Use Information Program to develop a comprehensive estimate of water use, complementing the data on the availability and quality of the Nation's water resources.

The program is part of the WRD Federal-State Cooperative Program and is designed to determine how much water is withdrawn for use, how much water is consumptively used, the purpose for which the water is used, and how much water is returned to the environment.

Activities

- Serves as the focal point for collecting and compiling water-use information at local, State, and Federal levels.
- Maintains and enhances a computerized data-storage and retrieval system at State and national levels.
- Devises new methods and techniques to improve and standardize the collection and analysis of water-use information.
- Prepares reports on trends in the use of water.
- Incorporates water-use data in water-resource assessments, investigations, and research.
- Conducts cooperative water-use investigations, such as the following:

—Connecticut Department of Environmental Protection (DEP) has been an active cooperator in the National Water-Use Information Program since it began in 1978.

The Connecticut DEP is concerned with assessing demands placed on all surface- and ground-water resources in Connecticut. Due to an early and heavy reliance upon automated data systems to manage and analyze water-use data, the Connecticut Water-Use Program supports projects that promote efficient and cost-effective means to evaluate past, present, and future needs for water. Major cooperative activities over the past few years include the following:

(1) Water Supply Shared Data Base—A computerized data base that was conceived and developed by the Connecticut DEP to be used by State agencies to maintain and share water-use information. The system is integrated with the Connecticut Geographic Information System (GIS) and contains site-specific data. Standard methodologies are used to aggregate the data to meet national needs.

(2) Geographic Information System Data Base—The Connecticut Water-Use Program is responsible for developing and maintaining the following digitized coverages at a scale of 1:24,000 on the Connecticut DEP GIS:

- Public supply wells, reservoirs, and watersheds.
- Public supply existing service areas.
- Public supply exclusive (future) service areas.
- Wastewater-treatment plants and sewer areas.
- Water diversions regulated by Connecticut DEP.

As a result of this active program, many water-use publications, maps, brochures, and posters have been produced to better inform water planners, managers, and the general public on the use of water in Connecticut.

—The Eastern Arkansas Comprehensive Study (EARCS) involves digital simulation of the Mississippi River Valley alluvial aquifer in a 26-county area. Conventional flow models provide data on boundary conditions, aquifer properties, recharge, and so forth that are used in constructing optimization, conjunctive use, and sustained yield models. Computer programs are used for optimization modeling. Using water-use projections through the year 2030, with the constraint of maintaining at least 20 feet of saturated aquifer thickness, these models optimize the amount of ground water and surface water that can be withdrawn to help meet the total water demand. The EARCS is an example of a progressive multiagency cooperative study in the area of applied hydrology and water management. Several cooperating State and Federal agencies are contributing data and expertise to the effort.

Recent Accomplishments

- Established water-use programs in 48 States and Puerto Rico.
- Developed the computerized Aggregate Water-Use Data System at the Federal level. Water-use estimates for 1985 for 12 categories of use have been compiled for each State by county and hydrologic subregion.
- Developed the computerized State Water-Use Data System for States to store and retrieve site-specific water-use information.
- Held a national water-use workshop to acquaint State and Federal personnel with the scope and objectives of the 1990 national water-use compilation.
- Held national training courses to acquaint State and Federal personnel with water-use concepts and procedures for entering data and maintaining the national and State water-use data systems.
- Prepared a national summary of water use, supply, and demand (Carr and others, 1990).
- Coordinated a National effort to compile 1990 water-use estimates for the United States, Puerto Rico, and the U.S. Virgin Islands, and documented estimation methods and results.

Recent Reports:

Carr, J.E., Chase, E.F., Paulson, R.W., and Moody, D.W., compilers, 1990, National water summary 1987—Hydrologic events and water supply and use: U.S. Geological Survey Water-Supply Paper 2350, 553 p.

Holland, T.W., 1992, Water-use data collection techniques in the southeastern United States, Puerto Rico, and the U.S. Virgin Islands: U.S. Geological Survey Water-Resources Investigations Report 92-4028, 72 p.

Solley, W.B., and others, 1988, Estimated use of water in the United States in 1985: U.S. Geological Survey Circular 1004, 82 p.

Solley, W.B., Pierce, R.R., and Perlman, H.A., 1992, Estimated use of water in the United States in 1990: U.S. Geological Survey Circular 1081, 76 p.

Funding

Source of funds	Fiscal year (dollars in millions)				
	1988	1989	1990	1991	1992
Federal-State Cooperative Program[1]	7.7	7.8	7.8	8.0	8.0

[1]Includes Federal and State shares of program funds.

Keywords

Water use, Supply, Demand, Consumption, Cooperative activities, Trends, Data systems.

Hydrologic Data-Collection Program

The Hydrologic Data-Collection Program is the basic program of the WRD for collecting and analyzing data for the Nation's surface water and ground water. These data are used to support the needs of Federal, State, and local governments. Data-collection stations are maintained at selected locations. Standardized records are collected on stream discharge (flow) and stage (height), reservoir and lake storage, ground-water levels, well and spring discharge, and the quality of surface water and ground water. Purposes of the program are to provide hydrologic data needed to support the mission of the WRD, and to respond to the mutual needs and concerns of Federal, State, and local agencies regarding management, development, regulation, conservation, and environmental protection of the Nation's water.

Activities

- Collects data required by court decree, treaty, or compact.
- Provides data to support activities of other Federal agencies.
- Provides data to support national programs.
- Operates stations to collect data on the quantity and quality of surface water and ground water at State and local levels with emphasis on collecting data in water-deficient areas, urban complexes, small watersheds, and areas of energy-resources development.
- Monitors streamflow and quality of water to detect trends in stream quality. (See section *National Stream-Quality Accounting Network.*)
- Monitors hydrologic characteristics at sites relatively unaffected by human activities. (See section *National Hydrologic Bench-Mark Program.*)

Recent Accomplishments

- Provided the basic data for water-resources appraisals, environmental impact statements, and energy-related studies. In establishing the baseline conditions of the Nation's water, this program became the foundation for solving emerging water issues.
- Provided data through two computerized systems—the National Water-Data Storage and Retrieval System and the National Water-Data Exchange.
- Published hydrologic data (annually) for each State, Puerto Rico, and the Trust Territories; and special appendixes (as needed), such as data for coal-producing areas.

Recent Reports:

Condes de la Torre, Alberto, 1992, Operation of hydrologic data-collection stations by the U.S. Geological Survey in 1991: U.S. Geological Survey Open-File Report 92-172, 52 p.

Funding

In fiscal year 1992, about $100 million was directed to data collection and analysis. The WRD Federal-State Cooperative Program provided 63 percent of the funding; other Federal agency reimbursements, 26 percent; and USGS Federal Program, 11 percent.

Keywords

Data collection, Streamflow, Stations, Discharge, Stage, Wells.

Summary of data-collection stations

Types of water data-collection stations	Number of stations—Fiscal year 1991				
	Federal Program	Federal-State Cooperative Program	Other Federal agencies	Combined support	Total
Stations (surface water):					
Discharge:					
Continuous record	517	4,057	1,866	906	7,346
Partial record	47	2,670	324	86	3,127
Stage only—Streams:					
Continuous record	12	251	277	46	586
Partial record	10	241	47	112	410
Stage only—Lakes/reservoirs:					
Continuous record	15	398	372	23	808
Partial record	9	225	85	3	322
Quality:					
Continuous record	28	378	174	73	653
Scheduled, long-term	486	1,462	238	136	2,322
Short-term or project	125	544	196	78	943
Wells (ground water):					
Water levels:					
Continuous record	137	2,005	131	103	2,376
Scheduled, long-term	1,334	22,085	1,035	296	24,750
Short-term or project	1,102	5,292	1,910	332	8,636
Quality:					
Scheduled, long-term	261	3,608	380	167	4,416
Short-term or project	647	2,273	933	346	4,199

National Stream-Quality Accounting Network

The National Stream-Quality Accounting Network (NASQAN) was implemented in 1973 to provide a consistent description of the quality of the Nation's surface water. Currently (1992), NASQAN consists of 411 sites within the United States and its Territories, and provides data for two objectives: to determine whether water quality was deteriorating, remaining unchanged, or improving; and to account for mass transport of constituents from major river basins and to the oceans. The consistency of data-collection procedures used in this program has created one of the most complete data bases of this type in the world.

Activities

- Collects streamflow and water-quality data at 411 sites to provide a nationally consistent data base for water-quality assessment and research.
- Conducts a program to relate time trends in NASQAN data to human activities in the basins.
- Evaluates the addition of new data-collection techniques, such as suspended-sediment chemistry, to expand the application of NASQAN data to emerging areas of water-quality concern.

Recent Accomplishments

- Published several reports examining water-quality conditions at NASQAN sites and comparing NASQAN water-quality data to data from other upstream sites in the NASQAN basin. For example, one report on the Umpqua River basin, Oregon, indicated water quality at the NASQAN site can be quite different from water-quality conditions in other areas of the basin (Schesty, 1990).
- Reviewed the NASQAN network to develop a narrative description for each site and a hypothesis for station operation. As a result of the review, 31 sites were added to the network, 26 placed in inactive status, and 91 discontinued.
- Published an article on the results of an investigation that examined long-term water-quality trends at more than 300 locations on major U.S. rivers. The results indicate influences on water-quality trends from terrestrial and atmospheric sources (Smith and others, 1987).

Recent Reports:

Schesty, T.L., 1990, Trends in water-quality data in Texas: U.S. Geological Survey Water-Resources Investigations Report 89-4178, 177 p.

Smith, R.A., Alexander, R.B., and Wolman, M.G., 1987, Water-quality trends in the Nation's rivers: Science, v. 235, p. 1607-1615.

Funding

	Fiscal year (dollars in millions)				
Source of funds	1988	1989	1990	1991	1992
Federal Program	4.5	4.6	4.6	4.7	4.7

Keywords

NASQAN, Water-quality trends, Mass transport, Streamflow.

National Hydrologic Bench-Mark Network

The National Hydrologic Bench-Mark Network (Bench-Mark Network) was started in 1958 to define the ambient water quality of streams in basins where the land surface has not been altered by humans. The Bench-Mark Network includes 58 stations located in 37 States. Selection of Bench-Mark Network basins was guided by several criteria: no artificial storage, regulation, or diversion of streams existed or was probable for many years; pumping from wells within the basin was minimal and should not materially affect ground water; conditions were favorable for accurate measurement of streamflow, and the chemical and physical quality of water; and the probability was small that human activity within the basin would alter streamflow or water quality.

Activities

- Collects, stores, and analyzes water-quantity data from 58 sites and water-quality data from 55 sites.
- Analyzes trends in water-quality data from the Bench-Mark Network.
- Evaluates data from Bench-Mark Network sites to determine processes that control water-quality trends at these sites, trace-element concentrations in snowmelt, and variability of stream acidity in the Northeastern United States.

Recent Accomplishments

- Determined trends in surface-water quality in natural environments of the United States by using data from the Bench-Mark Network (Smith and Alexander, 1983a).
- Observed small declines in sulfate concentrations in streams in the northeastern quarter of the Nation. Small increases in sulfate were seen at most southeastern and western sites where streams were measured. Regional sulfur dioxide emissions showed similar trends (Smith and Alexander, 1983b).

Recent Reports:

Smith, R.A., and Alexander, R.B., 1983a, A statistical summary of data from the U.S. Geological Survey's national water quality networks: U.S. Geological Survey Open-File Report 83-533, 20 p.

———1983b, Evidence for acid-precipitation-induced trends in stream chemistry at hydrologic bench-mark stations: U.S. Geological Survey Circular 910, 12 p.

Funding

	Fiscal year (dollars in millions)				
Source of funds	1988	1989	1990	1991	1992
Federal Program	0.7	0.8	0.8	0.9	0.9

Keywords

Bench-Mark Network, Ambient water quality, Water-quality trends, Snowmelt, Stream acidity.

Although water is often considered a common resource by neighboring States, it frequently is not available in sufficient quantity to satisfy the needs of all competing interests. Compacts, and sometimes adjudications (when a compact agreement cannot be reached), provide an accepted settlement with respect to a common water resource. Hydrologic data are sometimes required to apportion water resources. The courts often assign to the WRD the responsibility to provide impartial and scientifically reliable hydrologic information.

Activities

- Collects, analyzes, and publishes hydrologic information in support of adjudications and compacts. Surface-water data frequently required include maximum and minimum flows, frequency of such flows, and daily, monthly, and annual totals. Ground-water data frequently required include water use, water yields, and water levels.
- Monitors changes in the quality of water for selected characteristics, mainly the common ions.

Recent Accomplishments

- Provided hydrologic information on the Lower Colorado River program, which was conducted in cooperation with the U.S. Bureau of Reclamation, as required by a 1964 Supreme Court Decree.
- Furnished hydrologic data from over 500 streamflow stations, in accordance with adjudications and compacts throughout the Nation, to allow for the equitable apportionment of waters. The compacts concern parts of the Colorado, Arkansas, Bear, Big Blue, Yellowstone, Sabine, Belle Fourche, Republican, Pecos, Delaware, and Columbia Rivers; Costilla Creek; and the Rio Grande. The adjudications relate to streams across the country.

Funding

	Fiscal year (dollars in millions)				
Source of funds	1988	1989	1990	1991	1992
Federal Program	2.0	2.0	2.0	2.0	2.0
State and local agencies	.9	.9	.9	.9	.9
Total	2.9	2.9	2.9	2.9	2.9

Keywords

Court decrees, Compacts, Adjudications, Colorado River, Yellowstone River, Columbia River, Rio Grande.

National Water Information Clearinghouse

The National Water Information Clearinghouse is being designed to improve and expand the availability of water-resources information to traditional users and to the rapidly growing community of new users. The user community includes Federal, State, and local governmental agencies, academia, industry, and the general public. The clearinghouse is intended to upgrade and modernize the information systems that are used to service the growing user community; and to strengthen coordination and collaboration and improve access to existing sources of public and private information and clearinghouse services.

Activities

- Conducts outreach and training.
- Disseminates data and information about water resources, including water-data indexing and literature abstracting.
- Carries out educational programs.
- Establishes data exchange programs with other Federal and State agencies.

Recent Accomplishments

- Established a nationwide toll-free number, 1-800-426-9000, to promote easy access to the clearinghouse.
- Conducted workshops to further define clearinghouse user needs.
- Compiled a prototype directory of currently available water information and data for each State.
- The National Water Data Exchange (NAWDEX) responded to about 80,000 requests for data and information in 1992, and approximately 14,000 abstracts were added to the WRD water-resources scientific literature data base.

Funding

	Fiscal year (dollars in millions)				
Source of funds	1988	1989	1990	1991	1992
Federal Program	2.0	1.9	3.4	3.7	3.3

Keywords

Clearinghouse, Information system, Access, Dissemination, NAWDEX.

State Water Resources Research Institutes and National Water Resources Research Grants Programs

The Secretary of DOI has designated the USGS as the administering agency for Title I of the Water Resources Research Act of 1984 (the Act) (Public Law 98-242, as amended). Title I authorizes establishment of up to 57 State Water Resources Research Institutes (Section 104), and matching grants to non-Federal entities for research in water resources through the National Water Resources Research Grants Programs (Section 105).

Activities

- Provides matching grants to partially support operation of the State Water Resources Research Institutes.
- Evaluates the State Water Resources Research Institutes periodically, as required by the Act.
- Defines priority areas of research.
- Solicits, evaluates, and ranks water-resources research proposals.
- Monitors progress of research.

Recent Accomplishments

- Fifty-four State Water Resources Research Institutes in aggregate have been granted funds in 1 or more fiscal years since 1985 (see the following table).

  The number of grants issued annually since 1987 (Section 105) is as follows:

	Fiscal year					
	1987	1988	1989	1990	1991	1992
Grants awarded	34	38	36	40	36	17

- All State Water Resources Research Institutes were evaluated during the period fiscal years 1985 to 1987. Results of the evaluations were published by Ertel (1988).
- Published reports that provide information on the grant proposals.
- Annually published abstracts of the research conducted under each of the grants.

Recent Reports:

Ertel, M.O., 1988, Evaluation of State water-resources research instititutes: U.S. Geological Survey Open-File Report 88-85, 28 p.

Funding

	Fiscal year (dollars in millions)				
Source of funds	1988	1989	1990	1991	1992
Federal Program	0	0	0	0	0
Water Institutes[1]	5.7	5.7	5.7	5.6	5.6
Research grants[2]	4.4	4.4	4.4	4.4	1.8
Total	10.1	10.1	10.1	10.0	7.4

[1]State Water Resources Research Institutes provided matching funds in non-Federal to Federal ratios of 1.5:1 in 1987 and 1988, and 2:1 in 1989 and 1990.

[2]Grants must be matched on a 1:1 basis.

Keywords

State Water Resources Research Institutes, Research grants, Water Resources Research Act, Cooperative activities.

Population growth and expansion of agricultural and energy production have increased the competition for available water. Ground water constitutes a rising percentage of the total water used because a large part of existing surface water is already appropriated and feasible sites for the construction of large surface-water reservoirs are scarce. Ground-water quantity is an issue that is addressed by a number of WRD programs. Generally, the purposes of these programs include the determination of the extent and water-bearing characteristics of aquifers in the area of consideration and the effects of withdrawals on the ground-water systems.

Activities

- Conducts interpretive investigations of ground water throughout the United States ranging from reconnaissance studies to computer simulation of ground-water flow in complex, multiaquifer systems. About 900 studies were conducted in fiscal year 1992.
- Measures water levels periodically in about 36,000 observation wells.
- Develops and maintains a national ground-water data base.
- Conducts research, development, and documentation of ground-water-flow models.

Recent Accomplishments

- Conducted multidisciplinary hydrologic studies involving ground-water quantity in nearly every State, as part of the Federal-State Cooperative Program.
- Continued studies of the Nation's 26 most important aquifer systems under the Regional Aquifer-System Analysis (RASA) Program.
- Completed the following RASA studies: Great Basin of Nevada and Utah, Central Midwest, Central Valley (California), Floridan aquifer system, High Plains, Snake River Plain, Northern Great Plains, Northern Midwest, Southwest Alluvial Basins, Southeastern Coastal Plain, Northern Atlantic Coastal Plain, Upper Colorado River Basin, Columbia Plateau, Oahu, Northeast Glacial aquifers, Caribbean Islands, San Juan Basin, and Gulf Coastal Plain.
- Maintained a Ground-Water Site Inventory data base that contains hydrologic and geologic information on more than 1 million sites and more than 2 million water-level measurements.
- Developed sophisticated ground-water-flow models to better understand the ground-water systems and to provide insight into the effects of the application of various ground-water management schemes.
- Published 2 of 13 segments of the Ground Water Atlas of the United States.

Funding

Funding for WRD ground-water activities is derived from several sources. In fiscal year 1992, expenditures on ground-water studies approached $200 million (or about half of the total funds available from all sources), of which about one-half of this amount was directed towards water-quantity studies.

Keywords

Ground-water quantity, Observation wells, Ground-water data base, Ground-Water Site Inventory, Federal-State Cooperative Program.

Ground-water quality

The quality of the Nation's ground water is not well documented. Much is known about the distribution of common inorganic constituents in the Nation's ground water from data collection and interpretive studies under the WRD Federal-State Cooperative Program, the RASA Program, and other programs; however, much less is known about the distribution of trace elements and organic compounds. The situation is complicated further by problems involved in obtaining representative samples of contaminated ground water (for example, how to best sample for volatile organic substances without part of the material escaping) and in analytical techniques in the laboratory. The purpose of WRD ground-water-quality programs is to improve understanding of the factors controlling ground-water quality, to define the relation of water quality to ground-water-flow patterns, and to define the ambient or background water quality of aquifers.

Activities

- Collects and interprets ground-water-quality data as part of the Federal-State Cooperative Program and the RASA Program.
- Conducts studies ranging from analysis of contaminant movement to regional assessments of ground-water quality.
- Develops techniques for sampling organic compounds in ground water.
- Conducts research on the geochemical controls of ground-water quality and the fate and movement of ground-water contaminants at research sites in California, Colorado, New Hampshire, Massachusetts, New Jersey, Georgia, Arizona, and Minnesota.

Recent Accomplishments

- Conducted about 450 projects nationwide involving some aspect of ground-water quality during fiscal year 1992.
- Analyzed more than 73,000 water samples for organic and inorganic constituents and made more than 800,000 individual determinations during fiscal year 1992.

Funding

Funding for WRD ground-water activities is derived from several sources. In fiscal year 1992, about $200 million was spent on ground-water studies, of which about one-half of this amount involved some aspect of water quality.

Keywords

Ground-water quality, RASA, Federal-State Cooperative Program, Geochemistry, Water quality.

Ground-water protection—U.S. Geological Survey and U.S. Environmental Protection Agency coordination

Contamination of ground water is one of the most significant environmental issues facing the Nation. Within the next decade, large sums of money will be spent by the Federal, State, and private sectors to clean up existing hazardous-waste dumps and to prevent additional point- and nonpoint-source pollution of ground water. The design and implementation of programs to address ground-water contamination is hampered by limited scientific information on which to base policy decisions. The USGS makes available the skills and capabilities of WRD personnel to assist the USEPA and the States in understanding and resolving these problems.

Activities

- Provides the ground-water information needed for the design and implementation of ground-water-protection programs.
- Advises the USEPA on technical aspects of ground-water-protection issues.
- Defines specific areas in which the USEPA and the DOI will have active roles in responding to emergency contamination situations.
- Provides technical assistance to the States for designing and implementing local programs to protect aquifers and ground-water resources, such as designation of wellhead protection areas, using numerical modeling techniques.

Recent Accomplishments

- Entered into a number of interagency agreements with the USEPA for technical assistance in support of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) (Superfund), and the Resource Conservation and Recovery Act (RCRA) of 1976.
- Developed an interagency agreement with the USEPA Office of the Inspector General to provide assistance in the gathering of information and technical review of USEPA and USEPA-funded activities at selected Superfund sites in support of the Superfund Amendments and Reauthorization Act of 1986 (SARA).
- Developed a MOU with the USEPA for technical assistance related to environmental protection of Indian lands in USEPA Region V.

Funding

In fiscal year 1992, the USEPA provided about $5 million in reimbursements to the WRD for a range of tasks, including support of activities related to CERCLA and RCRA. In addition, through the USGS Federal-State Cooperative Program, about $2.6 million (in Federal and State funds) were provided for work related to Superfund.

Keywords

Environmental Protection Agency, Memorandum of Understanding, Interagency agreement, Contamination, RCRA, CERCLA, SARA, Superfund.

International Water Resources Program

The Office of the Assistant Chief Hydrologist for Research and External Coordination is responsible for directing the WRD program of international cooperation in the field of water resources. This office oversees international water-resources activities of the WRD, arranges visits and training for foreign nationals in various fields of hydrology, provides technical assistance to foreign governments through short-term assignments of WRD personnel, and facilitates the visiting scientists program. These activities are conducted through the following agreements: (1) with international governmental organizations, such as the United Nations, (2) with international nongovernmental organizations, such as the International Association of Hydrological Sciences, (3) between the U.S. Government and foreign governments or between the USGS and counterpart agencies of foreign governments, (4) between USGS scientists and foreign scientists and their parent organizations, and (5) with U.S. Government agencies, such as the U.S. Agency for International Development. The purpose of these agreements includes support of U.S. foreign policy and missions, promotion of international cooperation in earth sciences, collaborative research, and information transfer.

Activities

- Facilitates the transfer of foreign water-resources research results and methodology for potential application to domestic water programs.
- Oversees international water-resources investigations conducted by the WRD.
- Arranges for the provision of technical assistance to foreign and international water-resources activities requested by cooperating organizations.
- Responds to foreign requests for information or publications.
- Arranges itineraries and host visits of foreign nationals to the WRD.
- Represents or arranges for representation of the United States in the water programs of international intergovernmental and nongovernmental bodies.

Recent Accomplishments

- Arranged 159 missions in 1988, 153 missions in 1989, 203 missions in 1990, 161 missions in 1991, and 144 missions in 1992 for U.S. scientists to foreign countries.
- Arranged for 4 short-term technical assistance visits by WRD hydrologists in 1988, 17 in 1989, 14 in 1990, 13 in 1991, and 41 in 1992 to support water-resources programs in the Middle East, the Far East, Central and South America, and Africa.
- Directed an exchange program of hydrologic research information between the United States and the People's Republic of China.
- Directed a collaborative hydrologic-research program between the United States and the U.S.S.R.
- Arranged training programs for 14 foreign scientists and technicians in 1988, for 29 in 1989, for 20 in 1990, for 38 in 1991, and for 41 in 1992.
- Arranged missions to the United States for 37 scientists and administrators from foreign countries in 1988, for 52 in 1989, for 64 in 1990, for 51 in 1991, and for 46 in 1992.
- Directed a 5-year project to assess the ground-water resources of two major areas in Abu Dhabi where significant fresh ground water is known to occur.
- Completed, in 1992, a participating agency service agreement with the U.S. Agency for International Development to provide training, technical assistance, and research assistance to the Central Ground Water Board of India.
- Facilitated responses to requests from the Office of Foreign Disaster Assistance of the U.S. Agency for International Development for assistance relative to hydrologic hazards.
- Developed, in 1992, an MOU with the Public Works Research Institute, Ministry of Construction, Tsuhuba, Japan, for cooperation in the Field of Hydrology, Water Resources, and Global Climate.
- Developed, in 1992, an MOU with the University of Bergen, Kingdom of Norway, for Scientific and Technical Cooperation in the Earth Sciences. A Project Annex was initiated for joint research on the remote sensing and modeling of sea ice, oceans, and snow.

- Provided technical advice to the Department of State in support of the Water Working Group (WWG), President's Middle East Peace Initiative. USGS representative served as one of U.S. delegation to both the spring WWG meeting in Vienna, Austria, and the fall WWG meeting in Washington, D.C.

Funding (approximate)

Source of funds	Fiscal year (dollars in millions)				
	1988	1989	1990	1991	1992
Federal Program	0.1	0.1	0.1	0.1	0.1
Other Federal agencies, international organizations, and foreign governments	1.1	1.8	2.0	2.0	2.1
Total	1.2	1.9	2.1	2.1	2.2

Keywords

International activities, Visiting scientists, Training, People's Republic of China, U.S.S.R., Abu Dhabi, Middle East, Far East, Central America, South America, Africa, India, Japan, Norway, Ground water.

Nuclear Waste Hydrology

High-level radioactive wastes

The Nuclear Waste Policy Amendments Act of 1987 (Public Law 100-203) redirected the Nation's High-Level Nuclear Waste Program. This act mandates: (1) the termination of candidate-site screening at all potential sites for a deep geologic repository for the disposal of high-level radioactive waste (HLRW) other than Yucca Mountain, Nevada, and (2) the timely site characterization of the Yucca Mountain site to determine its suitability as a geologic repository for the disposal of high-level radioactive waste.

The congressionally funded USGS program in HLRW disposal began in the 1970's. The purpose of the program has been to study environments suitable for the disposal of HLRW, and processes, techniques, and methods to characterize sites. Studies have been conducted in support of the U.S. Department of Energy (DOE), the Nuclear Regulatory Commission (NRC), and the USEPA in their roles in the management of the Nation's high-level radioactive waste.

Currently, the USGS, WRD program in HLRW is focused on the characterization of Yucca Mountain in cooperation with the DOE. The WRD conducts most of the hydrologic and geologic research. Detailed planning and strict quality-assurance practices are necessary for all phases of the work.

Activities

- Oversees ongoing activities at the Yucca Mountain site, including monitoring of water levels, collection of weather data, and monitoring of seismic events.
- Oversees 50 detailed study plans for site-characterization activities at Yucca Mountain, which are either completed or in various stages of preparation.
- Conducts detailed studies of the unsaturated zone and the saturated zone, including hydrochemistry for the Yucca Mountain site.
- Assesses future geohydrologic conditions in the southern Great Basin that could result from potential climatic changes over the next 10,000 years.
- Studies geohydrologic and geochemical processes related to waste form, rock, and ground-water interaction.
- Conducts research on ground-water flow and solute transport in fractured rock.
- Develops instrumentation and techniques for characterization and monitoring of both saturated and unsaturated zones.
- Participates in the development of rules, regulations, and guidelines.
- Reviews significant reports of other agencies related to the disposal of nuclear waste.

Recent Accomplishments

- Developed a ground-water model of the Yucca Mountain site that is based on the assumption of doubling of rainfall. The model indicated that the resulting raised water table would be well below the repository horizon.
- Completed intense studies on calcite-silica vein deposits near the Yucca Mountain site. Study findings indicate that these deposits are not spring deposits caused by fluctuations in the water table, but are formed by the weathering effects of infiltrating precipitation.
- Completed a study of variations in the isotopic content of ground water and mineral species that provided a 250,000-year climatic record from Great Basin vein calcite (Winograd, and others, 1988). These study findings are a major contribution to the assessment of future climates and future hydrologic conditions of Yucca Mountain.
- Published report on the physical and chemical characteristics of topographically affected airflow in an open borehole at Yucca Mountain (Thorstenson and others, 1990) that describes the volume, composition, and isotopic signature of carbon dioxide of gas exhaled through a borehole on the crest of Yucca Mountain.
- Contributed to the DOE Site Characterization Plan and the Exploratory Shaft Test Plan for the characterization of the Yucca Mountain site.

- Conducted research in techniques of drilling, hydraulic testing, and geophysical methods for site characterization.
- Initiated research for improving the understanding of water and vapor flow in the unsaturated zone.
- Drilled an extensive series of shallow (20-90 meter) boreholes at the Yucca Mountain site and determined the soil moisture profiles in them. Comparison of these data with precipitation and water budget data indicates that a net water loss fromYucca Mountain occurs under the current arid conditions.

Recent Reports:

Dudley, W.W., Jr., 1990, Multidisciplinary hydrologic investigations at Yucca Mountain, Nevada, *in* Proceedings of the International Topical Meeting, High-Level Radioactive Waste Management: American Nuclear Society, LaGrange Park, Illinois, American Society of Civil Engineers, New York, N.Y., v. 1, p. 1-9.

Evernden, J.F., 1992, Safety of proposed Yucca Mountain Nuclear Repository as regards geological and geophysical factors; Evaluation of minority report by Archambeau and Price: U.S. Geological Survey Open-File Report 92-516, 98 p.

Flint, A.L., 1989, Characterization of unsaturated zone infiltration *in* Mattson, S.R., Broxton, D.E., Buono, A., Crowe, B.M., and Orkild, P.P., eds., Geology and hydrology of the proposed nuclear waste repository at Yucca Mountain, Nevada and the surrounding area, 1989, Field Trip Guide, Annual Meeting: Denver, Colorado, Geological Society of America.

Hoxie, D.T., 1990, Alternative conceptual model for the unsaturated-zone hydrogeologics system, Yucca Mountain, Nevada: Radioactive Waste Management and the Nuclear Cycle, v. 13, nos. 1-4, p. 73-75.

Stuckless, J.L., 1991, An evaluation of evidence pertaining to the origin of vein deposits exposed in Trench 14, Nevada Test Site, Nevada, *in* Proceedings of the Second International Conference on High-Level Radioactive Waste Management: American Nuclear Society, Lagrange Park, Illinois; New York, American Society of Civil Engineers, v. 2, p. 1429.

Thorstenson, D.C., Weeks, E.P., Haas, Herbert, and Woodward, J.C., 1990, Physical and chemical characteristics of topographically affected airflow in an open borehole at Yucca Mountain, Nevada, *in* Focus '89, Nuclear Waste Isolation in the Unsaturated Zone, Topical Meeting, September 17-21, 1989, Las Vegas, Nevada, Proceedings: LaGrange Park, Illinois, American Nuclear Society, Inc., p. 256-270.

Winograd, I.J., Szabo, B.J., Coplen, T.B., and Riggs, A.C., 1988, A 250,000-year climatic record from Great Basin vein calcite—Implications for the Milankovitch Theory: Science, v. 242, p. 1275-1280.

Funding

	Fiscal year (dollars in millions)				
Source of funds	1988	1989	1990	1991	1992
Federal Program	1.7	1.8	1.8	1.7	1.4
Other Federal agencies	.6	.2	0	0	0
DOE[1]	22.7	24.6	24.2	23.7	25.4
Total	25.0	26.6	26.0	25.4	26.8

[1]Includes funding for activities of the Geologic Division, the U.S. Bureau of Reclamation, and contractors.

Keywords

Nuclear waste disposal, Yucca Mountain, Nevada test site, Radioactive waste, Ground water, Climate, Department of Energy.

Low-level radioactive wastes

The WRD program in low-level radioactive-waste (LLRW) disposal consists of studies at commercial and Federal waste-disposal sites and related study areas and topical research to address special technical problems. The objective of the program is to develop geologic and hydrologic information to assist Federal agencies, States, and compacts of States in the development of effective disposal sites for LLRW. Under an interagency agreement with the DOE, the USGS will provide geologic and hydrologic support to the National Low-Level Radioactive Waste Management Program by assisting States and Regional Compacts in the siting and characterization of new LLRW disposal facilities.

The WRD has conducted hydrogeologic studies at most of the principal commercial and Federal LLRW disposal sites. Many of the principal hydrogeologic problems encountered in shallow land burial were identified. Summary reports and numerous topical reports on the findings have been published.

Activities

- Conducts research in the laboratory and in the field on processes controlling the performance of existing LLRW disposal sites such as Beatty, Nevada; West Valley, New York; and Sheffield, Illinois.
- Develops techniques and guidelines for the selection, characterization, and design of future LLRW disposal sites.
- Assists other Federal and State agencies in developing effective waste-management programs.
- Conducts topical research to address special technical problems.
- Studies the average annual rates of recharge from precipitation at various sites on the Hanford Reservation.
- Studies contamination of ground and surface waters by chemicals and radionuclides in the vicinity of the Weldon Spring, Missouri, Feed Materials Plant, raffinate pits, and quarry, in cooperation with DOE.

Recent Accomplishments

- Studied existing LLRW disposal sites (Bedinger, 1989). Lessons learned in that study could be applied to the siting and design, construction and maintenance, monitoring and modeling, and engineered barrier systems of future LLRW disposal sites.
- Investigated geologic and hydrologic factors that control migration of tritium from a closed LLRW disposal site in glacial drift and the underlying horizontally fractured dolomite (Nicholas and Healy, 1988).
- Summarized 10 years of hydrogeologic research at the Sheffield LLRW site and the implications of the topical studies concerning future LLRW disposal sites (Ryan, 1989).
- Provided technical assistance to State agencies and compacts in the selection and characterizations of new sites in accordance with the Low-Level Radioactive Waste Policy Amendments Act of 1985 (Public Law 99-240).
- Discovery that respiratory iron-reducing micro-organisms can reduce U(VI), the oxidized form of uranium, to U(IV). The reduced form is only slightly soluble suggesting that microbial reduction of uranium could be an effective method for removing uranium from contaminated waters.

Recent Reports:

Andraski, B.J., 1990, Water movement and trench stability at a simulated arid burial site for low-level radioactive waste near Beatty, Nevada, *in* Focus '89, Nuclear Waste Isolation in the Unsaturated Zone, Topical Meeting, September 17-21, 1989, Las Vegas, Nevada, Proceedings: LaGrange Park, Illinois, American Nuclear Society, Inc., p. 166-171.

Bedinger, M.S., 1989, Geohydrologic aspects for siting and design of low-level radioactive-waste disposal: U.S. Geological Survey Circular 1034, 36 p.

Carey, W.P., Lyverse, M.A., and Hupp, C.R., 1990, Hillslope erosion at the Maxey Flats radioactive waste disposal site, northeastern Kentucky: U.S. Geological Survey Water-Resources Investigations Report 89-4199, 37 p.

Fischer, J.M., 1992, Sediment properties and water movement through shallow unsaturated alluvium at an arid site for disposal of low-level readioactive waste near Beatty, Nye County, Nevada: U.S. Geological Survey Water-Resources Investigations Report 92-4032.

Lovley, D.R., Phillips, E.J.P., Gorby, Y.A., and Landa, E.R., 1991, Microbial reduction of uranium; Nature, v. 1250, p. 413-416.

Nicholas, J.R., and Healy, R.W., 1988, Tritium migration from a low-level radioactive-waste disposal site near Chicago, Illinois: U.S. Geological Survey Water Supply Paper 2333, 46 p.

Ryan, B.J., ed., 1989, Results of hydrologic research at a low-level radioactive-waste disposal site near Sheffield, Illinois: U.S. Geological Survey Open-File Report 88-318, 144 p.

Webster, D.A., and Bradley, M.W., 1988, Hydrology of the Melton Valley radioactive-waste burial grounds at Oak Ridge National Laboratory, Tennessee: U.S. Geological Survey Open-File Report 87-686, 103 p.

Funding

Source of funding	Fiscal year (dollars in millions)				
	1988	1989	1990	1991	1992
Federal Program	2.1	2.2	2.1	2.2	2.1
Other Federal agencies	1.3	1.5	2.0	2.0	1.8
Total	3.4	3.7	4.1	4.2	3.9

Keywords

Radioactive waste, Cooperative activities, Department of Energy, Nuclear waste disposal, Ground water.

Toxic Substances Hydrology Program

Contamination of surface water and ground water by toxic substances is considered by many to be one of today's most significant environmental issues. Billions of gallons of contaminated liquids and tons of industrial and agricultural chemicals are discharged into the environment each year. Virtually every State has water-quality problems resulting from point and nonpoint sources of contamination, which can cause extensive social and economic disruption. The purpose of the Toxic Substances Hydrology Program is to provide the Nation with earth sciences information to help identify, remediate, and prevent water-quality degradation by toxic chemicals.

Activities

- Conducts interdisciplinary research into the physical, chemical, and biological processes and factors that affect the transport, storage, and fate of toxic chemicals in surface- and ground-water systems.
- Conducts interdisciplinary field studies of the effect of contamination by crude oil, gasoline, sewage, wastes from metal mining, agricultural chemicals, and industrial solvents in rivers, estuaries, sand and gravel aquifers, and fractured rock aquifers.
- Develops methods to appraise the regional occurrence of toxic substances, such as pesticides and organic solvents in water, sediment, and biota, and to relate this occurrence to land use and environmental factors, such as soil characteristics.
- Develops study approaches, sampling techniques, field and laboratory measurement methods, and models of the fate and transport of chemicals for use in site investigations and remediation of contamination.
- Supports other Federal and State agencies in managing the quality of the Nation's water resources.

Recent Accomplishments

- Published more than 200 reports and technical papers that describe the fate and transport of toxic substances in streams, estuaries, unconsolidated aquifers, and bedrock aquifers.
- Began studies of the flow and transport of contaminants in a fractured-rock aquifer in New Hampshire, the movement of agricultural chemicals in a river-estuary system in California, the fate of spilled gasoline in sand and gravel in New Jersey, and the regional occurrence of agricultural pesticides in the midcontinent.
- Determined that thin zones of elevated chemical concentrations and microbiological activity are characteristic of ground-water-contaminant plumes because vertical mixing is limited. Delineation of these zones requires sampling at closely spaced intervals.
- Determined that bacteria can degrade organic contaminants in ground water and significantly retard pollutant migration. For example, anaerobic bacteria were found to degrade creosote and pentachlorophenol, and microbes were found to degrade volatile organic compounds associated with crude oil.
- Demonstrated that bacteria found in contaminated aquifers can move readily with the flowing ground water. Field evidence suggests that bacteria at a highly contaminated source area can "seed" downgradient areas of plumes.
- Discovered that photochemical reactions can affect concentrations of dissolved metals in streams. This may account for reports of widely fluctuating concentrations of metals in lakes and streams in mining areas.
- Demonstrated that the regional occurrence of manmade chemicals, such as industrial solvents and agricultural pesticides in shallow ground water, can be correlated with land use.
- Tested methods to collect ground-water samples for analysis of organic contaminants. Tests showed that the sampling device, pumping rate, and duration of pumping can significantly affect observed concentrations, thus, complicating interpretation of ground-water-quality data.
- Detected one or more herbicides in each of 146 water samples collected from eight sites on the Mississippi River and its major tributaries in April, May, and June 1991.
- Collected weekly rainfall samples at sites in 23 Midwestern and Northeastern States. Herbicides were detected in all 23 States, with the highest concentrations occurring in the Midwest.

Recent Reports:

Baehr, A.L., Hoag, G.E., and Marley, M.C., 1989, Removing volatile contaminants from the unsaturated zone by inducing advective air-phase transport: Journal of Contaminant Hydrology, v. 4, no. 1, p. 1-26.

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Barringer, T.H., Dunn, D.L., Battaglin, W.A., and Vowinkel, E.F., 1990, Problems and methods involved in relating land use to ground-water quality: Water Resources Bulletin, v. 26, no. 1, p. 1-9.

Ceazan, M.L., Thurman, E.M., and Smith, R.L., 1989, Retardation of ammonium and potassium transport through a contaminated sand and gravel aquifer—The role of cation exchange: Environmental Science and Technology, v. 23, no. 11, p. 1402-1408.

Eckhardt, D.A., Flipse, W.J., and Oaksford, E.T., 1989, Relation between land use and ground-water quality in the upper glacial aquifer in Nassau and Suffolk Counties, Long Island, New York: U.S. Geological Survey Water-Resources Investigations Report 86-4142, 35 p.

Franks, B.J., ed., 1987, U.S. Geological Survey program on toxic waste—Ground-water contamination: Technical meeting, 3rd, Pensacola, Florida, March 23-27, 1987, Proceedings: U.S. Geological Survey Open-File Report 87-109, p. 213.

Fuller, C.C., and Davis, J.A., 1989, Influence of coupling of sorption and photosynthetic processes on trace element cycles in natural waters: Nature, v. 340, no. 6228, p. 52-54.

Garabedian, S.P., and LeBlanc, D.R., 1991, Large-scale natural gradient tracer test in sand and gravel, Cape Cod, Massachusetts: 2. Analysis of spatial moments for a nonreactive tracer: Water Resources Research, v. 27, no. 5, p. 911-924.

Gibs, Jacob, and Imbrigiotta, T.E., 1990, Well-purging criteria for sampling purgeable organic compounds: Ground Water, v. 28, no. 1, p. 68-78.

Goolsby, D.A., Coupe, R.C., and Markovchick, D.J., 1991, Distribution of selected herbicides and nitrate in the Mississippi River and its major tributaries, April through June 1991: U.S. Geological Survey Water-Resources Investigations Report 91-4163, 35 p.

Grady, S.J., and Weaver, M.F., 1989, Evaluation of groundwater quality in relation to land use for stratified-drift aquifers in Connecticut, *in* Ragone, S.E., ed., Regional characterization of water quality—Proceedings of the Baltimore Symposium, May 1989: International Association of Hydrological Sciences, Publication No. 182, p. 19-29.

Harvey, R.W., and Barber, L.B., II, 1992, Associations of free-living bacteria and dissolved organic compounds in a plume of contaminated groundwater: Journal of Contaminant Hydrology, v. 9, p. 91-103.

Harvey, R.W., George, L.H., Smith, R.L., and LeBlanc, D.R., 1989, Transport of microspheres and indigenous bacteria in a sand aquifer—Results of natural- and forced-gradient tracer experiments: Environmental Science and Technology, v. 48, no. 6, p. 1197-1202.

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Funding

Source of funds	Fiscal year (dollars in millions)				
	1988	1989	1990	1991	1992
Federal Program	12.7	12.6	14.0	14.6	14.9

Keywords

Toxic substances, Surface water, Ground water, Chemistry, Water quality, Pollution, Hazardous substances.

National Water-Quality Assessment Program

In 1991, the WRD began a transition from a pilot program to a fully implemented National Water-Quality Assessment (NAWQA) Program. The long-term goals of this program are to describe the status and the trends of water-quality conditions for a large, diverse, and geographically distributed part of the Nation's ground- and surface-water resources; and to identify, describe, and explain the major natural and human factors that affect these observed conditions and trends.

Assessment activities will be conducted in 60 study units (major watersheds and aquifer systems) that represent a wide range of environmental settings nationwide and that account for a large percentage of the Nation's water use. The coordinated application of comparative hydrologic studies at a wide range of spatial and temporal scales will provide a basis for resources decisionmaking within the study units and a foundation for aggregation and comparison of findings to address water-quality issues of regional and national interest.

Activities

- Analyzes existing information and field studies ongoing in the first set of 20 study unit investigations started in 1991.
- Aggregates existing information and planning studies focused on national syntheses of pesticides and nutrients in surface and ground water.
- Plans national synthesis efforts focused on volatile organic compounds in ground water and the factors influencing invertebrates, algae, and fish in streams and rivers.
- Coordinates with Federal, State, and local agencies at study-unit and national levels to ensure that the assessment information meets the needs of other agencies to the maximum extent possible.

Recent Accomplishments

- Completed seven pilot projects to test and refine the concepts for the full-scale program.
- Completed evaluation of the NAWQA pilot program by the National Academy of Sciences in 1990. The Academy concluded that a national water-quality assessment program is needed and that the USGS is well qualified to implement such a program.
- Published more than 100 reports that described the design of the program, protocols to be used, and findings from the seven pilot studies.
- Published two non-technical publications and one video summarizing key findings and their implications for the general public.
- Completed assessment findings from the lower Kansas River pilot study that were later used by the Kansas State Board of Agriculture as the basis for establishing the Delaware River basin in northeast Kansas as the first inland Pesticide Management Area in the Nation that targets reducing the amount of atrazine in runoff that enters inland surface waters.
- Completed study showing elevated levels of pesticide DDT in fish in the Yakima River that has prompted the Washington Department of Public Health to begin additional studies to determine whether a public health advisory is warranted.
- Identified second set of 20 study-unit investigations to start in 1994 with the assistance of other agencies participating on the NAWQA Advisory Council.

Recent Reports:

Choquette, A.F., and Katz, B.G., 1989, Grid-based ground-water sampling—Lessons from an extensive regional network for 1,2-dibromoethane (EDB) in Florida: International Association for the Hydrologic Sciences, Conference Proceedings, Publication 182, May 1989, 79-86 p.

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Elder, J.F., 1989, Applicability of ambient toxicity testing to national or regional water-quality assessment: U.S. Geological Survey Open-File Report 89-55, 102 p.

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McKenzie, S.W., and Curtiss, D.A., 1989, Surface-water-quality assessment of the Yakima River basin, Washington—A pilot study: U.S. Geological Survey Open-File Report 89-60, 2 sheets.

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Parkhurst, D.L., Christenson, S.C., and Schlottman, J.L., 1989, Ground-water-quality assessment of the Central Oklahoma aquifer, Oklahoma—Analysis of available water-quality data through 1987: U.S. Geological Survey Open-File Report 88-728, 80 p.

Rinella, J.F., McKenzie, S.W., and Fuhrer, G.J., 1992, Surface-water-quality assessment of the Yakima River basin, Washington: Analysis of available water-quality data through 1985 water year: U.S. Geological Survey Open-File Report 91-453, 244 p.

Thomas, J.T., Welch, A.H., and Gunderson, L.S., 1990, Distribution and sources of uranium in ground water in the Carson River basin, western Nevada and eastern California, U.S.A.: Eos, American Geophysical Union Transactions, v. 71, no. 43, p. 1305.

Welch, A.H., Plume, R.W., Frick, E.A., and Hughes, J.L., 1991, Ground-water-quality assessment of the Carson River basin, Nevada and California—Analysis of available water-quality data through 1987: U.S. Geological Survey Open-File Report 89-382, 115 p., 2 sheets, scale 1:250,000.

Zogorski, J.S., Blanchard, S.F., Romack, R.D., and Fitzpatrick, F.A., 1990, Availability and suitability of municipal wastewater information for use in a national water-quality assessment: A case study of the upper Illinois River basin in Illinois, Indiana, and Wisconsin: U.S. Geolgoical Survey Open-File Report 90-375, 68 p.

Funding

	Fiscal year (dollars in millions)				
Source of funds	1988	1989	1990	1991	1992
Federal Program	7.2	7.1	7.0	18.2	28.5

Keywords

Ground-water quality, Surface-water quality, Regional assessment, United States.

Regional Aquifer-System Analysis Program

The RASA Program is a systematic study of a number of regional ground-water systems that represent a significant part of the Nation's water supply. A regional aquifer system may be of two general types: aquifers that are of regional extent, such as those beneath the Northern Great Plains, or groups of aquifers that share so many characteristics that investigation of a few of these aquifers can establish principles and hydrologic factors that control the occurrence, movement, and quality of ground water throughout the other aquifer systems. The purpose of the program is to provide the basic information and criteria needed to develop and manage ground-water supplies from a regional perspective.

Activities

- Determines the availability and chemical quality of water stored in each aquifer system.
- Determines the discharge-recharge characteristics and water budgets of each aquifer system.
- Determines the hydrogeologic and chemical controls that govern the response of aquifer systems to stresses.
- Develops computer-simulation models to assist in understanding the ground-water-flow regime and the changes in this regime brought about by human activities, such as withdrawal of water from an aquifer or artificial recharge to an aquifer.

Recent Accomplishments

- Identified 25 aquifer systems for study. Eighteen RASA field studies were completed: Central Midwest, Central Valley (California), Floridan aquifer system, Great Basin of Nevada and Utah, High Plains, Northern Great Plains, Northern Midwest, Snake River Plain, Southwest Alluvial Basins, Southeastern Coastal Plain, Northern Atlantic Coastal Plain, Upper Colorado River basin, Columbia Plateau, Oahu, Northeast Glacial aquifers, Caribbean Islands, San Juan basin, and Gulf Coastal Plain. Seven other studies are underway.
- Published more than 900 reports that describe the scientific findings of the RASA studies.
- Demonstrated the use of computer models to simulate the dynamic three-dimensional flow in the regional aquifers. During the investigations, simulation capabilities have evolved from the normal flow simulation to incorporating the effects of temperature in deep circulation zones, salt concentration on ground-water flow, and well penetration into many aquifer layers that "short circuit" flow systems of several individual aquifers; the interaction between streamflow and ground-water flow; and land subsidence due to withdrawals.
- Analyzed digitized satellite imagery to establish the distribution and intensity of agricultural irrigation and, with further interpretation, the magnitude of ground-water withdrawals.
- Developed geochemical concepts and models that evaluate interactions between solutes in water and minerals in aquifer material and the use of stable isotopes to infer the origin and age of ground water.
- Published the second segment of a "*Ground Water Atlas of the United States.*" This segment identifies all the important aquifers that underlie the States of Iowa, Michigan, Minnesota, and Wisconsin and presents maps and diagrams that locate and describe the properties of each aquifer (Olcott, 1992).
- Provided information to Federal, State, and local agencies. The New Jersey Department of Environmental Protection used a flow model developed by the Atlantic Coastal Plain RASA study team to manage the Coastal Plain aquifer in New Jersey in designated critical areas. The U.S. Bureau of Reclamation, the U.S. Fish and Wildlife Service, the U.S. Environmental Protection Agency, and the U.S. Department of Agriculture used RASA information to evaluate the effects on water resources of agricultural practices in the San Joaquin Valley of California. The South Carolina Department of Health and Environmental Control used RASA information to determine the relationship between waste-disposal sites and well locations. The U.S. Internal Revenue Service used information from the High Plains RASA study to evaluate tax depletion allowance. The Federal Land Bank used depth-to-water information resulting from the High Plains RASA study to appraise farm lands on the High Plains. Idaho water agencies used information resulting from the Snake River Plain RASA study in negotiations of water rights between irrigators and hydropower companies. The Idaho Department of Health and Welfare used Snake River Plain RASA information in the development of a Snake River aquifer management strategy and ground-water-quality management plan.

Recent Reports:

Anderson, T.W., Freethey, G.W., and Tucci, Patrick, 1992, Geohydrology and water resources of alluvial basins in south-central Arizona and parts of adjacent states: U.S. Geological Survey Professional Paper 1406-B, 67 p.

Freethey, G.W., and Cordy, G.E., 1991, Geohydrology of Mesozoic rocks in the Upper Colorado River basin in Arizona, Colorado, New Mexico, Utah, and Wyoming, excluding the San Juan basin: U.S. Geological Survey Professional Paper 1411-C, 118 p.

Frenzel, P.F., and Kaehler, C.A., 1992, Geohydrology and simulation of ground-water flow in the Mesilla basin, Dona Ana County, New Mexico, and El Paso County, Texas, *with a section on* Water quality and geochemistry, by S.K. Anderholm: U.S. Geological Survey Professional Paper 1407-C, 105 p.

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Miller, J.A., 1992, Summary of the hydrology of the Southeastern Coastal Plain aquifer system in Mississippi, Alabama, Georgia, and South Carolina: U.S. Geological Survey Professional Paper 1410-A, 38 p.

Newton, G.D., 1991, Geohydrology of the regional aquifer system, western Snake River Plain, southwestern Idaho: U.S. Geological Survey Professional Paper 1408-G, 52 p.

Olcott, P.G., 1992, Ground water atlas of the United States—Segment 9, Iowa, Michigan, Minnesota, and Wisconsin: U.S. Geological Survey Hydrologic Atlas 730-J, 31 p.

Robertson, F.N., 1991, Geochemistry of ground water in alluvial basins of Arizona and adjacent parts of Nevada, New Mexico, and California: U.S. Geological Survey Professional Paper 1406-C, 90 p.

Trapp, Henry, Jr., 1992, Hydrogeologic framework of the Northern Atlantic Coastal Plain in parts of North Carolina, Virginia, Maryland, Delaware, New Jersey, and New York: U.S. Geological Survey Professional Paper 1404-G, 59 p.

Trapp, Henry, Jr., and Meisler, Harold, 1992, The regional aquifer system underlying the Northern Atlantic Coastal Plain in parts of North Carolina, Virginia, Maryland, Delaware, New Jersey, and New York—Summary: U.S. Geological Survey Professional Paper 1404-A, 33 p.

Vorblesky, D.A., and Fleck, W.B., 1991, Hydrogeologic framework of the Coastal Plain of Maryland, Delaware, and the District of Columbia: U.S. Geological Survey Professional Paper 1404-E, 45 p.

Weiss, J.S., 1992, Geohydrologic units of the coastal lowlands aquifer system, south-central United States: U.S. Geological Survey Professional Paper 1416-C, 32 p.

Whitehead, R.L., 1992, Geohydrologic framework of the Snake River Plain regional aquifer system, Idaho and eastern Oregon: U.S. Geological Survey Professional Paper 1408-B, 32 p.

Young, H.L., 1992, Summary of ground-water hydrology of the Cambrian-Ordovician aquifer system in the northern Midwest, United States: U.S. Geological Survey Professional Paper 1405-A, 55 p.

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Funding

	Fiscal year (dollars in millions)				
Source of funds	1988	1989	1990	1991	1992
Federal Program	11.5	11.1	10.8	10.7	8.6

Keywords

RASA, Water supply, Aquifers, Ground-water management, Ground-water supplies, Ground-water quality, Computer models, Geochemistry of water, Regional ground-water studies.

Acid Rain Program

Since the late 1950's, the WRD has conducted numerous studies of the effects of precipitation chemistry on water quality, both in Federally funded research and in the Federal-State Cooperative Program. In 1982, because of increasing concern about the possible environmental effects of "acid rain," the WRD significantly increased the level of hydrologic research and broadened the program to include the effects of atmospheric deposition on limestone and marble building stones. In 1984, the WRD established an Office of Atmospheric Deposition Analysis to coordinate the acid-rain research.

The WRD Federal acid rain program has been carried out as part of the Federal interagency National Acid Precipitation Assessment Program (NAPAP) that was established by the Acid Precipitation Act of 1980 (Title VII of Public Law 96-294). Although the NAPAP statutory "sunset" was to have been September 30, 1990, the program was continued under the Clean Air Act Amendments of 1990 (Public Law 101-54). Purposes of the WRD program are to monitor the chemical composition of precipitation (rain and snow) nationwide and describe its variability geographically and with time; to determine the susceptibility of lakes and streams to acidification and to monitor susceptible areas for long-term changes, that may result from acidic deposition; to define the geochemical and hydrologic processes by which acidic deposition affects the quality of surface and ground waters in the United States; and to define the geochemical and atmospheric processes by which acidic deposition damages carbonate building stones.

Activities

- Serves in NAPAP as lead agency for the Task Group on Deposition Monitoring and is a member of the Working Group on Effects on Materials and Cultural Resources and the Task Group on Aquatic Effects.
- Coordinates the 150-site National Trends Network for monitoring precipitation chemistry nationwide. The WRD operates about 60 sites in the network; other sites are operated by a variety of Federal, State, university, and private organizations.
- Monitors 13 sites for long-term changes in water quality in areas identified by the Aquatic Effects Task Group as being sensitive to the effects of acid rain.
- Conducts studies in seven watersheds to define geochemical and hydrologic processes by which acidic deposition affects the quality of streams, lakes, and ground water.
- Conducts studies at three test-sample exposure sites and in the laboratory to define geochemical and atmospheric processes by which acidic deposition damages carbonate building stones.

Recent Accomplishments

- Produced a videotape for use in training operators of precipitation monitoring sites in the National Trends Network.
- Contributed to preparation of several of the set of 28 State-of-Science/State-of-Technology (SOS/T) reports that constitute a large part of the NAPAP final Phase I report to the President and Congress on its research results. Reports involving WRD contributors include SOS/T Report 6: Deposition Monitoring—Methods and Results, SOS/T Report 10: Watershed and Lake Processes Affecting Surface Water Acid-Base Chemistry, and SOS/T Report 19: Effects of Acidic Deposition on Materials. Also contributed to the Integrated Assessment report for Phase I.

Recent Reports:

Baedecker, P.A., Reddy, M.M., Reimann, K.J., and Sciammarella, C.A., 1992, Effects of acidic deposition on the erosion of carbonate stone—experimental results from the U.S. National Acid Precipitation Assessment Program (NAPAP): Atmospheric Environment, v. 26B, no. 2, p. 147-158.

Bricker, O.P., and Rice, K.C., 1989, Acidic deposition to streams: Environmental Science and Technology, v. 23, no. 4, p. 379-385.

Hooper, R.P., and Peters, N.E., 1989, Use of multivariate analysis for determining sources of solutes found in wet atmospheric deposition in the United States: Environmental Science and Technology, v. 23, no. 10, p. 1263-1268.

Puckett, L.J., 1990, Estimates of ion sources in deciduous and coniferous throughfall: Atmospheric Environment, v. 24A, no. 3, p. 545-555.

Puckett, L.J., and Bricker, O.P., 1992, Factors controlling the major ion chemistry of streams in the Blue Ridge and Ridge and Valley physiographic provinces of Virginia and Maryland: Hydrological Processes, no. 6, p. 79-98.

Stoddard, J.L., and Murdoch, P.S., 1991, Catskill Mountains: an overview of chronic and episodic acidity in dilute mountain streams, *in* Charles, D.F., ed., Acid deposition and aquatic ecosystems: Regional case studies: New York, Springer Verlag, p. 237-271.

Funding

	Fiscal year (dollars in millions)				
Source of funds	1988	1989	1990	1991	1992
Federal Program	3.0	2.9	2.9	3.1	3.2

Keywords

Acid rain, Precipitation, Acidic, Water quality, Materials damage.

Volcano Hazards Program

The USGS, has the primary responsibility in the Federal Government for investigating volcano hazards. Water-related activities include describing the nature and rates of hydrologic processes involved in cataclysmic volcano-related events, monitoring water resources in areas of potential volcanic eruption, defining mudflow and debris-flow hazards, and developing information for resource planning and management.

Activities

- Conducts studies and develops mathematical models to describe floods, sediment transport, and mudflows.
- Conducts geomorphic studies of the Mount St. Helens debris avalanche and mudflow deposits to assess and document the effects of continuing erosion and channel filling.
- Monitors and re-evaluates the stability of Mount St. Helens debris-dammed lakes.
- Monitors the Long Valley, California, hydrologic system for changes precursory to, or in response to, volcanic processes.
- Assesses volcanic hazards associated with lahars (debris flows from volcanoes) on a variety of volcanoes. Major activities include assessments at Mount St. Helens, Washington; Mount Hood, Oregon; and Mount Redoubt, Alaska.
- Provides consultation to other countries that have volcanic hazards.

Recent Accomplishments

- Measured and documented floods resulting from eruptions of Mount Redoubt, Alaska.
- Identified debris-flow hazards from Mount Rainier, Washington.
- Identified debris-flow hazards from Mount Shasta, California.
- Identified downstream changes in the properties of mudflows generated during the initial phases of the May 14, 1984, explosive event of Mount St. Helens by measuring velocity, discharge, and sediment concentrations along the Toutle River.
- Developed estimation techniques for determining ice volumes of glaciers on Cascade Range volcanoes to evaluate the magnitude of possible flooding during a volcanic eruption.
- Constructed and began initial operation of the 95-meter long concrete flume for debris-flow investigations at the H.J. Andrews Experimental Forest near Eugene, Oregon, in cooperation with the U.S. Forest Service.

Recent Reports:

Costa, J.E., and Schuster, R.L., 1988, The formation and failure of natural dams: Geological Society of America Bulletin, v. 100, no. 7, p. 1054-1068.

Farrar, C.D., Sorey, M.L., Rojstaczer, S.A., Steinemann, A.C., and Clark, M.D., 1989, Hydrologic and geochemical monitoring in Long Valley Caldera, Mono County, California, 1986: U.S. Geological Survey Water-Resources Investigations Report 89-4033, 69 p.

Hupp, C.R., Osterkamp, W.R., and Thornton J.L., 1987, Dendrogeomorphic evidence and dating of recent debris flows on Mount Shasta, northern California: U.S. Geological Survey Professional Paper 1396-B, p. B1-B39.

Iverson, R.M., and LaHusen, R.G., 1989, Dynamic pore-pressure fluctuations in rapidly shearing granular material: Science, v. 246, no. 4931, p. 796-799.

Iverson, R.M., and Reid, M.E., 1992, Gravity-driven groundwater flow and slope failure potential, parts 1 and 2: Water Resources Research, v. 28, p. 925-950.

Major, J.J., and Newhall, C.G., 1989, Snow and ice perturbation during historical volcanic eruptions and the formation of lahars and floods—A global review: Bulletin of Volcanology, v. 52, p. 1-27.

Meyer, William, and Sabol, M.A., 1989, Hydrology of the Castle Lake blockage, Mount St. Helens, Washington: U.S. Geological Survey Water-Resources Investigations Report 87-4272, 25 p.

Pierson, T.C., 1989, Hazardous hydrologic consequences of volcanic eruptions and goals for mitigative action—An overview, *in* Hydrology and disasters, Geneva, Switzerland, November 2-3, 1988: London, England, James and James, 17 p.

Scott, K.M., 1988, Origins, behavior, and sedimentology of lahars and lahar runout flows in the Toutle-Cowlitz River system: U.S. Geological Survey Professional Paper 1447-A, p. A1-A74.

Scott, K.M., Pringle, P.T., and Vallance, J.W., 1992, Sedimentology, behavior, and hazards of debris flows at Mount Rainier, Washington: U.S. Geological Survey Open-File Report (prior to release as Professional Paper) 90-385, 106 p.

Funding

Source of funds	Fiscal year (dollars in millions)				
	1988	1989	1990	1991	1992
Federal Program	3.4	3.4	3.3	4.5	4.2

Keywords

Volcanoes, Volcanic hazards, Lahars, Debris flows, Mudflows, Hazards.

National Water Summary Program

Periodic analysis of the condition of the Nation's water resources is needed to evaluate the effectiveness of water programs and to assist in the formulation of water policies. The National Water Summary Program assembles and synthesizes information about changes and trends in the availability, quality, and use of water resources. Objectives of the program are to describe the nature and extent of water issues, to develop and maintain maps and national summary statistics to describe water conditions, to improve methods of evaluating and characterizing effects of land and water uses on the distribution and availability of water resources, and to conduct research to improve techniques for summarizing water-resources conditions.

Activities

- Assembles and synthesizes existing information about water availability, quality, and use; trends in water conditions; and the nature of water issues.
- Publishes a biennial water summary, which describes hydrologic events and water conditions, and discusses major water issues of concern.

Recent Accomplishments

- Developed a data base from which national maps of pesticide application have been made and prepared for publication. The data base contains county-level data on application of 90 pesticides.
- Published five National Water Summary reports (U.S. Geological Survey, 1984; 1985; Moody and others, 1986; 1988; Carr and others, 1990).
- Created the water-quality data base and PT2 software, which have been used successfully to analyze water-quality data by hydrologists in every District. This accomplishment provided for the preparation of the 1990-91 National Water Summary and spun off into a support system for the NAWQA program and highly visible cooperation with the USEPA.

Recent Reports:

Carr, J.E., Chase, E.B., Paulson, R.W., and Moody, D.W., compilers, 1990, National water summary 1987—Hydrologic events and water supply and use: U.S. Geological Survey Water-Supply Paper 2350, 553 p.

Moody, D.W., Carr, Jerry, Chase, E.B., and Paulson, R.W., compilers, 1988, National water summary 1986—Hydrologic events and ground-water quality: U.S. Geological Survey Water-Supply Paper 2325, 560 p.

Moody, D.W., Chase, E.B., and Aronson, D.A., compilers, 1986, National water summary 1985—Hydrologic events and surface-water resources: U.S. Geological Survey Water-Supply Paper 2300, 506 p.

U.S. Geological Survey, 1984, National water summary 1983—Hydrologic events and issues: U.S. Geological Survey Water-Supply Paper 2250, 243 p.

———1985, National water summary 1984—Hydrologic events, selected water-quality trends, and ground-water resources: U.S. Geological Survey Water-Supply Paper 2275, 467 p.

———1990, National water summary 1987—Hydrologic events and water supply and use: U.S. Geological Survey Water-Supply Paper 2350, 553 p.

———1991, National water summary 1988-89—Hydrologic events and floods and droughts: U.S. Geological Survey Water-Supply Paper 2375, 591 p.

Funding

	Fiscal year (dollars in millions)				
Source of funds	1988	1989	1990	1991	1992
Federal Program	1.4	1.4	1.4	1.6	1.7

Keywords

Water-resources assessment, Policy, Trends, Issues, Statistical summary, Conditions, Land use, Water, Water quality, Supply and demand, Water use, Floods, Droughts.

Wetlands

Wetlands, one of the Nation's most important natural resources, serve a variety of hydrologic functions, including flood storage and flood abatement, nutrient cycling, and sediment retention and stabilization. The WRD wetland investigations are directed at increasing understanding of basic hydrologic, geologic, and biogeochemical processes in wetlands. The WRD collects, analyses, and disseminates information on wetlands for Federal and State agencies.

Activities

- Conducts studies throughout the United States on various aspects of wetland hydrology, including hydrogeology of selected wetlands, effects of ground-water pumpage on wetlands, and evapotranspiration from wetlands.
- Investigates the effects of wetlands on water quality, sediment deposition, and nutrient cycling in many States, including Massachusetts, Colorado, Arkansas, Oregon, North Dakota, and New York.
- Conducts studies of contaminants in wetlands including selenium in Utah and mercury in Wisconsin.
- Assesses the effectiveness of wetlands as wastewater-treatment sites.
- Assists agencies responsible for wetland management and regulation, such as the U.S. Fish and Wildlife Service, the U.S. Army Corps of Engineers, the USEPA, the National Oceanic and Atmospheric Administration, and the Federal Highway Administration.
- Conducts long-term research on the submersed aquatic macrophyte populations (aquatic bed wetlands) in the tidal Potomac River. Emphasis is on the factors controlling the distribution and abundance of submerged aquatic vegetation populations and on the effects of tidally controlled fluxes of water from these wetlands on water chemistry in the river.

Recent Accomplishments

- Developed a conceptual framework for assessing cumulative effects on the hydrology of nontidal wetlands.
- Demonstrated that high selenium concentrations in wetlands in the Ouray National Wildlife Refuge and other wetlands in Utah were responsible for death and population declines in various waterfowl species.
- Determined that the water chemistry of prairie pothole wetlands is dependent upon their position in the ground-water-flow system, as well as the duration or permanence of water.
- Increased understanding of the relation of wetlands to ground- and surface-water-flow systems and ground-water recharge and discharge.
- Showed that submerged plant growth and survival in the tidal Potomac River and estuary is primarily related to the availability of light. Light penetration is affected by suspended sediment and phytoplankton. Reduction of nutrient loading in the tidal river decreased the probability of severe algal blooms, such as have occurred in past years, and resulted in the return of submersed aquatic plant beds after an absence of decades.
- Worked cooperatively with the USEPA's Chesapeake Bay Program, the Virginia Institute of Marine Science, the University of Maryland, and Harford Community College to synthesize water-quality and vegetation data from four different regions of the bay and to develop habitat requirements and restoration goals for submersed aquatic vegetation.
- Obtained data at the Cottonwood Lake area National Waterfowl Production area in North Dakota between 1988 and 1992, which continued to show how wetlands respond to persistent dry conditions. These responses differ depending upon the position of the wetland with respect to the ground-water-flow system. Changes in the relation of a wetland to ground water can affect recharge-discharge relations, salinity within the wetland, and the vegetative composition of the wetland. Dry conditions at the site appeared to reflect local phenomenon as wetlands tens of miles to the west and east still contain water.
- Selected wetland resources as the topic of the 1992-93 National Water Summary by the USGS. Invited contributions to the report have been drawn from the Nation's leading wetland scientists. Emphasis of the report will be on hydrologic functions, but other aspects of wetlands to be discussed include current Federal, State, and local government activities. Much of the report is dedicated to individual articles on wetlands of each State. Prototypes of the State articles are nearing completion.

Recent Reports:

Carter, Virginia, and Rybicki, N.B., 1990, Light attenuation and submersed macrophyte distribution in the tidal Potomac River and Estuary: Estuaries, v. 13, no. 4, p. 441-451.

Carter, Virginia, Rybicki, N.B., and Hammerschlag, Richard, 1991, Effects of submersed macrophytes on dissolved oxygen, pH, and temperature under different conditions of wind, tide and bed structure: Journal of Freshwater Ecology, v. 6, no. 2, p. 121-133.

LaBaugh, J.W., 1988, Relation of hydrogeologic setting to chemical characteristics of selected lakes and wetlands within a climate gradient in the North-Central United States: Verhandlungen Internationale Vereinigung Limnologie, v. 23, p. 131-137.

_____1989, Chemical characteristics of water in northern prairie wetlands, *in* van der Valk, A., ed., Northern prairie wetlands: Ames, Iowa, Iowa State University Press, p. 56-90.

_____1991, Spatial and temporal variation in chemical characteristics of ground water adjacent to selected lakes and wetlands in the North-Central United States: Verhandlungen Internationale Vereinigung Limnologie, v. 24, p. 1588-1594.

LaBaugh, J.W., and Swanson, G.A., 1992, Changes in chemical characteristics of water in selected wetlands in the Cottonwood Lake area, North Dakota, U.S.A., 1967-89, *in* Robarts, R.D., and Bothwell, M.L., eds., Aquatic Ecosystems in semi-arid regions, Implications for Resource Management: Saskatoon, Saskatchewan, Canada, Environment Canada, The National Hydrology Research Institute Symposium Series no. 7, p. 149-162.

LaBaugh, J.W., Winter, T.C., Adomaitis, V.A., and Swanson, G.A., 1987, Hydrology and chemistry of selected prairie wetlands in the Cottonwood Lake area, Stutsman County, North Dakota, 1979-82: U.S. Geological Survey Professional Paper 1431, 26 p.

Swanson, G.A., Winter, T.C., Adomaitis, V.A., and LaBaugh, J.W., 1988, Chemical characteristics of prairie lakes in south-central North Dakota—their potential for influencing use by fish and wildlife: U.S. Fish and Wildlife Service Technical Report 18, 44 p.

Funding

Funding for this activity for fiscal year 1992 is derived from several sources and is approximately $5.5 million.

Keywords

Wetlands, Nutrient cycling, Macrophytes, Waterfowl.

Flood Hazards

The WRD defines the magnitude and frequency of flood-peak discharges, the areas inundated, the changes in stream sediment transport, and the alterations to stream channels for use by flood-management agencies. The purposes of this activity are to provide flood information for use by managers and planners during and after floods; to improve the technology required by planners, designers, engineers, and decisionmakers to mitigate future flood losses of life, property, and income as a result of flooding; to contribute to better understanding of the hydrologic processes that control the occurrence and distribution of floods.

Activities

- Collects hydrologic data and information during extreme floods.
- Analyzes, interprets, and provides hydrologic data and information to the public and private sectors.
- Provides real-time streamflow data and other hydrologic information to support the flood forecasting and regulating activities of water-management agencies. For example, the National Weather Service (NWS) uses data from about 3,000 WRD-operated stations in forecasting river stages.

Recent Accomplishments

- Developed statistical techniques for estimating the frequency and magnitude of flooding in 16 States.
- Assessed flood hazards at bridges and other sites at more than 25 locations in more than 15 States.
- Applied limited hydraulic techniques to flood-insurance studies in 200 communities in 17 States. Study was conducted in cooperation with the Federal Emergency Management Agency (FEMA).
- Developed and tested improved methods of flood-frequency analysis and generalized least-squares regression analysis that ensure more accurate estimates of flood magnitude and frequency at ungaged sites.
- Developed paleohydrologic, geomorphic, and botanical techniques for identifying, dating, and quantifying historic floods.
- Documented the November 1985 floods in West Virginia, Virginia, Maryland, and Pennsylvania; the October 1986 floods in Alaska; the March 1987 floods in New York; the December 1987 floods in Arkansas and Tennessee; the February 1989 floods in Kentucky; 1990 floods in Oregon, Alabama, Georgia, Florida, Ohio, Arkansas, and Iowa, and about 15 other noteworthy floods.
- Documented the January 1982 floods in the San Francisco Bay area, California, and the March 1982 floods in Indiana and neighboring States in cooperation with the National Weather Service (NWS).
- Completed model studies of backwater and flow distribution at proposed highway crossings of the Sabine River, Texas (Gilbert and Myers, 1989), and the Congaree River, South Carolina, and at the New York State Thruway crossing of Schoharie Creek (Froehlich and Trent, 1989).

Recent Reports:

Burkham, D.E., 1988, Methods for delineating flood-prone areas in the Great Basin of Nevada and adjacent States: U.S. Geological Survey Water-Supply Paper 2316, 20 p.

Cobb, E.D., Evaluation of limited-detail methods for flood-insurance studies, *in* Proceedings of the 1990 Flood Plain Management Conference, Toronto, Canada, March 12-14, 1990: 16 p.

Cooley, M.E., 1990, Use of paleoflood investigations to improve flood-frequency analyses of plains streams in Wyoming: U.S. Geological Survey Water-Resources Investigations Report 88-4209, 75 p.

Froehlich, D.C., and Trent, R.E., 1989, Hydraulic analysis of the Schoharie Creek bridge, *in* Ports, M.A., ed., Hydraulic engineering—1989 National Conference on Hydraulic Engineering, New Orleans, Louisiana, August 14-18, 1989, Proceedings: American Society of Civil Engineers, p. 887-892.

Gilbert, J.J., and Myers, D.R., 1989, Analysis of water surface and flow distribution for the design flood at a proposed highway crossing of the Sabine River near Tatum, Texas: U.S. Geological Survey Water-Resources Investigations Report 88-4231, 36 p.

Glatfelter, D.R., and Chin, E.H., 1988, Floods of March 1982 in Indiana, Ohio, Michigan, and Illinois: U.S. Geological Survey Professional Paper 1467, 36 p.

Hjalmarson, H.W., and Thomas, B.E., 1992, New look at regional flood-frequency relations for arid lands: American Society of Civil Engineers, Journal of Hydraulic Engineering, v. 118, no. 6, p. 868-886.

Inman, E.J., 1987, Simulation of flood hydrographs for Georgia streams: U.S. Geological Survey Water-Supply Paper 2317, 26 p.

———1988, Flood-frequency relations for urban streams in Georgia: U.S. Geological Survey Water-Resources Investigations Report 88-4085, 36 p.

Jennings, M.E., Atkins, J.B., and Inman, E.J., 1989, Estimating urban flood-frequency characteristics, *in* Ports, M.A., ed., Hydraulic engineering—1989 National Conference on Hydraulic Engineering, New Orleans, Louisiana, August 14-18, 1989, Proceedings: American Society of Civil Engineers, p. 516-521.

Koltun, G.F., and Roberts, J.W., 1990, Techniques for estimating flood-peak discharges of rural, unregulated streams in Ohio: U.S. Geological Survey Water-Resources Investigations Report 89-4126, 68 p., 1 plate.

Krug, W.R., Conger, D.H., and Gebert, W.A., 1992, Flood-frequency characteristics of Wisconsin streams: U.S. Geological Survey Water-Resources Investigations Report 91-4128, 185 p.

McClain, D.L., 1990, Flood of February 1989 in Kentucky: U.S. Geological Survey Open-File Report 90-158, 13 p.

Parrett, Charles, Hull, J.A., and Omang, R.J., 1987, Revised techniques for estimating peak discharges from channel width in Montana: U.S. Geological Survey Water-Resources Investigations Report 87-4121, 34 p.

Sauer, V.B., 1989, Urban flood frequency and hydrograph analysis, *in* Ports, M.A., ed., Hydraulic engineering—1989 National Conference on Hydraulic Engineering, New Orleans, Louisiana, August 14-18, 1989, Proceedings: American Society of Civil Engineers, p. 379-385.

Sloto, R.A., 1988, Effects of urbanization on storm-runoff volume and peak discharge of Valley Creek, eastern Chester County, Pennsylvania: U.S. Geological Survey Water-Resources Investigations Report 87-4196, 32 p.

Thomas, W.O., Jr., and Landers, M.N., 1989, Regionalization of flood characteristics, *in* Ports, M.A., ed., Hydraulic engineering—1989 National Conference on Hydraulic Engineering, New Orleans, Louisiana, August 14-18, 1989, Proceedings: American Society of Civil Engineers, p. 372-378.

Webb, R.H., and Betancourt, J.L., 1992, Climatic variability and flood frequency of the Santa Cruz River, Pima County,Arizona: U.S. Geological Survey Water-Supply Paper 2379, 40 p.

Funding

About $5 million was expended in fiscal year 1990 to conduct flood-related investigations in cooperation with States and other Federal agencies. The FEMA provided about $0.7 million to conduct flood-insurance studies. An additional $1 million was expended on research related to methods of flood measurement, computation, and statistical analysis. Finally, about $5 million of the cost of operating surface-water gaging stations can be attributed to the collection, analysis, and documentation of flood data. Information for fiscal year 1992 is not available.

Keywords

Hazards, Floods, Sediment transport, Stream channels, Streamflow, National Weather Service, Stage, Statistical summary, Insurance, Federal Emergency Management Agency, Federal-State Cooperative Program.

Urban Hydrology

The WRD has been studying urban runoff since the 1950's. Since 1971, the WRD has conducted 104 urban hydrology studies, some of which are continuing. These studies have investigated the effects of urbanization on runoff quantity (especially of peak flows), sediment transport, and runoff quality. From 1979 to 1983, the WRD conducted an intensive study of urban-runoff quality in cooperation with the USEPA.

Activities

- Acquires and analyzes urban-runoff and runoff-quality data from a number of communities throughout the United States.
- Assembles urban-runoff and runoff-quality data and documents the data for ready availability to users.
- Analyzes urban runoff data so that estimates of runoff characteristics can be made at ungaged sites and the effects of runoff control measures can be evaluated.
- Evaluates national methods for urban-runoff and runoff-quality prediction.

Recent Accomplishments

- Continued operation of four highly instrumented urban stormwater-detention sites in Florida, Kansas, New York, and Wisconsin.
- Compiled and analyzed urban atmospheric deposition water-quality data for 31 gaging sites in 10 cities.
- Compiled a map report for 95 urban stormwater sites in 22 cities.
- Completed national statistical regionalization of urban stormwater quality for stormwater loads, event mean concentrations, and for long-term annual and seasonal characteristics. Three reports and two journal articles were published; one journal article won the 1989 American Water Resources Association award for best paper.
- Supported the work of Task Committees by the American Society of Civil Engineers on the USGS Urban Gaging Networks and Urban Stormwater Detention.
- Planned a study of nationwide urban flood-frequency prediction in cooperation with the U.S. Department of Agriculture, Soil Conservation Service.
- Completed documentation of a microcomputer program for National Flood Frequency (NFF) in association with the Federal Highway Administration and the FEMA. NFF makes urban flood-peak and hydrograph estimates.
- Began national activity related to the USEPA municipal permitting regulation passed November 16, 1990. WRD has ongoing programs in 25 cities in 12 States comprising state-of-the-art monitoring programs at 125 sites. The urban stormwater-quality monitoring sites operated by USGS are located on small land use catchments and include monitoring of rainfall, runoff, and water chemistry for 140 chemical constituents. The largest WRD monitoring network is located in the Dallas-Ft. Worth, Texas, area and includes 30 sites with a sampling of 210 water-quality storm events. The national WRD stormwater-quality program under the National Pollution Discharge Elimination System (NPDES) program aggregates to about $7 million (two-thirds unmatched). The program is expected to continue for 5 years at most sites.

Recent Reports:

Driver, N.E., Mustard, M.H., Rhinesmith, R.B., and Middelburg, R.F., 1985, U.S. Geological Survey urban-stormwater data base for 22 metropolitan areas throughout the United States: U.S. Geological Survey Open-File Report 85-337, 219 p.

Driver, N.E., and Tasker, G.D., 1988, Techniques for estimation of storm-runoff loads, volumes, and selected constituent concentrations in urban watersheds in the United States: U.S. Geological Survey Water-Supply Paper 2363, 44 p.

Ebbert, J.C., and Wagner, J.R., 1987, Contributions of rainfall to constituent loads in storm runoff from urban catchments: Water Resources Bulletin, v. 23, no. 5, p. 867-871.

Jennings, M.E., ed., 1991, Urban hydrology symposium, Denver, Colorado, November 4-8, 1990, Proceedings: American Water Resources Association, 339 p.

Jennings, M.E., and Cookmeyer, E.N., 1989, Plans for national flood frequency by microcomputer, *in* Ports, M.A., ed., Hydraulic engineering—1989 National Conference on Hydraulic Engineering, New Orleans, Louisiana, August 14-18, 1989, Proceedings: American Society of Civil Engineers, p. 386-391.

Jennings, M.E., and Tasker, G.D., 1988, Estimation of urban stormwater quality, *in* Abt, S.R., and Gessler, Johannes, eds., Hydraulic engineering—1988 National Conference on Hydraulic Engineering, Colorado Springs, Colorado, August 8-12, 1988, Proceedings: American Society of Civil Engineers, p. 78-83.

Mustard, M.H., Driver, N.E., Chyr, John, and Hansen, B.G., 1988, U.S. Geological Survey urban-stormwater data base of constituent storm loads; characteristics of rainfall, runoff, and antecedent conditions; and basin characteristics: U.S. Geological Survey Water-Resources Investigations Report 87-4036, 328 p.

Pope, L.M., Jennings, M.E., and Thibodeaux, K.G., 1988, Instrumentation for a dry-pond detention study, *in* Abt, S.R., and Gessler, Johannes, eds., Hydraulic engineering—1988 National Conference on Hydraulic Engineering, Colorado Springs, Colorado, August 8-12, 1988, Proceedings: American Society of Civil Engineers, p. 84-89.

Tasker, G.D., and Driver, N.E., 1988, Nationwide regression models for predicting urban runoff water quality at unmonitored sites: Water Resources Bulletin, v. 24, no. 5, p. 1091-1101.

Funding

	Fiscal year (dollars in millions)				
Source of funds	1988	1989	1990	1991	1992
Federal Program	0.2	0.2	0.2	na[1]	na
Federal-State Cooperative Program	1.6	1.6	1.6	na	na
Total	1.8	1.8	1.8	na	na

[1]Not available.

Keywords

Urban hydrology, Runoff, Peak flow, Sediment, Environmental Protection Agency, Stormwater, Floods, Soil Conservation Service, Atmospheric deposition, Federal Emergency Management Agency.

Nonpoint Sources of Pollution

Diffuse nonpoint sources of water pollution, such as agricultural and urban runoff, constitute a continuing threat to water quality that is neither well understood nor defined. The WRD conducts water-quality investigations that encompass almost all aspects of the hydrology of nonpoint sources—from collecting and reporting hydrologic data to conducting basic research to better understand the fundamental processes that control nonpoint-source pollution.

Activities

- The NAWQA describes the status and trends of the Nation's surface- and ground-water resources. A major focus of the program is estimating the contribution of nonpoint sources to water pollution.
- Data collection and analysis includes operation of continuous-record stream gages, which are used to compute pollution loads, and water-quality monitoring stations. The NASQAN and the Bench-Mark Networks are part of this effort.
- Within the Federal-State Cooperative Program, a number of nonpoint-source effects, such as agriculture, storm runoff, and the effects of land-management practices, are evaluated on a local or regional scale.
- The Toxic Substances Hydrology Program includes such nonpoint-pollution components as the effects of agriculture and urban areas, ground-water contamination, and land use.
- The NRP improves knowledge of the fundamental processes that affect the fate and transport of sediment and chemicals through hydrologic systems. Nonpoint-pollution components include sediment, nutrient, and trace element studies.

Recent Accomplishments

- A reconnaissance of surface waters in 10 Midwestern States determined that detectable levels of triazine herbicides were present in 55 percent of the 150 stream sites. The streams were sampled in early spring 1989 before new application of herbicides to fields. Subsequent sampling after herbicide application yielded detectable levels at about 90 percent of the sites.
- Recently established ground-water-quality monitoring programs have detected pesticides in a significant number of shallow ground-water supplies throughout Iowa. Increasing concern about the leaching of agricultural chemicals into aquifers has highlighted the need to better understand the movement of these contaminants. Data collected by the State indicate that nearly 56 million pounds of herbicides are applied annually to Iowa fields.
- An initial effort to document the occurrence of pesticides and nitrate in intensively developed agricultural areas of Missouri took place in 1986 and 1987. Ground water and streams were sampled at 129 sites in the southeast lowlands area. As a result, 23 different pesticides were detected, and at least 1 pesticide was present at most sites. Nitrate concentrations exceeded drinking water standards in 10 of 40 samples from domestic water supplies. This effort continued in 1988 with collection of samples from about 60 domestic wells in northwestern Missouri.
- The USGS and the City of Memphis, Tennessee, began a study of hazardous wastes at a closed landfill, which also is an USEPA Superfund site. Concern exists about possible contamination of the underlying aquifer that provides drinking water for almost 1 million people. Toxic wastes at this site are residues of pesticide manufacturing, which have been detected in local soils, sediments, biota, and ground and surface waters.

Funding

Funding for USGS activities related to nonpoint-source pollution does not appear as a line item in the USGS budget, but is derived from multiple sources because projects may occur in any of several Federal budget line items, as well as the Federal-State Cooperative Program.

Keywords

Nonpoint sources, Agriculture, Urban runoff, Pollution loads, Land management, Toxic substances, Pesticides.

Erosion and Sedimentation

Accelerated sedimentation is caused by such human activities as agriculture, timber harvesting, mining, urbanization, and the construction of dams and other channel-control structures. The purpose of the WRD sediment activities is to provide a more complete understanding of sedimentation processes and to develop and use mathematical models to estimate the effect of human activities on stream systems.

Activities

- Collects, analyzes, and reports data on sediment concentration, discharge, and particle-size deposition at about 170 surface-water stations nationwide on a daily basis and at about 900 stations on a periodic basis.
- Conducts special studies to define sedimentation problems in specific locations and to transfer the results and knowledge to other areas with similar problems. About 100 sedimentation-related studies are in progress; a like number of studies have sedimentation as a secondary issue.
- Conducts research projects on measurement and prediction of sediment transport, mechanics of bedload-transport processes, storage of sediment in river systems, cumulative effects of sediment resulting from coal mining, development of sediment-sampling and sediment-analysis instruments, and changes in channel form as a result of river regulation.

Recent Accomplishments

- Developed sediment-sampling instruments used by all Federal agencies and many foreign countries for the collection of sediment data (Beverage and Williams, 1989; Tai and others, 1991).
- Documented sediment transport by the Colorado River and its tributaries in the Grand Canyon for use by the U.S. Bureau of Reclamation and the WRD in evaluating proposed power generation release cycles from Glen Canyon Dam, Arizona (Andrews, 1990).
- Developed techniques to estimate recurrence intervals of debris and mudflows connected with activities of the Cascade Range volcanoes. This information is being developed for use by Federal and State planning agencies in designing dams, roads, and bridges (Hammond, 1989; Dinehart, 1991).
- Defined the effects of channelization of streams in western Tennessee (Simon, 1989).
- Documented the effects of sedimentation on a proposed reservoir (Naftz and Barclay, 1991).
- Conducted two new projects of national scope: measurement of stream-channel scour at bridges during floods (Landers and Trent, 1991) and evaluation of the potential for scour at bridges in participating States (Butch, 1991).

Recent Report:

Andrews, E.D., 1990, Sediment transport in the Colorado River basin: Colorado Ecosystem and Dam Management Symposium, Santa Fe, New Mexico, May 25-26, 1990, 43 p.

Beverage, J.P., and Williams, D.T., 1989, Comparison: US P-61 and Delft sediment samplers: Journal of Hydraulic Engineering, v. 115, no. 12, p. 1702-1706.

Butch, G.K., 1991, Measurement of scour at selected bridges in New York, *in* Federal Interagency Sedimentation Conference, 5th, Las Vegas, Nevada, March 18-21, 1991, Proceedings: Subcommittee on Sedimentation, Interagency Advisory Committee on Water Data, v. 1, p. 2-113-2-120.

Dinehart, R.L., 1991, Sediment data for streams near Mount St. Helens, Washington, v. 3, Water years, 1984-87: Open-File Report 91-219, 166 p.

Hammond, S.E., 1989, Comparison of sediment transport formulas and computation of sediment discharges for the North Fork Toutle and Toutle Rivers, near Mount St. Helens, Washington: U.S. Geological Survey Open-File Report 88-463, 18 p.

Landers, M.L., and Trent, R.E., 1991, A national bridge scour data collection program: Nashville, Tennessee, American Society of Civil Engineers Symposium, 10 p.

Naftz, D.L., and Barclay, C.S.V., 1991, Selenium and associated trace elements in soil, rock, water, and streambed sediment of the proposed Sandstone Reservoir, south-central Wyoming: U.S. Geological Survey Water-Resources Investigations Report 91-4000, 69 p.

Sams, J.I., III, and Witt, E.C., III, Simulation of streamflow and sediment transport in two surface-coal-mined basins in Fayette County, Pennsylvania: Water-Resources Investigations Report 92-4093, 106 p.

Simon, Andrew, 1989, The discharge of sediment in channelized alluvial streams: Water Resources Bulletin, v. 25, no. 6, p. 1177-1188.

Tai, D.Y., Jennings, M.E., White, K.D., and Garcia, L.A., 1991, Evaluation of a modified automatic sampler for the collection of water samples for analysis of trace organic compounds or suspended sediment: U.S. Geological Survey Open-File Report 91-469, 26 p.

Funding

Funding in 1992 for the sediment and erosion program includes $3.9 million for sediment data collection, and $3.9 million for bridge-scour investigations. In addition, significant, but untabulated, funding exists for part or all of the many interpretive projects and research activities that deal with sediment and erosion.

Keywords

Erosion, Sediment, Stations, Bedload, Colorado River, Debris flow, Volcanoes, Reservoirs, Stream-channel scour.

Estuaries

Estuaries, which are highly productive ecosystems that provide habitats for waterfowl and fish populations, are among the most heavily used and important of the Nation's surface-water resources. Their value for water supply, commerce, recreation, and food depends, to a large extent, on the degree to which the estuaries are affected by human activities. Because estuaries trap and accumulate particulate matter and associated contaminants, they are particularly susceptible to nutrient enrichment and to contamination by toxic substances that are derived from municipal and industrial effluents, as well as from urban and agricultural runoff. To fully assess the effects of human activities on the natural resources of the Nation's estuaries, the WRD undertakes intensive studies of the effects of changing hydrologic, ecologic, and water-quality conditions in estuaries and their tributary streams.

Activities

- Collects hydrodynamic data and develops numerical models to study effects of river inflow, wind, and tides on water circulation and mixing in selected estuaries.
- Studies the effects of climate variability on estuaries.
- Defines dominant processes and rate controlling chemistry of river-estuary systems.
- Conducts studies of the distribution, transport, fate, and ecological significance of suspended sediments, nutrients, trace metals, and organic contaminants.
- Defines processes controlling variability in the distribution, abundance, and production of biotic communities.
- Studies processes affecting biological availability of contaminants.

Recent Accomplishments

- Applied and calibrated two- and three-dimensional hydrodynamic models to the major embayments of San Francisco Bay with the objective of determining the magnitude and location of variations in water currents and salinity that result from changes in freshwater inflows.
- Used numerical models to examine wind-forcing on circulation in the Pamlico and Neuse River Estuaries.
- Determined elevations of the 1989 Hurricane Hugo storm surge at more than 300 sites along the South Carolina coast; some surges were as high as 20 feet above sea level.
- Determined that sedimentation has increased in the Potomac and the Tillamook Estuaries since the Holocene (anthropogenic influences), but that little or no sediment from external sources is transported through the Potomac Estuary.
- Determined that atmospheric conditions (barometric pressure patterns) in the northeast Pacific region influence variability in California stream, estuary, and coastal ocean chemistry.
- Determined that a close coupling exists between freshwater inflow and phytoplankton biomass and production in San Francisco Bay, with unusually low biomass and primary production during the drought that has persisted since 1987.
- Demonstrated that an Asian clam recently introduced accidentally into San Francisco Bay has become the numerically dominant benthic invertebrate throughout the upper estuary and is probably responsible for the dramatic reduction in phytoplankton biomass and consequent changes in the estuary food web.
- Measured seasonal primary production, nutrient distributions, and hydrographic properties of Tomales Bay, California, as part of a multidisciplinary, multiinstitutional study of estuary biogeochemistry.
- Determined that climate patterns (temperature and light during growing periods), as well as anthropogenic disturbance, are important to the distribution and abundance of submersed macrophyte beds in the tidal Potomac River.
- Characterized spatial distributions and temporal fluctuations of bioavailable trace elements, separating biologic, hydrologic, and anthropogenic contributions to observed concentrations in San Francisco Bay organisms and sediments.
- Used historical information on estuarine water quality, land use, agricultural statistics, fertilizer use, forest data, population, and other data to determine spatial and temporal trends in water quality in the Albemarle and Pamlico Sounds.

- Used a Lagrangian sampling to follow the transport of four rice pesticides (carbofuran, methyl parathion, molinate, and thiobencarb) along the lower Sacramento River above the San Francisco Bay Estuary.
- Conducted a study of nonpoint-source runoff into South San Francisco Bay demonstrating that freshwater plumes are rapidly mixed in the estuary, with tidal ebb, tidal flood, and longshore currents determining the distribution of runoff-associated contaminants.
- Modeled waste assimilative capacity in the Intracoastal Waterway in South Carolina.
- Assessed the effects on water quality and productivity of Charlotte Harbor, Florida, as a result of land-use changes, increased freshwater diversion, and increased wastewater flows that result from progressive urbanization.
- Conducted water-quality monitoring in the Houston, Texas, ship channel (dissolved oxygen, temperature, conductivity); Cook Inlet, Alaska (tides, streamflow); Long Island Sound, New York (nutrients in seven streams and estuaries); Intracoastal Waterway and Cooper River, South Carolina (salinity); Albemarle-Pamlico Sounds (temperature, conductivity, and dissolved oxygen at multiple depths at each of 35 sites), to determine baseline water-quality conditions and to evaluate the effects of management actions on water quality.
- Initiated a study of the effects of freshwater diversions and sea-level rise on the salinity of the Toms and Metedeconk River embayments in Barnegat Bay and the estuaries of the Great Egg Harbor and Tuckahoe Rivers, New Jersey.
- Used cadmium to calcium ratios in a benthic foraminifer collected from sediment cores from the mouth of San Francisco Bay to show that coastal upwelling has decreased over the past 4,000 years. This finding is in agreement with predictions of atmospheric general circulation models that northwesterly winds that drive upwelling became weaker as summer insolation in the northern hemisphere has decreased.
- Demonstrated through three decades of observations of dissolved water column nitrogen and nearly two decades of observations of metals in estuarine clams that major water-quality improvements have been achieved in San Francisco Bay as a result of improvements in waste-treatment practices.
- Coupled a decade of field measurements in San Francisco Bay with model results to explain the physical mechanisms that contribute to the occurrence of phytoplankton blooms.

Recent Reports:

Bales, J.D., 1990, Data-collection program for Pamlico River estuary model calibration and validation, *in* Spaulding, M.L., ed., Estuarine and coastal pollutant transport modeling: American Society of Civil Engineers, p. 492-501.

Burau, J.R., and Cheng, R.T., 1989, A vertically averaged spectral model for tidal circulation in estuaries: U.S. Geological Survey Water-Resources Investigations Report 88-4126, 31 p.

Cain, D.J., and Luoma, S.N., 1990, Influence of seasonal growth, age, and environmental exposure on Cu and Ag in a bivalve indicator, Macoma balthica, in San Francisco Bay: Marine Ecology Progress Series, v. 60, p. 45-55.

Cloern, J.E., 1991, Tidal stirring and phytoplankton bloom dynamics in an estuary: Journal of Marine Research, v. 49, p. 203-221.

Cloern, J.E., Powell, T.M., and Huzzey, L.M., 1989, Temporal changes in salinity, suspended sediments, and phytoplankton biomass and productivity over tidal time scales, pt. 2 of Spatial and temporal variability in South San Francisco Bay (USA): Estuarine, Coastal and Shelf Science, v. 28, no. 6, p. 599-613.

Luoma, S.N., Johns, C., Fisher, N.S., Steinberg, N.A., Oremland, R.S., and Reinfelder, J.R., 1992, Determination of selenium bioavailability to a benthic bivalve from particulate and solute pathways: Environmental Science and Technology, v. 26, p. 485-491.

McPherson, B.F., and Miller, R.L., 1990, Nutrient distribution and variability in the Charlotte Harbor estuarine system, Florida: Water Resources Bulletin, v. 26, no. 1, p. 67-80.

Peterson, D.H., Cayan, D.R., Festa, J.F., Nichols, F.H., Walters, R.A., Slack, J.V., Hager, S.E., and Schemel, L.E., 1989, Climate variability in an estuary—Effects of riverflow on San Francisco Bay, *in* Peterson, D.H., ed., Aspects of climate variability in the Pacific and the western Americas: American Geophysical Union Geophysical Monograph, v. 55, p. 419-442.

Powell, T.M., Cloern, J.E., and Huzzey, L.M., 1989, Horizontal distributions of salinity, suspended sediments, and phytoplankton biomass productivity, pt. 1 of Spatial and temporal variability in South San Francisco Bay (USA): Estuarine, Coastal and Shelf Science, v. 28, no. 6, p. 583-597.

Stoker, Y.E., Henderson, S.E., and McPherson, B.F., 1989, Hydraulic and salinity characteristics of the tidal reach of the Peace River, southwestern Florida: U.S. Geological Survey Water-Resources Investigations Report 88-4162, 37 p.

van Geen, L., Luoma, S.N., Fuller, C.C., Anima, R., Clifton, H.E., and Trumbore, S., 1992, Evidence from Cd/Ca ratios in foraminifera for greater upwelling off California 4,000 years ago: Nature, v. 358, p. 54-56.

Funding

	Fiscal year (dollars in millions)	
Source of funds	1991	1992
Federal Program	10.5	14.0

Keywords

Estuaries, Global change, Bays, Macrophytes, Sounds.

Ice and Snow

Concerns over long-term climate change have brought about increased interest in ice and snow. New remote sensing technology has enabled scientists to track changing sea-ice distribution and the spatial variations of snowpacks. These changes can have substantial effects on local and global climate. Public interest has increased due to the dramatic retreat of the Columbia Glacier and the potential threat of calved icebergs on oil-tanker operations near Valdez, Alaska, and the advance of the Hubbard Glacier and other surging glaciers. WRD research on these topics began more than 30 years ago. The purpose of this work is to acquire long-term data on the variations of sea ice, snow, ice sheets, and glaciers; to analyze the natural processes operative in these poorly understood parts of the hydrologic cycle; and to develop predictive capabilities in assessing their responses to meteorologic and hydrologic stresses.

Activities

- Participates in the design, testing, and utilization of microwave satellites dedicated to ice, ocean, and climate research.
- Participates in the design and execution of international ice/ocean/atmosphere interaction experiments in the polar regions.
- Utilizes remotely sensed data collected by aircraft and satellites to investigate the thickness and extent of snow and icepacks in polar regions and the contiguous 48 States.
- Monitors the movement and changes in ice mass of selected glaciers and develops numerical modeling techniques to predict their future advances and retreats.
- Develops models to predict the effect of climatic warming (for example, associated with a rise in atmospheric carbon dioxide) on glacier size and glacier-derived runoff.

Recent Accomplishments

- Performed pioneering work on the development of microwave satellites that observe the entire Arctic and Antarctic sea-ice packs through the clouds on a day-and-night basis.
- Published the first comprehensive 4-year study of the monthly to interannual variations of the Arctic and Antarctic sea-ice packs in cooperation with the National Aeronautics and Space Administration (NASA).
- Developed numerical modeling techniques that enabled the WRD to predict for the first time the advance and retreat of glaciers. As predicted, observations show that the Columbia Glacier is in retreat and that the Hubbard Glacier is advancing.
- Applied the passive microwave-detection capabilities of the NASA Nimbus-7 satellite to map the water content of snow in the upper Colorado River basin to better predict water availability and flood potential associated with the snowmelt.
- Analyzed the 9-year Scanning Multichannel Microwave Radiometer (SMMR) observations of the Arctic and Antarctic sea ice, 1979-87, and found a statistically significant decrease in the Arctic sea ice, that is not seen in the Antarctic sea ice.

Recent Reports:

Gloersen, P., and Campbell, W.J., 1991, Recent variations in Arctic and Antarctic sea-ice covers: Nature, v. 352, no. 6330, p. 33-36.

Josberger, E.G., Campbell, W.J., Gloersen, P., Chang, A.T.C., Rango, A., in press, Snow conditions and hydrology of the Upper Colorado River basin from satellite passive microwave observations: Annals of Glaciology.

Funding

Funding for this activity is derived from several sources. In fiscal year 1992, approximately $0.9 million was spent on snow and ice studies.

Keywords

Climate, Global sea-ice variation, Ice sheet dynamics, Snow cover variations, Glacier variations.

Irrigation Drainage Program

In response to concerns expressed by the U.S. Congress over contamination at the Kesterson National Wildlife Refuge in California, the DOI started a program in 1985 to identify the nature and extent of irrigation-induced water-quality problems that might exist in other areas of the Western United States. A DOI Task Group prepared a comprehensive plan for reviewing irrigation-drainage concerns for areas where the DOI might have responsibility. Initially, the Task Group identified 19 locations in 13 States that warranted reconnaissance-level investigations. These locations relate to three specific areas of DOI responsibility: irrigation or drainage facilities constructed or managed by the DOI, national wildlife refuges managed by the DOI, and other migratory-bird or endangered-species management areas that receive water from DOI-funded projects.

To accomplish the investigations, interagency study teams were formed for each location. Scientists—from the WRD (team leader), the U.S. Fish and Wildlife Service, the U.S. Bureau of Reclamation, and the Bureau of Indian Affairs—were named to conduct the investigations at each location. Media investigated at each location include surface and ground water, bottom sediment, and biota.

Results of the completed reconnaissance-level investigations and preliminary data from the ongoing reconnaissance investigations and detailed studies have provided several generalizations regarding areas where problems have been detected: (1) irrigation drainage problems are prevalent in the Western United States; (2) elevated concentrations of trace elements have been detected in several of the study areas, and pesticides have been found in some of the study areas; (3) alkaline oxidized soils that contain elevated concentrations of trace elements in semiarid environments indicate potential problem areas; (4) selenium, boron, arsenic, and mercury are the constituents found most often at elevated concentrations in water, bottom sediment, and biota in the study areas; (5) contamination problems are mostly area specific; (6) concentrations of arsenic and selenium tend to vary inversely; and (7) the highest concentrations of constituents occur in internally drained basins.

Activities

- Compiles a list of areas that fall under the scope of the DOI management strategy.
- Prepares detailed work plans for reconnaissance investigations.
- Plans and conducts intensive studies to determine the extent, magnitude, effects, and exposure pathways that cause contamination in areas where contamination warrants further study.
- Prepares reports and makes results of studies available to the public and private sectors.

Recent Accomplishments

- Prepared the departmental management strategy for identifying and addressing irrigation-induced water-quality problems that involve DOI responsibilities.
- Published 87 reports and journal articles.
- Initiated a synthesis of all data collected since the program began in 1986.

Funding

	Fiscal year (dollars in millions)				
Source of funds	1988	1989	1990	1991	1992
Federal Program	3.6	4.2	2.8	2.8	2.8

Keywords

Irrigation drainage, Kesterson National Wildlife Refuge, Water quality, Selenium, Trace elements, Biota.

Indian Water Rights

Decisions on Indian water rights will have a major effect on the existing pattern of water allocation in the Western United States. The WRD collects hydrologic data and conducts water-resources investigations on tribal lands in cooperation with the Bureau of Indian Affairs (BIA) and with individual tribes under the Federal-State Cooperative Program. The purpose of these studies is to define the location, quantity, and quality of water available on Indian lands; to determine how the water supply varies in terms of quantity and quality; to describe the natural or historical condition of the resource; and to appraise the potential of the resource for further development.

Activities

- Participates in the planning and deliberations on Indian water rights with representatives of the DOI Solicitor's Office, the Justice Department, the BIA, and the Indian tribes.
- Conducts hydrologic investigations on Indian lands in Arizona, Idaho, Montana, South Dakota, and Washington (1992).

Recent Accomplishments

- Completed project and report related to adjudication of Federal and Indian water rights.
- Began project in the Clearwater and Salmon River basins in Idaho in support of Federal and Indian tribal claims for reserved instream water rights.
- Completed an assessment of the water resources of the White Earth Indian Reservation, Minnesota.
- Prepared reports describing the hydrogeology and model simulation of ground-water flow of the San Andres-Glorieta aquifer system, Pueblos of Acoma and Laguna, New Mexico.
- Conducted studies in the Rio Puerco river basin, Arizona, for the Navajo-Hopi New Lands Commission related to the relocation of the Navajo Indians.
- Conducted 21 studies, in 1992, related to Indian Water Rights and water resources.

Funding

In fiscal year 1992, about $2.7 million was spent on studies related to water resources on Indian lands. About 40 percent of these funds were transfers from the BIA, and the remainder were funds from individual Indian tribes that are matched as part of the Federal-State Cooperative Program.

Keywords

Indian, Tribal, Water rights, Water resources.

Global Change Hydrology

The Global Change Hydrology Program is a major component of the USGS Global Change Research Program. It is a diverse, multidisciplinary research and monitoring activity focusing on (1) the collection of basic hydrologic and biogeochemical data associated with processes that affect and are affected by climatic variability and related global systems change, (2) understanding the physical and biogeochemical mechanisms that govern how the hydrologic system influences and responds to climatic variability and change, and (3) the development of a capability to predict hydrologic and biogeochemical processes as a function of climatic variability and change.

Activities

- Conducts research, interpretive studies, and data collection in the following topical areas: water and carbon budgets, sensitivity of water resources, climate and hydrologic diagnostics, and global modeling.

Recent Accomplishments

- Initiated a program of intensive field investigations focusing on Water, Energy, and Biogeochemical Budget (WEBB) processes at five sites: Sleepers River Watershed (Vermont), Trout Lake (Wisconsin), Loch Vale Experimental Watershed (Colorado), Panola Mountain Experimental Watershed (Georgia), and Luquillo Experimental Forest (Puerto Rico). These long-term process investigations are designed to improve understanding and prediction of water and carbon fluxes, their interactions, and their relations to climatic variables, over a range of spatial and temporal scales.
- Published the results of a 3-year study of the sensitivity of the hydrology and water resources of the Delaware River to climatic variability and change.
- Initiated a joint study with the U.S. Bureau of Reclamation focusing on the development of techniques and procedures for evaluating water resources and water-resources systems under climate uncertainty in the Western United States. The 3-year study is being conducted in the Gunnison Basin (Colorado), the American Basin (California), and the Truckee and Carson Basins (Nevada). The American, Truckee, and Carson watersheds have adjacent catchments located in the northern Sierra Nevada mountains.
- Published a study of the relation between fire occurrence in the Southwestern United States and the Southern Oscillation (Swetnam and Betancourt, 1990). Fire scar and tree growth chronologies (from 1700 to 1905) and fire statistics (since 1905) from Arizona and New Mexico show that large areas burn after dry springs associated with the high phase of the Southern Oscillation (La Niña). Because fires lag certain related atmospheric and oceanic patterns by one or more seasons, the relation between climatic variability in the tropical Pacific and fires could have forecasting value and, thus, important implications for fire and watershed management.
- Completed a major study designed to develop transferable methods for understanding the sensitivity of water resources to climate variability and change in the Delaware River basin. Results from this study show that a transient warming trend would cause an increase in the proportion of winter precipitation that is converted to runoff, a reduction in snow accumulation, and a reduction in spring runoff in the northern part of the basin.

Recent Reports:

Gloersen, P., and Campbell, W.J., 1991, Recent variations in Arctic and Antarctic sea-ice covers: Nature, v. 352, p. 33-36.

Hay, L.E., McCabe, G.J., Wolock, D.M., and Ayers, M.A., 1991, Simulation of precipitation by weather type analysis: Water Resources Research, v. 27, p. 493-501.

Hostetler, S.W., and Benson, L.V., 1990, Paleoclimatic implications of the high stand of Lake Lahontan derived from models of evaporation and lake level: Climate Dynamics, v. 4, p. 207-217.

Milly, P.C.D., 1991, A refinement of the combination equations for evaporation: Surveys in Geophysics, v. 12, p. 145-154.

———1992, Potential evaporation and soil moisture in general circulation models: Journal of Climate, v. 5, p. 209-226.

Swetnam, T.R., and Betancourt, J.L., 1990, Fire-Southern Oscillation relations in the southwestern United States: Science, v. 249, no. 4972, p. 1017-1020.

Wolock, D.M., and Hornberger, G.M., 1991, Hydrological effects of changes in atmospheric carbon dioxide levels: Journal of Forecasting, v. 10, p. 105-116.

Funding

Source of funds	Fiscal year (dollars in millions) 1990	1991	1992
Federal Program	2.0	7.0	7.7

Keywords

Global change, Climate, Paleohydrology, Cold regions hydrology, General circulation models.

Lake Hydrology

Lakes and reservoirs are important sources of water supply and recreation and a significant component of the Nation's water resources. The WRD lake hydrology investigations are directed at increasing understanding of the basic principles controlling the interaction of lakes with the atmosphere, surface water, and ground water, including associated chemical fluxes. The studies also include research on internal processes and cycling within lake ecosystems. The studies emphasize integration of theoretical and experimental field work.

Activities

- Conducts long-term research on the physical, chemical, and biological processes of lakes. Research sites are in Colorado, Florida, Minnesota, Nebraska, Nevada, New Hampshire, North Dakota, New York, and Wisconsin.
- Conducts extensive studies on lakes with specific water-quality problems, such as Lake Travis and Lake Houston, Texas; Little Rock Lake, Wisconsin; and Lake Tahoe, California and Nevada.
- Interprets and analyzes data on a national scale to assess the general condition of lake quality in the United States. These studies are directed principally toward eutrophication, metal contamination, and acid rain.
- Assists agencies responsible for lake management, such as the U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, U.S. Bureau of Reclamation, and Bonneville Power Authority.

Recent Accomplishments

- Showed that seepage from lakes greatly affects ground-water chemistry, which results in different chemical characteristics of ground water on different sides of lakes.
- Demonstrated that ground-water seepage to lakes has a significant influence on lake and wetland life that, in turn, influences waterfowl habitat and food production.
- Demonstrated through long-term research that evaporation rates are not uniform, but can vary by as much as 35 percent from year to year.
- Demonstrated that seepage from lakes can occur through a large area of lakebed offshore at the same time that water-table slopes are toward the lake causing seepage into the lake in the near-shore littoral zone.
- Demonstrated that lakes in identical physiographic and climatic settings can differ substantially in chemical and biological characteristics because of greatly different water-residence times.
- Developed a national framework for a unified and comprehensive research program on the hydrology of wetlands.

Recent Reports:

LaBaugh, J.W., in press, Spatial and temporal variation in chemical characteristics of ground water adjacent to selected lakes and wetlands in the north central United States: Verhandlungen Internationale Vereinigung Limnologie, v. 24.

Peters, N.E., and Murdock, P.S., 1985, Hydrogeologic comparison of an acidic-lake basin with a neutral-lake basin in the west-central Adirondack Mountains, New York: Water, Air, and Soil Pollution, v. 26, p. 387-402.

Rosenberry, D.O., 1990, Inexpensive ground water monitoring methods for determining hydrologic budgets of lakes and wetlands, *in* Proceedings of the National Conference on Enhancing the States' Lake and Wetland Management Programs, Chicago, Illinois, May 18-19, 1989: U.S. Environmental Protection Agency and North American Lake Management Society, p. 123-131.

Sturrock, A.M., Winter, T.C., and Rosenberry, D.O., 1992, Energy-budget evaporation from Williams Lake, a closed lake in north-central Minnesota: Water Resources Research, v. 28, no. 6, p. 1606-1617.

Wiche, G.J., 1990, Evaporation computed by energy-budget and mass-transfer methods, and water balance estimates for Devils Lake, North Dakota, 1986-88: North Dakota State Water Commission Water-Resource Investigation 11, 52 p.

Winter, T.C., 1992, A physiographic and climatic framework for hydrologic studies of wetlands, *in* Robards, R.D., and Bothwell, M.L., eds., Aquatic Ecosysems in Semi-Arid Regions, Implications for Resource Management: Saskatoon, Saskatchewan, Canada, Environment Canada, The National Hydrology Research Institute Symposium series no. 7, p. 127-148.

Winter, T.C., and Woo, Ming-Ko, 1990, Hydrology of lakes and wetlands, *in* Wolman, M.G., and Riggs, H.C., eds., Surface water hydrology: Boulder, Colorado, Geological Society of America, The Geology of North America, v. O-1, p. 159-187.

Funding

Funding for this activity is derived from several sources. For the past few fiscal years, funding for lake hydrology studies was between $2 million to $3 million.

Keywords

Lakes, Reservoirs, Eutrophication, Acid precipitation, Wetlands.

Support Functions

Instrumentation Program

Modern technologies have greatly increased the WRD's capability to conduct hydrologic investigations. Computers, communications satellites, automated radios, and various other electronic devices--some unique to the science of hydrology—are used to sense, sample, record, and communicate large quantities of water-resources information. The WRD, through its Hydrologic Instrumentation Facility at Stennis Space Center, Mississippi; the Federal Interagency Sediment Project at Minneapolis, Minnesota; and the Satellite Data Relay Project at Reston, Virginia, is working to improve hydrologic instruments and to support their use in the WRD data-collection activities.

Activities

- Works to expand the number of hydrologic parameters that can be automatically monitored at field stations.
- Identifies requirements, prepares specifications, and conducts competitive procurements to obtain hydrologic instrumentation.
- Designs and develops hydrologic data-collection and telemetry instruments that are not available from the private sector.
- Provides assistance to field offices in the use and application of instruments through consulting, training, documentation, and direct project assistance.
- Tests and evaluates commercially available instruments to insure compliance with WRD reliability, performance, and accuracy standards.
- Supplies, calibrates, and repairs instruments.
- Coordinates the planning and use of the Geostationary Operational Environmental Satellites (GOES) for the relay of hydrologic data to District Offices from automated data-collection stations.
- Develops computerized procedures for data collection, handling, and entry into the NWIS.

Recent Accomplishments

- Developed valves to improve reliability of point-integrating suspended-sediment samplers. Special valves were designed for sediment-chemistry studies.
- Purchased and deployed new electronic data loggers with shaft encoders for measuring water levels.
- Established a new serial-digital-interface standard for connecting sensors to automated field data loggers.
- Distributed new software to convert output from a wide array of electronic data loggers to a format compatible with the NWIS.
- Upgraded equipment for measuring stream velocities (current meters) and obtaining water samples for rivers under ice cover.
- Initiated testing of WRD-developed liquid-solid-phase sampler for organics.
- Completed testing of a modified commercial sampler for organics.
- Completed testing of ground-water samplers for volatile organics.
- Procured pressure-type water-level sensors and planned laboratory acceptance tests.
- Procured ultrasonic velocity meters and downhole recorders for purchase or rent by WRD field offices.
- Upgraded equipment for sampling river-bed deposits.
- Specified and tested the first version of a portable field computer for supporting automated field instruments.
- Tested and refined the Dynatrol vibrating U-tube fluid-density gage for automated field measurement of suspended sediment.
- Assisted USGS Districts and other Federal agencies to establish GOES telemetry at more than 3,000 WRD hydrologic stations to increase access to real-time data.
- Began operational use of a dedicated real-time communications line to NWS computers for backup of WRD-operated GOES direct-readout ground stations.

- Expanded the number of WRD network of owned and operated direct-readout ground stations to seven with the addition of Texas and Puerto Rico.
- Developed jointly with industry and the Office of Surface Water a broad-band acoustic doppler meter for sensing shallow and deep water velocity profiles, depths, and boat movement; integrating these data; and computing discharge in streams, rivers, canals, and estuaries.

Recent Reports:

Beverage, J.P., and Williams, D.T., 1989, Comparison—US P-61 and Delft sediment samplers: American Society of Civil Engineers Journal of Hydraulic Engineering, Paper 24186, v. 115, no. 12, p. 1702-1706.

Ficken, J.H., and Tai, D.Y., 1988, Activities of the U.S. Geological Survey's Hydrologic Instrumentation Facility in support of hazardous- and toxic-substances programs, *in* Mallard, G.E., ed., U.S. Geological Survey Toxic Substances Hydrology Program: Proceedings of the technical meeting, Phoenix, Arizona, September 26-30, 1988: U.S. Geological Survey Water-Resources Investigations Report 88-4220, p. 625-631.

Glysson, G.D., and Skinner, J.V., 1990, Relation between the National Handbook of Recommended Methods for Water Data Acquisition and American Society for Testing and Materials Standards: American Society for Testing and Material Standards Symposium on Monitoring Water in the 1990's, June 11-14, 10 p.

Holland, R.R., and Rapp, D.H., 1988, Results of qualification tests on water-level sensing instruments, 1986: U.S. Geological Survey Open-File Report 88-193, 34 p.

Johnson, R.A., and Rorabaugh, J.I., 1988, Operating manual for the R200 downhole recorder with Husky Hunter retriever: U.S. Geological Survey Open-File Report 88-455, 111 p.

Latkovich, V.J., 1991, Hydrologic Instrumentation Facility annual report: U.S. Geological Survey Open-File Report 92-132, 75 p.

Olive, T.E., 1989, Results of qualification tests on water-level sensing instruments, 1987: U.S. Geological Survey Open-File Report 89-397, 37 p.

Shope, W.G., 1987, The U.S. Geological Survey's national real-time hydrologic information system using GOES satellite technology, *in* Proceedings of Applications of Remote Sensing Technology in Tidal Hydraulics, American Society of Civil Engineers Specialty Conference, Williamsburg, Virginia, August 1987: American Society of Civil Engineers, 9 p.

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_____1992, The use of satellite data relay by the U.S. Geological Survey for near real-time hydrologic data collection: Proceedings of the 1992 national conference of the U.S. Committee on Irrigation and Drainage, Phoenix, Arizona, October 1992, 12 p.

——in press, Hydrologic data acquisition and handling from field instrumentation to the National Water Information Systems computers: U.S. Geological Survey Open-File Report.

Skinner, J.V., 1989, Model B sediment-concentration gage—Factors influencing its reading and a formula for correcting its errors: St. Paul, Minnesota, U.S. Army Corps of Engineers District, Report JJ, 34 p.

——1989, History of the Federal Interagency Sedimentation Project, *in* Symposium on sediment transport: American Society of Civil Engineers, 7 p.

Funding

	Fiscal year (dollars in millions)				
Source of funds	1988	1989	1990	1991	1992
Federal Program	1.6	1.7	1.6	1.7	1.7

Keywords

Instrumentation, Data relay, Sediment, Satellite telemetry, Hydrologic data collection, Field stations.

National Water-Quality Laboratory

To support water-resources investigations, the WRD operates the National Water-Quality Laboratory (NWQL) at Arvada (near Denver), Colorado. The NWQL is equipped with the most modern and sophisticated instrumentation that permits inorganic, organic, trace-metal, and heavy-metal analysis of precipitation, surface and ground water, bottom sediment, aquatic animal and plant tissue, and aquifer material. To provide research and development of improved analytical and field sampling methods, a Methods Research and Development Program was established as a part of the NWQL in fiscal year 1987.

Activities

- Provides physical, chemical, and biological analyses in support of the WRD water-resources investigations.
- Provides continuous quality assurance for all analyses through development of statistical quality-control processes.
- Provides rapid access through computers to water-quality data.
- Develops techniques for sampling of organics in surface and ground water.
- Develops protocol for quality control of field and laboratory activities.
- Develops more efficient inorganic and organic analytical techniques for analyses of water and sediment.
- Develops plans for an improved, more complete laboratory-management computer system.
- Plans for increased NWQL capabilities to meet analytical requirements of the NAWQA program.
- Provides field assistance to districts for investigating extent of soil contamination by synthetic organic compounds.
- Provides instructors for classes at the USGS National Training Center.

Recent Accomplishments

- Performed 832,000 water-quality analyses on 41,600 samples in fiscal year 1989.
- Improved efficiency through data-transfer automation of 90 percent of inorganic program instrumentation.
- Implemented more efficient ion-chromatographic techniques for determination of sulfate, chloride, and fluoride anions.
- Developed a field bank and spike program for improved quality assurance of field sampling, preservation, and shipping processes, as well as interlaboratory bias assessment.
- Developed computer-generated control-chart systems for routine quality monitoring of inorganic analyses.
- Published revised manuals for organic and inorganic analytical methods.
- Published a manual for quality-control procedures and policies.
- Initiated studies to determine efficiency of recovery of triazine, carbamate, and organophosphorus compounds from water.
- Installed new chromatograph-mass spectometry equipment for determination of nitrogen-containing herbicides.
- Implemented immunoassay-screening techniques for nitrogen-containing herbicides.
- Provided an estimted $11.0 million in analytical services to client Districts in 1991. This amount is up from $8.3 million in 1990. The laboratory is developing several new analytical methods for the NAWQA program.

Recent Reports:

Patton, C.J., and Truitt, E.P., in press, Methods of analysis by the U.S. Geological Survey National Water-Quality Laboratory—Determination of total phosphorus by a Kjeldahl digestion method and an automated colorimetric finish that includes dialysis: U.S. Geological Survey Open-File Report 92-146.

Sandstrom, M.W., Wydoski, D.S., Schroeder, M.P., Zamboni, J.L., and Foreman, W.T., 1992, Methods of analysis by the U.S. Geological Survey National Water-Quality Laboratory—Determination of organonitrogen herbicides in water by solid-phase extraction and capillary-column gas chromatography/mass spectrometry with selected-ion monitoring: U.S. Geological Survey Open-File Report 91-519, 26 p.

Funding

Source of funds	Fiscal year (dollars in millions)				
	1988	1989	1990	1991	1992
USGS offices or other Federal agencies requesting analytical work	5.8	7.9	7.6	13.0	15.0

Keywords

Laboratory, Water quality, Instrumentation, Analytical methods, Quality control.

National Training Center

The USGS National Training Center was established in 1977 in Lakewood, Colorado, to provide specialized training in water resources sciences for USGS personnel and others connected with USGS activities. The Center also offers training in hydrologic science and techniques through special courses for international hydrologists and college professors.

Many of the training courses offered at the facility provide for technology transfer from the research program to operations program of the USGS. As a result of the many and diverse technical skills taught at the National Training Center, the water resources scientists in the USGS are among the foremost in the world.

Activities

- Conducts formal training in all areas of hydrology for USGS personnel, representatives from cooperating agencies, and selected international and university participants. Provides hydrologic courses on groundwater, surface-water, and water quality ranging from basic concepts to advanced three-dimensional modeling approaches.
- Serves as a site for seminars, conferences, and meetings of large groups.
- Administers specialized correspondence courses for USGS personnel in selected hydrologic topics.

Recent Accomplishments

- Provided 80 hydrologic training courses to 1,426 personnel in fiscal year 1992, including 702 hydrologists, 299 hydrologic technicians, and 270 students from cooperating agencies and organizations. In addition, 22 international hydrologists and 25 college professors received hydrologic training in special courses.

Funding

	Fiscal year (dollars in millions)				
Source of funds	1988	1989	1990	1991	1992
USGS funds allocated to the Center[1]	0.6	0.6	0.61	0.68	0.68

[1]Funding allocation for operation and maintenance of the Center does not include the costs of the actual courses.

Keywords

Training, Water-resources methods, Technical skills, Cooperative activities, Seminars, Conferences, Correspondence courses, Videotapes, Meetings.

DISSEMINATION OF INFORMATION

The USGS is the Nation's lead agency in the collection of water data and the dissemination of information on water resources. The WRD makes water data and information readily and equally available to water managers, policymakers, the scientific community, and the public.

The WRD has published the results of its studies for more than 100 years. The information is multipurpose and, after initial use, becomes a basis for future resource evaluation and water-management decisions. The WRD releases information through several publication series and through computerized systems, accessible through the NWIS.

A description of the publications series, the types of information presented, examples of the series, and the number of reports released during 1981-92 are shown below.

- Water-Supply Paper—Significant interpretive results of hydrologic investigations that are considered to be of broad interest.
- Professional Paper—Comprehensive or topical reports on any earth science subject of interest to multidiscipline scientific audiences.
- Bulletin—Significant interpretive results of earth science investigations of broad interest, including computer applications.
- Circular—Summaries of topical investigations or programs that are of immediate and broad public interest.
- Map series, such as Hydrologic Investigations Atlas—Significant results of hydrologic investigations presented in map format.
- Techniques of Water-Resources Investigations Report—Descriptions of methods and techniques used in collecting, analyzing, and processing hydrologic data for technically oriented audiences.
- Geological Survey Yearbook—Selected significant activities of the WRD that are summarized each year for general audiences.
- Water-Resources Investigations Report—Comprehensive or topical interpretive reports and maps, mainly of local or short-term interest, for interdisciplinary audiences.
- Open-File Report—Compilations of data and preliminary interpretive reports or maps of limited interest or reports or maps awaiting formal publication that require interim release.
- Water-Data Report—Water-year data on streamflow, ground-water levels, and quality of surface and ground water for each State, Puerto Rico, the Virgin Islands, and the Trust Territories; published annually.
- National Water Conditions—Monthly news release that summarizes the national water situation for water-resources-oriented audiences.

With the exception of the *National Water Conditions*, which is a form of news release, all the above publication series are listed in two catalogs--*Publications of the Geological Survey, 1879-1961*, and *Publications of the Geological Survey, 1962-70*--and in yearly supplements to these catalogs for 1971 through 1992.

As new publications are released, each is announced in the monthly list, *New Publications of the Geological Survey*. This listing is available upon request to the public.

Many topical reports of scientific interest are published in technical and scientific journals to make the information readily available to those in related fields of study. Other reports of local interest are published by cooperating State agencies and made available within that State. These types of publications are announced in the monthly list described previously.

In addition to the above described traditional book and map reports, the WRD also releases information in film, video, slide-cassette, and electronic or machine-readable formats. For example, U.S. Geological Survey Open-File Report 84-606 is a video presentation of mud and debris flows. Abstracts of reports from 1967 to date are available on compact disk from the Water-Resources Scientific Information Center.

Number of reports approved for release or publication by the WRD

Type of report	Number of approved reports by calendar year											
	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992[1]
Water Supply Paper	28	13	30	22	22	22	37	22	12	14	24	7
Professional Paper	13	12	16	13	14	12	16	10	5	16	10	2
Bulletin	0	1	1	3	1	2	1	4	1	2	0	0
Circular	12	3	10	1	5	4	6	4	2	0	1	3
Techniques of Water Resources Investigations	3	3	3	2	1	2	2	5	2	3	6	3
Map Series	13	13	20	18	21	20	8	9	9	7	3	3
Water-Resources Investigations Reports	200	222	283	398	344	270	281	244	206	208	198	147
Open-File (book and map) Reports	265	275	192	220	208	158	130	115	111	92	196	231
Water Data Reports	78	76	74	64	77	64	74	83	86	82	72	72
Administrative releases	2	10	4	5	4	70	50	10	6	26	27	24
Outside publications (includes State publications, journal articles, abstracts, and other related items)	495	599	582	702	858	835	923	1,068	1,130	995	1,058	825
Flood-prone area mapping project: Maps[2]	129	173										
Total (exclusive of flood-prone maps and pamphlets)	1,109	1,227	1,215	1,448	1,555	1,459	1,528	1,574	1,570	1,445	1,595	1,317

[1]Data through September 1992.

[2]The flood-prone area mapping project was completed in 1982.

INDEX OF KEYWORDS

*USGPO: 1993-750-232/80019