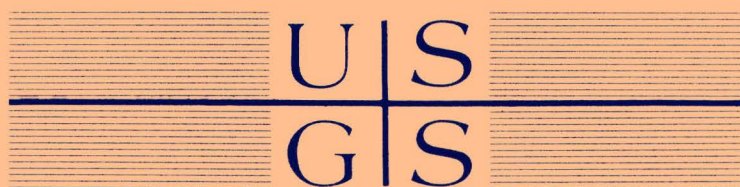


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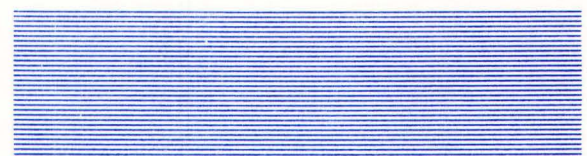
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U.S. Geological Survey
Open-File Report 87-111



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1987

John E. Moore and C. William Cardin, Editors



U.S. Geological Survey
Open-File Report 87-111

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INTRODUCTION

Effective management of water resources requires an understanding of hydrologic systems and the factors that determine the distribution, availability, and quality of water. Within the Federal Government, the U.S. Geological Survey has the principal responsibility for providing hydrologic information and for appraising the Nation's water resources. The water resources activities of the U.S. Geological Survey are diverse, ranging from research investigations of specific aspects of the hydrologic cycle to large programs of regional water-resources investigations, such as the Regional Aquifer System Analyses.

This report describes the U.S. Geological Survey's water resources activities. Some activities, such as the acid rain program, are mandated by line items in the Survey's fiscal year 1987 budget. Others, such as floods, sediment, and snow and ice, are topics of general interest to the water resources community. Still others are related to current water issues, such as nonpoint sources of pollution, the irrigation drainage problem of the western San Joaquin Valley, and national ground-water protection.

In many cases, there is considerable overlap in the topical descriptions. The Survey's water resources research program, for example, conducts investigations that are applicable to virtually all of the activities listed in this book. 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 exceeds by a considerable amount the Survey's budget for water resources activities.

The report first describes the water-resources mission of the U.S. Geological Survey and discusses the principal sources of funds that support the activities. The remainder of the report consists of descriptions of 39 of the most significant water resources activities. An index appears at the end of the report.

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

- ° Introduction--the problem or issue addressed by the activity and a statement of purpose.
- ° Activities--examples of investigations underway.
- ° Recent accomplishments--examples of findings or achievements.
- ° Funding--an indication of the size of the program in terms of funding. Where possible, the funding of activities is given by source for fiscal years 1983 to 1987.

WATER RESOURCES MISSION OF THE U.S. GEOLOGICAL SURVEY

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

- ° Collects data on a systematic basis to determine the quantity, quality, and use of surface and ground water, and the quality of precipitation.
- ° Conducts water resources investigations and assessments at national, State, and local scales, characterizes water resources conditions, and provides the capability to predict the impact on the resource of managerial actions, proposed development plans, and natural phenomena.
- ° Conducts basic and problem-oriented hydrologic and water-related research that is likely to 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.
- ° Provides scientific and technical assistance in hydrology to other Federal agencies, to State and local agencies, 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 which include the State Water Resources Research Institute Program (Section 104) and the Water Resources Research Grant Program (Section 105).

Authority for carrying out the Survey's mission derives from legislation of 1879, which established the Geological Survey; and 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 relating 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, assigned to the Department of the Interior by Office of Management and Budget Circular A-67, was delegated to the U.S. Geological Survey and its Water Resources Division by the Department. Most recently, the Department of the Interior designated the Survey as the administering agency for Title I of the Water Resources Research Act of 1984.

BUDGET AND SOURCES OF FUNDS

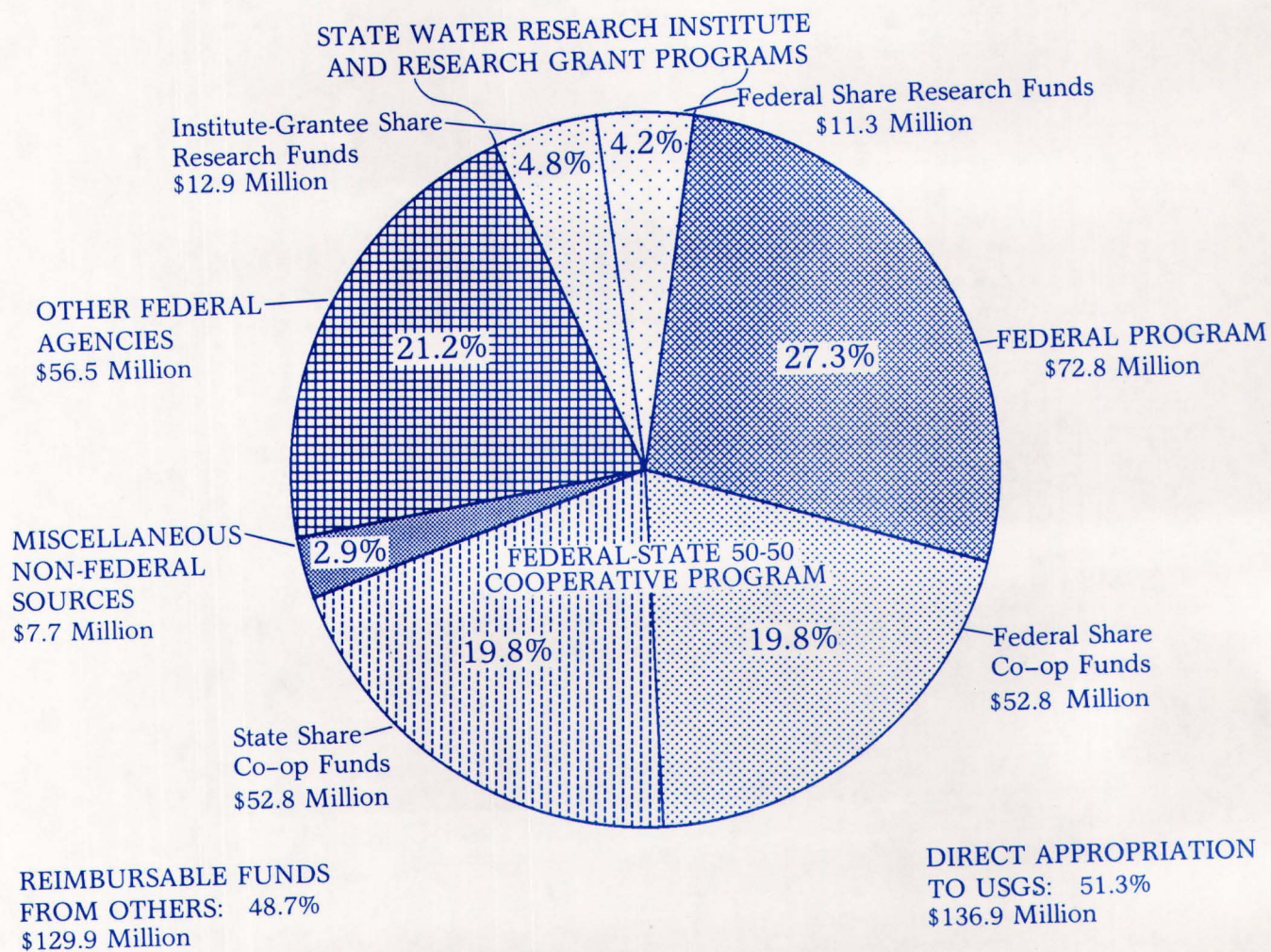
Funds to support the water resources activities performed by the U.S. Geological Survey are derived from four principal sources.

- o Federal Program--Funds for the Federal Program are appropriated by the Congress, and are specifically identified in the annual Geological Survey budget. These funds are used to support research, data collection, high-priority topical programs, the coordination of all Federal programs related to collection of water data, and internal support services. In fiscal year 1986, this funding was \$72.9 million; the estimated funding for fiscal year 1987, at the enacted level, is \$72.8 million.
- o Federal-State Cooperative Program--Federal funds are appropriated by the Congress and used to match those 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 Geological Survey represents national responsibilities and the cooperating agencies represent State and local interests. In fiscal year 1986, these joint funds amounted to \$99.5 million; the estimated funding for fiscal year 1987, at the enacted level, is \$105.7 million.
- o State Water Resources Research Institute and Research Grant Programs--Federal funds are appropriated by Congress and used to match those from 54 State Water Resources Research Institutes. In fiscal year 1986, the matching ratio for the Institutes Program was 1:1; in fiscal year 1987, it changed to 1:1 1/2, with the Institutes providing the larger share of funding. For the Research Grants Program, the matching ratio remains at 1:1. In fiscal year 1986, these joint funds amounted to \$21.9 million; the estimated funding for fiscal year 1987, at the enacted level, is \$24.2 million.
- o Other Federal Agencies Program--In this program, the funds are transferred to the U.S. Geological Survey as reimbursement for work performed at the request of another Federal agency. In fiscal year 1986, this funding amounted to \$54.6 million; and for fiscal year 1987, the estimated funding is \$56.5 million.

Additional sources of funds include unmatched reimbursable funds from State and local government agencies and Federal Energy Regulatory Commission licensees. In fiscal year 1986, these funds amounted to \$9.0 million; the estimated funding for fiscal year 1987 is \$7.7 million.

The total water resources budget for fiscal year 1986 was \$257.1 million, and is estimated to total \$266.8 million at the enacted level in fiscal year 1987

WATER RESOURCES INVESTIGATIONS FUNDING IN FY 1987 (Enacted)



U.S. Geological Survey Funding for Water Resources Activities
in FY 1987 -- Total \$266.8 Million (Enacted)

WATER RESOURCES ACTIVITIES

ACID RAIN

Since the late 1950's, the U.S. Geological Survey (USGS) 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 USGS significantly increased its level of hydrologic research and broadened its program to include the effects of atmospheric deposition on limestone and marble building stones. In 1984, the USGS established an Office of Atmospheric Deposition Analysis to coordinate its acid-rain research.

The USGS's Federal acid-rain program is carried out as part of the Federal interagency National Acid Precipitation Assessment Program (NAPAP), which was established by the Acid Precipitation Act of 1980 (Title VII of PL 96-294). Purposes of the program are:

- ° Measure nationwide the amount, chemical character, and variability of atmospheric deposition (rain and snow).
- ° Determine the susceptibility of lakes and streams to acidification, and monitor susceptible areas for long-term changes which may result from acid deposition.
- ° Define the geochemical and hydrologic processes by which acid deposition affects the quality of surface and ground waters in the United States.
- ° Define the geochemical and atmospheric processes by which acid deposition damages carbonate building stones.

Activities

- ° Serves as lead agency for the Task Group on Atmospheric Deposition and Air Quality Monitoring and the Task Group on Effects on Materials and Cultural Resources, and as a member of the Aquatic Effects Task Group, of NAPAP.
- ° Coordinates the 150-site National Trends Network for monitoring precipitation chemistry nationwide. The USGS operates about 50 sites in the network. The other sites are operated by a variety of Federal, State, university, and private organizations.
- ° Monitors 14 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 acid deposition affects the quality of streams, lakes, and ground water.
- ° Conducts studies at five test-sample exposure sites to define geochemical and atmospheric processes by which acid deposition damages carbonate building stones.

Recent Accomplishments

° Prepared the following reports:

- Laird, L.B., Taylor, H.E., and Kennedy, V.C., 1986, Snow chemistry of the Cascade-Sierra Nevada mountains: Environmental Science and Technology, v. 20, n.3, p. 275-290. The snowpack in the higher Cascades and Sierra Nevadas is not strongly acidified by anthropogenic activities at the present time. However, the ammonium content of the snow is somewhat lower and the heavy metal content is somewhat higher in areas downwind of major metropolitan and industrial areas.
- Lins, H.F., 1987, Trend analysis of monthly sulfur dioxide emissions in the conterminous United States, 1975-1984: submitted to the journal Atmospheric Environment. An analysis of monthly sulfur-dioxide emissions by State for the 48 conterminous States indicated downward trends in 32 States, uptrends in 10 States, and no trends in 6 States. One distinct emissions pattern occurred commonly throughout the country--an initial emissions increase, peaking between 1977 and 1978, followed by a shallow and undulating decrease through the end of 1984. This pattern is considered to represent the "national" trend for the period.
- Schertz, T.L., and Hirsch, R.M., 1985, Trend analysis of weekly acid rain data--1978-83: U.S. Geological Survey Water-Resources Investigations Report 85-4211. An analysis of more than 4000 precipitation samples collected weekly at 19 sites in 13 States showed no clear pattern of changes in overall acidity, measured as pH. However, sulfate and nitrate, indirect indicators of precipitation acidity, showed widespread and substantial downward trends in concentration in the Eastern United States, where most of the sites are located.
- Smith, R.A., and Alexander, R.B., 1986, Correlations between stream sulfate and regional SO₂ emissions: Nature, v. 322, n. 6081, p. 722-724. A comparison of annual sulfur-dioxide emissions in the Eastern United States from 1967 to 1980, with stream-sulfate measurements made in 15 undeveloped watersheds during the same period, indicated that the two forms of sulfur were correlated on a regional basis. It also showed that although watersheds in the Southeast received a smaller fraction of regional sulfur emissions than did watersheds in the Northeast, they retained a much larger fraction of the sulfur received than those in the Northeast due to regional differences in the retention of deposited sulfur by basin soils and vegetation.

Funding

Source of Funds	Fiscal Year (\$ in millions)				
	1983	1984	1985	1986	1987
Federal funds	2.4	3.0	3.1	3.0	2.9

COORDINATION OF FEDERAL WATER-DATA ACQUISITION

The Department of the Interior, through the U.S. Geological Survey (USGS), coordinates the water-data acquisition activities of all agencies of the Federal Government. The responsibility was delegated by the Office of Management and Budget in 1964, and the Office of Water Data Coordination was established to implement the program. The objectives of the Water-Data Coordination Program include:

- ° Exercise leadership in achieving coordination of water-data acquisition activities.
- ° Maintain a central catalog of information on water data for the Nation.
- ° Prepare the Federal Plan for Water-Data Acquisition.
- ° Coordinate the planning, design, and implementation of a national water-data and information network.

Activities

- ° Organizes and convenes meetings of two special advisory committees representing Federal, State, and local governments, other organizations, and selected technical experts to advise the Secretary of the Interior on water-data acquisition. The advisory committees include representatives of 34 Federal agencies and 27 State and local agencies, technical societies, universities, and private businesses.
- ° Directs the preparation of the Federal Plan for Water-Data Acquisition.
- ° Documents, considers, and, as appropriate, implements recommendations of the advisory committees.
- ° Updates, as needed, the "National Handbook of Recommended Methods for Water Data Acquisition."

Recent Accomplishments

- ° Aided implementation of the National Water-Use Information Program, the National Stream Quality Accounting Network, the National Water-Data Exchange, and the River Quality Assessment Program of the USGS, on recommendation from advisory committees.
- ° Published a catalog of information on water-data acquisition activities from information supplied by more than 180 Federal liaison officials and 450 voluntary participants at State and local levels.
- ° Updated the hydrologic unit map of Alaska.
- ° Sponsored pilot studies in Colorado, Ohio, and Oregon on Water-Quality Data Acquisition Activities.
- ° Prepared a hydrologic unit map for the United States and for each of the States.

- ⁰ Prepared and distributed worldwide about 10,000 copies of "The National Handbook of Recommended Methods for Water Data Acquisition."

Funding

Source of Funds	Fiscal Year (\$ in millions)				
	1983	1984	1985	1986	1987
Federal funds	.9	.9	1.0	.9	.9

EROSION AND SEDIMENTATION (Sediment)

Accelerated sedimentation is caused by human activities such as agriculture, timber harvesting, mining, urbanization, and the construction of dams and other channel control structures. The purpose of the U.S. Geological Survey's (USGS) sediment activities is to provide a more complete understanding of sedimentation processes, and to develop and use mathematical models to estimate the impact of human activities on stream systems.

Activities

- ° Collects, analyzes, and reports data on sediment concentration, discharge, and particle-size deposition at 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 60 sedimentation-related studies are in progress.
- ° Carries out research projects on:
 - Measurement and prediction of sediment transport.
 - Mechanics of bedload-transport processes.
 - Storage of sediment in river systems.
 - Cumulative impacts of sediment resulting from coal mining.
 - Development of sediment-sampling and sediment-analysis instrumentation.

Recent Accomplishments

- ° Developed sediment-sampling instrumentation used by all Federal agencies and many foreign countries for the collection of sediment data.
- ° Estimated total sediment transport in the Snake and Clearwater Rivers near Lewiston, Idaho, which allowed the U.S. Army Corps of Engineers to lower the elevation of proposed levees around Lewiston. This resulted in saving several million dollars in construction costs.
- ° 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 USGS in evaluating proposed power generation release cycles from Glen Canyon Power Station.
- ° Developed techniques to estimate recurrence intervals of debris and mud flows 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.

- ° Defined the effects of channelization of streams in western Tennessee. The report "Man-Induced Channel Adjustment in Tennessee Streams" (Water-Resources Investigations Report 82-4098) provided the Tennessee Department of Transportation with information concerning channel stability in relation to river crossing structures.
- ° Developed a mathematical model to estimate sediment yields from surface coal mines in Pennsylvania and Maryland, and from a low-level nuclear waste site in Illinois.
- ° Defined sediment input to major water-supply reservoirs in Puerto Rico. This study pointed out the rapid sedimentation of the water-supply reservoirs for San Juan, Puerto Rico, and that the expected useful life of these reservoirs is less than 30 years.

Funding

Funding for this activity does not appear as a line item in the USGS budget but is derived from several sources.

In fiscal year 1987, approximately \$10 million will be expended on sediment studies.

ESTUARIES

Estuaries are potentially the most biologically productive portions of the ocean, but they are among the most fragile areas of the Nation's coastal environment. More than half of the Nation's population is concentrated within 50 miles of an estuary. The value of estuaries for water supply, commerce, recreation, and food supply depends to a large extent on their "health." Fresh and salt water meet and mix in estuaries, producing complex hydrodynamic, chemical, and biological environments. Estuaries are also highly efficient sediment traps that retain sediment-associated pollutants such as nutrients, metals, and organic chemicals. The trapped nutrients may be recycled from the bottom sediments, promoting eutrophication. The metals and organics often concentrate in the life forms, damaging the ecological cycle and making higher forms unsuitable for human consumption. In 1968, the U.S. Geological Survey (USGS) began intense studies of the impacts of changing hydrologic and water-quality conditions in estuaries and tributary streams. The purposes of these investigations include:

- ° Define present and past water-column and benthic conditions in selected U.S. estuaries.
- ° Monitor inputs of nutrients, sediments, metals, and organic chemicals into these estuaries.
- ° Develop conceptual and mathematical models to predict the effects of changes in inputs on estuarine water quality and ecology.

Activities

- ° Conducts studies of circulation of water and the transport of sediments, nutrients, and pollutants in San Francisco Bay and the Potomac River Estuary, Tampa Bay, Hillsborough Bay, Charlotte Harbor, and Cape Coral Canal System in Florida.
- ° Conducts interdisciplinary research into the effects of upland supplies and benthic recycling of nutrients on estuarine phytoplankton ecology and submersed vegetation.
- ° Determines the partitioning of trace metals among the components of estuarine sediments and ascertains the influence of this geochemical partitioning and the physiological characteristics of various benthic fauna on the biological uptake of these metals.
- ° Assesses the effects on water quality and productivity of Charlotte Harbor, Florida, due to land-use changes, increased freshwater diversion, and increased wastewater flows resulting from progressive urbanization.
- ° Determines the supply of sediments and pollutants by major tributaries to Chesapeake Bay and assesses some of the effects of geology and land-use practices on the loadings to these tributaries.
- ° Studies the hydrology of the Cape Fear River and of various sounds and estuaries in North Carolina.

- ° Develops a model for computing discharge into the Chowan River Estuary, North Carolina.
- ° Determines discharge into Mobile Bay, Alabama, using electromagnetic velocity meters.
- ° Studies the recolonization of benthic invertebrate communities within the Potomac River Estuary following summer anoxia.

Recent Accomplishments

- ° Defined subbottom geology and recent historical (300 years) sedimentation rates for the tidally influenced Potomac River to determine how rates have changed over time.
- ° Conducted circulation surveys in San Francisco Bay cooperatively with several State and local agencies. Results indicate that long-term circulation patterns play an important part in determining fates of pollutants in the Bay.
- ° Developed a model of water-column stability to aid in predicting phytoplankton blooms in South San Francisco Bay.
- ° Described short- and long-term fluctuations of trace-metal concentrations in sediments and clams in north San Francisco Bay, in cooperation with the U.S. Bureau of Reclamation.
- ° Documented the reappearance of native submersed vegetation in the tidal river portion of the Potomac River, and in cooperation with the Corps of Engineers, recorded the appearance and spread of the exotic species Hydrilla.
- ° Published six journal articles and one open-file report in 1986 dealing with the Potomac River and Estuary (there are now fifty publications resulting from the Potomac Estuary study).
- ° Conducted a series of sediment-trap deployments to directly measure the net downward mass transport rate of particulate material in the Potomac Estuary.
- ° Mapped the temporal and spatial extent of anoxia in the Potomac Estuary since 1984 and conducted interdisciplinary research on processes involved in or affected by anoxia.

Funding

Funding for this activity does not appear as a line item in the USGS budget but is derived from several sources.

In fiscal year 1987, the USGS will spend about \$4 million on studies in estuaries and bays. \$2.7 million of Federal funds will support studies in the San Francisco Bay and Potomac River Estuaries. About \$1.3 million will support Federal-State Cooperative Program studies.

FEDERAL-STATE COOPERATIVE ACTIVITIES

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, which continues today.

State and local agencies contribute at least half the cost of U.S. Geological Survey (USGS) investigations of regional and local water problems and conditions. From these and other investigations, the USGS acquires much of the hydrologic information needed for planning, developing, and managing the Nation's water resources. More than 900 State and local agencies and the USGS work together in selecting the investigations, producing 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 USGS's water resources activities.

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 USGS are supported by the Federal-State Cooperative Program.
- ° Conducts interpretive investigations (about 500 in fiscal year 1986) at the request of cooperators.
- ° Conducts investigations of current water issues such as ground-water contamination, 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 served 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.
- ° Developed preliminary information that shows an unexpectedly large body of fresh ground water extends seaward from Atlantic City, New Jersey.
- ° Provided geohydrologic information for evaluation of potential landfill sites in San Diego County, California.
- ° 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.

- ° Stimulated interest in legislation to protect aquifers which are the sole source of public water supplies, through an investigation of the Edwards Limestone Aquifer in Texas,
- ° Evaluated the water quality in numerous streams and aquifers, and assessed the existing and potential impacts of contamination from toxic wastes.

Funding

Source of Funds	Fiscal Year (\$ in millions)				
	1983	1984	1985	1986	1987
Federal-State Cooperative funds ¹	93.9	103.0	110.0	106.5	111.2

¹ The funds shown in the table represent both the Federal and State shares of the Cooperative Program.

GROUND-WATER PROTECTION--USGS AND EPA COORDINATION

Contamination of ground water is one of the most significant environmental issues facing the country. 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 problems. The design and implementation of programs to address these problems is hampered by limited scientific information on which to base policy decisions. The U.S. Geological Survey makes available the skills and capabilities of USGS personnel to assist the Environmental Protection Agency (EPA) 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 EPA on technical aspects of ground-water protection issues.
- ° Defines specific areas in which EPA and the Department of the Interior 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.

Recent Accomplishments

- ° Implemented Memorandums of Understanding with the EPA Office of Ground-Water Protection, related to the protection of the Nation's ground-water quality.
- ° Entered into an interagency agreement with the EPA Office of Pesticides, related to ground-water contamination by agricultural chemicals.
- ° Provided technical information for the EPA Office of Solid Waste and Emergency Response, in support of CERCLA, the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (Superfund), and RCRA, the Resource Conservation and Recovery Act of 1976.
- ° Began preparation of an umbrella agreement with the EPA to provide training and develop programs relevant to the EPA's technical needs.

Funding

In fiscal year 1986, EPA provided about \$1.6 million, most of which was in support of activities under CERCLA and RCRA.

GROUND-WATER QUALITY

The degree of contamination of the Nation's ground water is not well documented. Much is known about the distribution of the common inorganic constituents in the Nation's ground water from data collection and interpretive studies under the U.S. Geological Survey's (USGS) Federal-State Cooperative Program, Regional Aquifer System Analysis (RASA) Program, and other programs. Much less is known about the distribution of trace elements and organic compounds in ground water. The situation is complicated further by problems involved in obtaining representative samples of contaminated ground water (for example, what are the best ways to sample for volatile organic substances without part of the material escaping?) and in analytical techniques in the laboratory. The purpose of ground-water quality programs of the USGS is to improve understanding of the factors controlling ground-water quality, define the relation of water quality to ground-water flow patterns, and define the natural or background water quality of aquifers.

Activities

- ° Collects and interprets ground-water quality data as part of the Federal-State Cooperative and RASA Programs.
- ° Conducts studies ranging from site-specific 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 control of ground-water quality and the fate and movement of ground-water contaminants at research sites in Florida, Massachusetts, Minnesota, and Washington.

Recent Accomplishments

- ° Conducted more than 300 projects nationwide involving some aspect of ground-water quality during fiscal year 1986.
- ° Analyzed more than 15,000 water samples for organic and inorganic constituents; made more than 220,000 individual determinations during fiscal year 1986.

Funding

Funding for this activity does not appear as a line item in the USGS budget but is derived from several sources. In fiscal year 1987, the USGS will spend about \$30 million on ground-water studies involving some aspect of water quality.

GROUND-WATER QUANTITY

Population growth and expansion of agricultural and energy production have increased the competition for available water supplies. 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 U.S. Geological Survey programs. Generally, the purposes of these programs in terms of water quantity 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

- o 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--more than 500 studies in fiscal year 1987.
- o Measures water levels periodically in about 36,000 observation wells.
- o Develops and maintains a national ground-water database.
- o Conducts research, development, and documentation of ground-water flow models.

Recent Accomplishments

- o Conducted multidisciplinary hydrologic studies involving ground-water quantity in virtually every State, as part of the Federal-State Cooperative Program.
- o Continued studies of the Nation's 28 most important aquifer systems under the Regional Aquifer-System Analysis (RASA) Program.
- o Completed 10 Regional Aquifer System Analysis studies--Alluvial Basins of Nevada and Utah, Atlanta Coastal Plain, Central Midwest, Central Valley (California), Floridan Aquifer, High Plains, Snake River Plain, Northern Great Plains, Northern Midwest, and Southwest Alluvial Basins.
- o Developed the Ground-Water Site Inventory database which contains hydrologic and geologic information on more than 900,000 sites and more than 2 million water-level measurements.
- o 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.

Funding

Funding for this activity does not appear as a line item in the USGS budget but is derived from several sources. In fiscal year 1987, the USGS expenditures on ground water will be about \$90 million, of which about two-thirds will be directed towards water-quantity studies.

HAZARDOUS SUBSTANCES IN SURFACE WATER AND SEDIMENT

The introduction of synthetic organic chemicals and trace metals into the Nation's rivers through human activities has had an adverse impact upon the suitability of these waters as a source of drinking water and as a habitat for aquatic life. Toxic substances enter surface waters from sources such as industrial effluents, urban runoff, drainage from active and abandoned mines, agricultural use of pesticides, and through contaminated ground water. The U.S. Geological Survey (USGS) has addressed this problem to some extent in the Federal Program and the Federal-State Cooperative Program. In 1984, the USGS established a new program with the objective of increasing knowledge about contamination of surface water and sediments by hazardous substances at a national scale.

Activities

- ° Conducts detailed field investigations to determine the occurrence, distribution, and movement of different groups of hazardous substances in rivers.
- ° Conducts interdisciplinary research into the processes affecting the fate of hazardous substances within river basins.
- ° Conducts basic research into the fundamental physical, chemical, and biological processes which govern the distribution, movement, and fate of toxic substances in surface waters and sediment, and which affect concentrations in aquatic life.
- ° Develops study approaches, sampling techniques, and measurement methods to evaluate the occurrence, magnitude, movement, importance, and fate of hazardous substances. For example, work is underway on methods to determine trace-metal concentrations retained on various size fractions of sediment, and to improve methods for determining organic substances in sediment and water.
- ° Carries on research projects focusing on the physical, chemical, and biological processes which affect the movement and fate of toxic substances.

Accomplishments

- ° Started three multi-year river-basin studies in 1985 and 1986, to develop sampling and measurement techniques and to determine the occurrence, distribution, and movement of different groups of hazardous substances. Combining applied and basic research, the long-term intensive investigations are:
 - Calcasieu River, Louisiana, contaminated with organic chemicals from urban and industrial wastes and petrochemical plants.
 - Whitewood Creek and Belle Fourche River system, South Dakota, contaminated by mine wastes which include arsenic, cadmium, silver, and copper.

--Upper Arkansas River, Colorado, contaminated by mine drainage
containing cadmium, copper, iron, lead, manganses, nickel, and zinc.

Funding

Source of Funds	Fiscal Year (\$ in millions)				
	1983	1984	1985	1986	1987
Federal funds ¹	---	0.1	1.5	2.4	2.4

¹ Hazardous substances in surface water and sediment is not a line item in the budget. The activity is funded under Toxic Waste Hydrology.

HYDROLOGIC DATA COLLECTION

The Hydrologic Data-Collection Program is the basic program of the U.S. Geological Survey (USGS) for collecting and analyzing data on the Nation's surface 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 to provide standardized records on stream discharge (flow) and stage (height), reservoir and lake storage, ground-water levels, well and spring discharge, and the quality of surface and ground water. The purposes of the program are to:

- ° Provide the hydrologic data needed to support the obligations and concerns of the Federal Government.
- ° Provide the hydrologic data needed to respond to the mutual needs and concerns of State, local, and Federal 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 needed to support activities of other Federal agencies.
- ° Provides data needed to support national programs, such as energy studies.
- ° Operates stations to collect data on the quantity and quality of surface and ground water at local and State 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 National Stream Quality Accounting Network (NASQAN).
- ° Monitors hydrologic characteristics at sites relatively unaffected by human activities. See 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, 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 data annually for each State, Puerto Rico, and the Trust Territories. Published as needed special appendixes, such as data for coal-producing areas.

Types of Water-Data Collection Stations	Number of Stations--Fiscal Year 1986				
	Federal Program	Federal/State Cooperative Program	Other Federal Agencies	Combined Support	Total
<u>Stations (Surface water):</u>					
discharge:					
Continuous record.....	540	3,449	1,522	1,568	7,079
Partial record.....	32	3,150	345	134	3,661
Stage Only--Streams:					
Continuous record.....	19	244	247	30	540
Partial record.....	1	425	32	10	468
Stage Only--Lakes/Reservoirs:					
Continuous record.....	9	319	231	139	698
Partial record.....	6	281	88	35	410
Quality:					
Continuous record.....	86	346	228	71	731
Scheduled, long-term...	489	1,246	342	166	2,243
Short-term or project..	24	712	84	89	909
<u>Wells (Ground water):</u>					
Water levels:					
Continuous record.....	98	1,952	171	238	2,459
Scheduled, long-term...	595	19,680	1,318	2,393	23,986
Short-term or project..	1,253	7,752	839	652	10,496
Quality:					
Scheduled, long-term...	40	4,521	143	236	4,940
Short-term or project..	285	3,548	671	312	4,816

Funding

In fiscal year 1986 about \$85 million was directed to data collection and analysis. Sixty percent of the funding came from the USGS's Federal-State Cooperative Program, 29 percent from other Federal agency reimbursements, and 11 percent from the USGS Federal Program.

HYDROLOGIC DATA FOR COURT DECREES AND COMPACTS

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 U.S. Geological Survey 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 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 in cooperation with the Bureau of Reclamation, as required by the 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

Source of Funds	Fiscal Year (\$ in millions)				
	1983	1984	1985	1986	1987
Federal funds	1.9	2.0	2.1	2.1	2.0
State and local funds	.9	.9	.9	.9	.9
Total	2.8	2.9	3.0	3.0	2.9

HYDROLOGIC EFFECTS OF ENERGY-RESOURCES DEVELOPMENT (Coal Hydrology and Oil-Shale Hydrology)

The U.S. Geological Survey's Coal Hydrology Program was started in 1975, to provide the water data and hydrologic information needed to evaluate the effects of mining and reclamation on streams and aquifers to aid in the leasing and permitting process for mining coal of Federal lands. Currently, the program provides baseline hydrologic information on coal-mining areas to Federal and State regulatory agencies for use by the coal industry in planning and managing mining and reclamation operations.

The Oil-Shale Program provided information to help assure the sound development of the Nation's oil-shale resources by determining the quality and quantity of water available, and by developing the capability to predict the potential impacts of both surface mining and in situ mining on water resources.

Activities

- ° Acquires and disseminates hydrologic information on existing and potential coal-mining areas throughout the country.
- ° Upgrades hydrologic data networks and implements hydrologic studies in major coal areas.
- ° Collects baseline data on the quantity and quality of surface and ground water in oil-shale areas of Colorado, Utah, and Wyoming.
- ° Improves techniques for interpreting hydrologic data and develops mathematical models for predicting the effects of mining and reclamation on water resources.
- ° Develops the capability to predict the effects of both surface and in situ retorting of oil shale on local water resources.
- ° Conducts hydrologic studies in the Piceance, Parachute-Roan Creek, Green River, and Uinta Basins of Colorado, Utah, and Wyoming. These studies include aquifer tests, mathematical models of the aquifer, and the reaction of waste products in the surface-water and ground-water system.

Recent Accomplishments

- ° Published water-data indexes for the major coal provinces.
- ° Published a State-by-State bibliography of coal hydrology.
- ° Prepared 57 Coal Area Hydrology reports that summarize pertinent hydrologic data in the Nation's principal coal areas nationwide.
- ° Expanded hydrologic data-collection network for improved definition and characterization of regional hydrology in coal areas and Federal oil-shale lease areas.

- ° Developed predictive basin models to simulate the effects of various coal-mining and land-use changes.
- ° Developed hydrologic models of the Piceance Creek in Colorado to predict effects of mining and retorting of oil-shale on surface-water and ground-water resources.
- ° Published more than 500 reports pertaining to coal hydrology, and more than 50 reports concerning oil-shale hydrology during the last 10 years of the program. Examples of completed reports are:
 - Hydrology and Geochemistry of coal-mining area in Montana.
 - Hydrogeochemical consequences of strip mining in the Fort Union Group, North Dakota.
 - Hydrogeology of potential mining areas in the Warrior coalfield, Alabama.
 - Baseline water quality of Iowa's coal region.
 - Ground-water and surface-water models of the oil-shale areas.
 - Sediment production and transport from the oil-shale area.
 - Chemistry of leachates from oil-shale pits.
 - Chemical effects of wastes from in situ retorts.
 - Acidification of lakes in the oil-shale areas.
- ° Conducted educational programs in hydrology and developed instructional manuals for personnel of the Bureau of Land Management and Office of Surface Mining.

Funding (coal)

Source of Funds	Fiscal Year (\$ in million)				
	1983	1984	1985	1986	1987
Federal funds	6.8	4.4	1.0	---	---
Federal-State Cooperative funds	6.0	6.4	8.6	8.4	4.4
Other Federal Agencies	2.9	1.6	0.9	0.8	0.4
Total	15.7	12.4	10.5	9.2	4.8

Funding (oil-shale)

Source of Funds	Fiscal Year (\$ in million)				
	1983	1984	1985	1986	1987
Federal funds	1.2	0.3	0.3	0.3	---

HYDROLOGIC HAZARDS (Floods)

The U.S. Geological Survey (USGS) defines the magnitude and frequency of flood-peak discharges, the areas inundated, changes in stream sediment transport, and 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.
- ° Improve the technology required by planners, designers, engineers, and decision makers to mitigate future flood losses of life, property, and income.
- ° Contribute to better understanding 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 uses data from about 2,900 USGS-operated stations in forecasting river stages.

Recent Accomplishments

- ° Completed model studies of backwater and flow distribution at crossings of the Pearl River by highways I-10 and U.S. 90 near Slidell, Louisiana. Published reports documenting the results.
- ° Developed statistical techniques to estimate the frequency and magnitude of flooding at ungaged stream sites in 9 States.
- ° Applied limited hydraulic techniques to flood-insurance studies in 515 communities in 35 States and used standard step-backwater techniques in 38 communities in 11 States, in cooperation with the Federal Emergency Management Agency (FEMA).
- ° Developed and tested generalized least-squares regression techniques which improve estimates of the magnitude and frequency of flooding at ungaged sites.
- ° Developed paleohydrologic techniques to identify and date historic floods.

- ° Documented the April 1979 Floods in Mississippi and Alabama in cooperation with the National Weather Service (U.S. Geological Survey Professional Paper 1319).
- ° Documented the October 1983 floods in southwestern and central Oklahoma (U.S. Geological Survey Open-File Report 85-494), the May 1984 floods in Tulsa, Oklahoma (U.S. Geological Survey Hydrologic Atlas 707), and the August 1985 flood in Cheyenne, Wyoming (U.S. Geological Survey Hydrologic Atlas 699).

Funding

Funding for this activity does not appear as a line item in the USGS budget but is derived from several sources.

Approximately \$1 million will be expended in fiscal year 1987 to conduct site-specific, flood-related investigations in cooperation with States and other Federal agencies. An additional \$0.7 million will be expended on research related to floods and flood-frequency analysis and on the documentation of flood events. FEMA will provide about \$0.4 million to conduct flood-insurance studies. Finally, about \$1 million of the cost of operating surface-water gaging stations can be attributed to the collection of flood data.

INDIAN WATER RIGHTS

Decisions on Indian water rights will have a major impact on the existing pattern of water allocation in the western States. The U.S. Geological Survey (USGS) collects hydrologic data and performs water-resource 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 for Indian tribes is to define the location, quantity, and quality of water available on Indian lands; determine how the water supply varies in terms of quantity and quality; describe the natural or historical condition of the resource; and appraise the potential of the water resource for further development.

Activities

- ° Participates in the planning and deliberations on Indian water rights with representatives of the Department of the Interior Solicitor's Office, the Justice Department, BIA, and the Indian tribes.
- ° Conducts hydrologic investigations on Indian lands in Arizona, California, Idaho, Minnesota, Montana, New Mexico, Oregon, Washington, and Wisconsin.

Recent Accomplishments

- ° Installed three test wells in the Bidahochi Formation near the northwest corner of Zuni tribal lands in New Mexico, and five observation wells near the Zuni-Pueblo test-production well to help determine the yield, variability, and quality of water supplies.
- ° Completed a report on the water quality of the Lower Puyallup River Valley and adjacent uplands for use of the Puyallup Indian Nation in Washington.
- ° Evaluated ground-water conditions of the Cahuilla Indian Reservation documenting changes in ground-water levels and chemical quality that occurred in the area during 1973-86.
- ° Collected water-quality data from nine different lakes as part of an assessment of the water resources of the White Earth Indian Reservation.

Funding

Funding for this activity does not appear as a line item in the USGS budget but is derived from several sources.

In fiscal year 1986, approximately \$2 million will be spent on studies related to Indian water-rights. About one-half of these funds are transfers from the Bureau of Indian Affairs; the remainder are funds from individual Indian tribes which are matched as part of the Federal-State Cooperative Program.

INSTRUMENTATION

Modern technologies have greatly increased the U.S. Geological Survey's (USGS) capability to conduct hydrologic investigations. Computers, communications satellites, automated radios, 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 USGS, through its Hydrologic Instrumentation Facility at Bay St. Louis, Mississippi, and the Satellite Data Relay Project at Reston, Virginia, is working to improve hydrologic instruments and to increase their use in the USGS's data collection activities.

Activities

- ° Works to expand the number of hydrologic parameters that can be automatically monitored at field stations.
- ° Plans and develops hydrologic data-collection and telemetry instrumentation.
- ° Tests and evaluates commercially available instrumentation.
- ° Supplies and repairs instruments.
- ° Coordinates the planning, procurement, and use of the Geostationary Operational Environmental Satellites (GOES) for the relay of hydrologic data by District offices.
- ° Develops computerized procedures for handling data prior to the entry of data into the National Water Information System.

Recent Accomplishments

- ° Initiated a comprehensive test and evaluation program to qualify hydrologic data-collection instrumentation for use by the Federal Government.
- ° Assisted USGS Districts and other agencies to establish GOES satellite telemetry at more than 2000 USGS hydrologic stations to increase their access to real-time data.

Funding:

Source of Funds	Fiscal Year (\$ in millions)				
	1983	1984	1985	1986	1987
Federal funds	2.0	2.0	1.9	1.8	1.6

INTERNATIONAL HYDROLOGY

The Office of the Assistant Chief Hydrologist for Research and External Coordination is responsible for directing the U.S. Geological Survey's (USGS) program of international cooperation in the field of water resources. The office represents the USGS in international water-resources investigations, arranges visits and training for foreign nationals in various fields of hydrology, and facilitates the visiting scientists program. These activities are conducted through (1) international governmental organizations such as the United Nations, (2) international non-governmental organizations such as the International Association of Hydrological Sciences, (3) government-to-government agreements, (4) scientist-to-scientist exchange, and through (5) U.S. agencies such as the U.S. Agency for International Development. Additional purposes include support of U.S. foreign policy and missions, promotion of international cooperation in earth sciences, and information transfer.

Activities

- ° Investigates and monitors foreign water-resources research and methodology for potential applications to domestic water programs.
- ° Plans and directs international water-resources investigations.
- ° Responds to all foreign requests for information or publications.
- ° Arranges itineraries and is the host for all visits of foreign nationals to the Water Resources Division.
- ° Represents the United States in the water programs of international inter-governmental and non-governmental bodies.

Recent Accomplishments

- ° Arranged missions for 119 U.S. scientists to foreign countries in 1985 and for 133 in 1986.
- ° Planned and directed hydrologic assistance programs of the USGS in the Near East, Far East, and Central and South America.
- ° Directed an exchange program of hydrologic information between the United States and the Peoples Republic of China.
- ° Monitored an exchange program of hydrologic information between the United States and Spain.
- ° Arranged training programs for 30 foreign scientists and technicians in fiscal year (FY) 1985 and for 29 in 1986.
- ° Arranged missions to the United States for 69 scientists and administrators from foreign countries in 1985 and for 58 in 1986.
- ° Responded to requests from the Office of Foreign Disaster Assistance, Agency for International Development.

Funding

Source of Funds	(Fiscal Year (\$ in millions))				
	1983	1984	1985	1986	1987
Federal funds	0.2	0.2	0.2	0.2	---
Department of State, Treasury, foreign government funds	2.3	1.5	1.3	1.0	---
Total	2.5	1.7	1.5	1.2	---

IRRIGATION DRAINAGE STUDIES

The quality of irrigation drainage water and its potential effects on human health, fish, and wildlife are of increasing concern. High concentrations of selenium have been detected in subsurface drainage from irrigated land in the western part of the San Joaquin Valley, California. High incidences of mortality, birth defects, and reproductive failures have been observed in water fowl nesting in Kesterson Reservoir (CA) where drainage water from the western San Joaquin Valley is impounded. High concentrations of selenium have also been detected in fish, plants, and birds exposed to drainwater. In addition to selenium, arsenic and toxic heavy metals have been detected in numerous areas in the Western United States that receive irrigation drain-water.

In October 1985, the Department of the Interior (DOI) formed a technical Interbureau Task Group, chaired by the U.S. Geological Survey (USGS), to recommend a comprehensive plan for reviewing irrigation drainage concerns. The purpose of the Irrigation Drainage Studies is to determine whether irrigation drainage has caused or has the potential to cause harmful effects on human health, fish and wildlife, or impair drainage water for other uses. The DOI is committed to identifying the extent of present or potential concerns in three specific irrigation-drainage situations: (1) project irrigation or drainage facilities constructed or managed by DOI; (2) National Wildlife Refuges that receive irrigation drain water; and (3) other migratory-bird or endangered-species management areas that receive water from department-funded projects.

Activities

- ° Compiles a list of areas that fall under the scope of the DOI management strategy.
- ° Prepares detailed work plans for field-screening studies.
- ° Makes results of studies available to both the public and private sectors.
- ° Plans the conduct of intensive studies to determine the extent, magnitude, impacts, and causes of contamination problems.

Recent Accomplishments

- ° Prepared the departmental management strategy for identifying and addressing irrigation-induced water-quality problems that involve DOI responsibilities.
- ° Prepared a protocol for interbureau field-screening studies needed to help determine whether corrective action is needed in selected areas.
- ° Began field-screening studies in nine areas in seven Western States.

- ° Prepared the report "Preliminary Evaluation of Selenium Concentrations in Ground and Surface Water, Soils, Sediment, and Biota from Selected Areas in the Western United States."

Funding

Source of funds	Fiscal Year (\$ in millions)				
	1983	1984	1985	1986	1987
Federal Funds	---	---	1.0	0.8	3.6

LAKE HYDROLOGY

Lakes and reservoirs are important sources of water supply and recreation, and a significant component of the Nation's water resources. The U.S. Geological Survey's (USGS) 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 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, Washington, and Wyoming.
- ° Conducts extensive studies on lakes with specific water-quality problems such as Reelfoot Lake, Tennessee; Lake Houston, Texas; and Lake Clara, Wisconsin.
- ° 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 and acid rain.
- ° Assists agencies responsible for lake management, such as the U.S. Fish and Wildlife Service, U.S. Corps of Engineers, Bureau of Reclamation, and Bonneville Power Authority.

Recent Accomplishments

- ° Showed that seepage from lakes greatly affects ground-water chemistry, resulting 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 which, in turn, influences waterfowl habitat and food production.
- ° Increased understanding of the role of lakes in the hydrologic system with respect to ground-water recharge and discharge by defining ground-water flow systems relative to lakes.
- ° Obtained humic substances from the surface and deep water of Freemont Lake in Wyoming. This is a "first" from the standpoint of determining the concentration and abundance of natural organics in lakes.

Funding

Funding for this activity does not appear as a line item in the USGS budget but is derived from several sources.

In fiscal year 1986, total funding for lake hydrology studies was about \$2.0 million.

NATIONAL HYDROLOGIC BENCH-MARK NETWORK

The National Hydrologic Bench-Mark Network was started in 1958 to define the natural water quality of streams in basins where the land surface has not been altered by man. The Hydrologic Bench-Mark Network includes 58 stations located in 37 States. Selection of Bench-Mark basins was guided by the following criteria:

- ° No artificial storage, regulation, or diversion existed or was probable for many years.
- ° Pumping from wells within the basin was minor and should not materially affect ground water.
- ° Conditions were favorable for accurate measurement of streamflow, and the chemical and physical quality of water.
- ° 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 53 sites.
- ° Analyzes trends in water-quality data from the Bench-Mark Network.
- ° Evaluates data from Bench-Mark sites to determine:
 - Processes which control water-quality trends at Bench-Mark sites.
 - Trace-element concentrations in snowmelt.
 - Variability of stream acidity in the northeastern United States.

Recent Accomplishments

- ° Determined trends in surface-water quality in natural environments of the United States using data from the Hydrologic Bench-Mark Network. (U.S. Geological Survey Open-File Report 83-533.)
- ° 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, R. A., and Alexander, R. B., 1983, Evidence for acid-precipitation-induced trends in stream chemistry at Hydrologic Bench-Mark Stations: U.S. Geological Survey Circular 910.

Funding

Source of Funds	Fiscal Year (\$ in millions)				
	1983	1984	1985	1986	1987
Federal funds	0.6	0.6	0.6	0.6	0.7

NATIONAL STREAM QUALITY ACCOUNTING NETWORK (NASQAN)

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, and to determine whether water quality was deteriorating, remaining unchanged, or improving. NASQAN currently consists of 437 sites within the United States and its Territories, and provides data for two objectives: (1) to determine surface-water quality trends, and (2) to account for mass transport of constituents between major river basins, and to the oceans. The consistency of data-collection procedures used in this program has created one of the most complete and best quality-assured data-bases of its type in the world.

Activities

- ° Collects streamflow and water-quality data at 411 sites to provide a nationally consistent database 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 upstream. (U.S. Geological Survey Water Resources Investigations Report 85-4253.)
- ° Reviewed the entire NASQAN network to develop a narrative description for each site, and a hypothesis for station operation. The review resulted in site changes which included 91 discontinued, 26 inactive, and 31 added to the network.
- ° Accepted to be published in Science, journal of the American Association for the Advancement of Science: an article that examines long-term water-quality time trends at more than 300 locations on major U.S. rivers. The results indicate influences on water-quality trends from terrestrial and atmospheric sources. ("The Nation's Rivers Revisited" by R.A. Smith, R.B. Alexander, and M.G. Wolman.)

Funding

Source of Funds	Fiscal Year (\$ in millions)				
	1983	1984	1985	1986	1987
Federal funds	4.3	4.4	4.5	4.5	4.4

NATIONAL TRAINING CENTER

The U.S. Geological Survey (USGS) training facility was established in 1977 in Lakewood, Colorado, to provide specialized training for USGS personnel and others connected with USGS activities. The facility offers training in hydrologic science and techniques that is not generally available elsewhere, as well as specialized training in support of the programs of the other USGS Divisions and other Federal agencies.

The center is able to incorporate new research results in its courses, and increase the technical skills of personnel. It also enables newly recruited personnel to obtain training in special methods required in water-resources investigations.

Activities

- ° Conducts formal training for USGS personnel, representatives from cooperating agencies, and selected international participants. Hydrologic topics range from basic ground-water concepts to advanced three-dimensional modeling of ground-water flow.
- ° Serves as a site for seminars, conferences, and meetings of large groups.
- ° Administers specialized correspondence courses for USGS personnel in selected hydrologic topics, management, and administration.

Recent Accomplishments

- ° Provided support for 39 water-resources-program related training courses attended by 753 personnel in FY 1986, including 474 professional hydrologists, and 115 students from cooperating agencies and organizations.
- ° Provided support for 248 courses presented by other USGS Divisions and other Federal agencies, attended by 3,615 participants.
- ° Provided support for 416 conferences, meetings, and seminars involving 5,267 participants.

Funding

Source of Funds	Fiscal Year (\$ in millions)				
	1983	1984	1985	1986	1987
USGS funds allocated to the Training Center ¹	.5	.5	.55	.45	.51

¹ Funding allocation for operation and maintenance of the Training Center. Does not include the costs of the actual courses.

NATIONAL WATER-QUALITY ASSESSMENT

The Nation's continued growth and vitality is linked to the quality of its water resources. Through combined Federal, State, and local efforts, the quality of many rivers and streams has improved significantly in the past two decades, even as growing industrial activity and population produced increases in water use and the volume of wastewater.

However, despite the improvement, several water-quality issues remain. These include the possible contamination of surface and ground water from nonpoint-source discharges, acid precipitation, and the disposal of hazardous waste. Cost-effective solutions may be difficult because solutions by onsite treatment may be impractical and may require changes in industrial processes or land-use practices. Further progress in water-quality improvement will require increased knowledge of the nature and extent of these potential problems, as well as the physical, chemical, and biological processes affecting water quality in streams and aquifers.

In 1986, the U.S. Geological Survey (USGS) began a National Water-Quality Assessment Program to:

- ° Provide nationally consistent descriptions of the current status of water quality for a large, diverse, and geographically distributed part of the Nation's water resources.
- ° Define trends in water quality that have occurred over recent decades and provide a baseline for evaluating future trends in water quality.
- ° Provide an understanding of the factors which influence water quality, and thereby provide the basis to forecast change and evaluate the likely effect on water quality of various proposed remedial actions.

Activities

- ° Develops long-range plans for the implementation of a national water-quality assessment program, including the identification of areas to be included in the assessment.
- ° Evaluates the policy and economic aspects of information produced by a National Water-Quality Assessment Program.
- ° Develops strategies for assessing inorganic and organic target constituents in ground and surface waters.
- ° Establishes field sampling and laboratory analytical protocols for the program, including quality-assurance procedures.
- ° Develops a program of biological activities to be included under a National Water-Quality Assessment Program.

Recent Accomplishments

- ° Started seven pilot studies--four surface-water projects (Illinois River, Kansas River, Kentucky River, and Yakima River) and three ground-water projects (Carson basin, Central Oklahoma aquifer, and Delmarva Peninsula), to test, and modify as needed, assessment concepts and approaches in preparation for possible full implementation of the National Water Quality Assessment Program.
- ° Established National Water-Quality Assessment committees and advisors--consisting of USGS scientists, and scientists and managers of other Federal, State, and local agencies--to enhance communication and coordination and to seek their advice and comments on various aspects of the program.

Funding

Source of Funds	Fiscal Year (\$ in millions)				
	1983	1984	1985	1986	1987
Federal funds	---	---	---	2.5	7.0

NATIONAL WATER-QUALITY LABORATORY

To support its water-resources investigations, the U.S. Geological Survey (USGS) operates the National Water-Quality Laboratory, located near Denver, Colorado. The facility is equipped with the most modern and sophisticated instrumentation which permits inorganic, organic, trace-metal, and heavy-metal analysis of precipitation, surface and ground water, bottom sediment, aquatic animal and plant tissue, and aquifer materials. An additional water-quality laboratory operated by the USGS at Atlanta, Georgia was made a part of the Denver operation in April 1986.

Activities

- ° Provides physical, chemical, and biological analyses in support of the USGS's water resources investigations.
- ° Develops methods of analysis of organic and inorganic substances in water and sediment.
- ° Provides continuous quality assurance for all analyses.
- ° Uses computerized techniques to provide rapid access to water-quality data.

Recent Accomplishments

- ° Performed 665,000 water-quality analyses on 44,500 samples in fiscal year 1986.
- ° Consolidated the Atlanta, Georgia, and Denver, Colorado, laboratories into one facility at Denver.
- ° Began a major reorganization of the consolidated laboratory with major emphasis toward strengthening methods development and quality assurance.
- ° Completed construction of a hazardous-materials containment room for preliminary analysis, to ensure a safe working environment.

Funding

Source of funds	Fiscal Year (\$ in millions)				
	1983	1984	1985	1986	1987
USGS offices or other Federal agencies requesting analytical work	5.3	7.3	7.5	6.6	7.1

NATIONAL WATER SUMMARY

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:

- ° Describe the nature and extent of water issues.
- ° Develop and maintain maps and national summary statistics to describe water conditions.
- ° Improve methods of evaluating and characterizing effects of land and water uses on the distribution and availability of water resources.
- ° 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 an annual water summary which describes hydrologic events and water conditions and discusses major water issues of concern.

Recent Accomplishments

- ° Prepared a map of the United States at a scale of 1:3,168,000 showing the location of surface-water and land-related resources developments, such as dams and reservoirs.
- ° Developed an inventory of annual water imports and exports for major river basins in the West.
- ° Developed a database from which national maps of pesticide application can be made. The database contains county-level data on application of 186 pesticides.
- ° Published "National Water Summary 1983--Hydrologic Events and Issues," which included a State-by-State overview of major water-related issues, a perspective on national water issues, and a calendar of major hydrologic events.
- ° Published "National Water Summary 1984--Hydrologic Events, Selected Water-Quality Trends, and Ground-Water Resources."
- ° Published "National Water Summary 1985--Hydrologic Events and Surface-Water Resources."
- ° Prepared for publication "National Water Summary 1986--Hydrologic Events and Ground-Water Quality."

⁰ Completed plans for publication of "National Water Summary 1987--
Hydrologic Events and Water Supply and Demand."

Funding

Source of Funds	Fiscal Year (\$ in millions)				
	1983	1984	1985	1986	1987
Federal funds	0.3	1.3	1.3	1.4	1.4

NATIONAL WATER-USE INFORMATION

The quantity and quality of water used in the Nation is of importance to a broad range of public and private interests, including water policy makers, planners, managers, and water users. The U.S. Geological Survey (USGS) 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 1977, upon recommendation of the Advisory Committee on Water Data for Public Use, the USGS established the National Water-Use Information Program to complement the data on the availability and quality of the Nation's water resources.

The program is part of the USGS's Federal-State Cooperative Program and is designed to meet the need for uniform information on water use, and the mutual needs of State and Federal governments. The purpose of the program is to determine how much fresh and saline surface and ground water is withdrawn nationwide, how much water is consumed during use, and how much water is returned for further use.

Activities

- ° Assists the States in the collection and compilation of water-use data.
- ° Incorporates water-use data in water resource assessments, investigations, and research.
- ° Develops a computerized data storage and retrieval system at the 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.

Recent Accomplishments

- ° Established water-use programs in 48 States and Puerto Rico.
- ° Developed the computerized National Water-Use Data System at the Federal level. As of December 1986, 46 States had entered 1985 estimates for 12 categories of water use.
- ° Developed the computerized State Water-Use Data System for States to store and retrieve site-specific water-use information.
- ° Held regional water-use workshops to acquaint State and Federal personnel with the scope and objectives of the program, and to initiate training in procedures for entering data and maintaining the National and State Water-Use Data Systems.

⁰ Prepared 15 State water-use reports in 1986, bringing to 90 the total number of reports completed under the Water-Use Program. Examples of reports include:

--Callahan J.A., 1985, Water Use in the Delta Counties of Mississippi, 1983: U.S. Geological Survey Water Resources Investigations Report 85-4187.

--Pierce, R.R. and others, 1984, Georgia Irrigation, 1970-80: A Decade of Growth: U.S. Geological Survey Water-Resources Investigations Report 83-4177, 29 p.

--Patch, J.C., and Haffield, N.D., 1984, Estimated Use of Water for North Dakota, 1982: North Dakota Water Commission Information Series No. 33.

Funding

Source of Funds	Fiscal Year (\$ in millions)				
	1983	1984	1985	1986	1987
Federal-State Cooperative funds	6.4	7.8	7.8	7.3	7.7

¹ Includes both Federal and State shares of program funds.

NONPOINT SOURCES OF POLLUTION

Diffuse nonpoint sources of water pollution, such as agricultural, urban, mining, industrial, and construction runoff, constitute a continuing threat to water quality that is neither well understood nor defined. The U.S. Geological Survey (USGS) conducts water-quality investigations encompassing almost all aspects of the hydrology of nonpoint sources, from collecting and reporting hydrologic data, to conducting basic research for better understanding the fundamental processes that control nonpoint-source pollution.

Activities

- ° Monitors water quality at a nationwide network of 411 sites (National Stream Quality Accounting Network) representing major drainage basins, and at a nationwide network of 53 sites located in pristine areas (Hydrologic Benchmark Network).
- ° Conducts urban runoff studies to better understand the factors that control urban nonpoint-source pollution.
- ° Conducts research on the fundamental processes of pollutant mobilization, transport, degradation, and fate, with increased emphasis on nonpoint sources of toxic substances in surface water and sediments.

Recent Accomplishments

- ° Conducted 190 projects in fiscal year 1985, each of which focused on at least one source of nonpoint-source pollution including: urban and construction, 33 projects; agriculture, 17; industrial, 10; mining, 103; other, 27.
- ° Participated with the Environmental Protection Agency and other Federal agencies in the development of a national nonpoint-source policy.
- ° Completed urban runoff studies at 22 sites to define storm-water loadings in relation to basin characteristics.
- ° Completed 57 reports on the hydrology of major coal-mining provinces in the East, Midwest, and Rocky Mountains.
- ° Concluded arrangements with the Agricultural Research Service of the U.S. Department of Agriculture for a joint investigation in southwest Georgia to improve knowledge of the transport and fate of agricultural chemicals in surface and ground water.
- ° Continued to monitor nutrient loads from major tributaries to the Chesapeake Bay.

Funding

Funding for this activity does not appear as a line item in the USGS budget but is derived from several sources. Approximately one-quarter of the USGS's water program involves some aspect of nonpoint-source pollution. It is estimated that about \$57 million will be spent on activities related to nonpoint-source pollution in fiscal year 1987.

NUCLEAR WASTE DISPOSAL--HIGH-LEVEL

The Nuclear Waste Policy Act of 1982 mandates that high-level radioactive waste derived from nuclear power development be disposed of safely in deep mined facilities. The earth science problems associated with this endeavor are complex. The U.S. Geological Survey Nuclear Waste Hydrology Program began in 1979. Its purpose is to study environments, processes, and techniques and methods to characterize sites in support of the Department of Energy (DOE), the Nuclear Regulatory Commission (NRC), and the Environmental Protection Agency (EPA) in their responsible roles in the program of managing civilian radioactive waste.

Activities

- ° Identifies environments with effective natural multiple barriers to the movement of radionuclides.
- ° Develops techniques and methods for characterizing geohydrologic environments.
- ° Investigates processes related to radionuclide migration.
- ° Contributes to development of rules, regulations, and guidelines.
- ° Reviews significant reports by other agencies as related to disposal of radioactive waste.
- ° Defines the technical basis for determining the hydrologic suitability of the DOE Nevada Test Site for the disposal of high-level nuclear waste. See Nuclear Waste Disposal--Nevada Test Site.
- ° Consults with the DOE on site-specific technical problems.

Recent Accomplishments

- ° Completed a prototypical study of the Basin and Range physiographic province in close cooperation with the involved States to define areas that have geohydrologic conditions for multiple natural barriers.
- ° Completed a reconnaissance study in the east to determine if buried crystalline rocks might be used to construct a repository.
- ° Conducted research in techniques of drilling, hydraulic testing, and geophysical methods of characterizing environments.
- ° Conducted research in the hydrology of fractured rock and of unsaturated geohydrologic environments.
- ° Contributed significantly to development of siting guidelines of the DOE.
- ° Contributed significantly to development of a proposed rule by the NRC to define the technical criteria for disposal of high-level radioactive wastes in geologic repositories.

- ° Contributed significantly to development of a proposed regulation by the EPA to establish environmental radiation protection standards.
- ° Reviewed drafts of environmental assessments to aid in the selection of sites for further study, leading to the choice of an acceptable site for the first repository for civilian high-level radioactive waste.

Funding

Source of Funds	Fiscal Year (\$ in million)				
	1983	1984	1985	1986	1987
Federal funds	4.5	4.8	4.7	4.4	1.7
Other Federal agency funds ¹	.7	.7	.6	.6	.6
Total	5.2	5.5	5.3	5.0	2.3

¹ Does not include DOE funds for the Nevada test site study (See Nuclear Waste Disposal--Nevada Test Site).

NUCLEAR WASTE DISPOSAL--LOW LEVEL

Low-level nuclear wastes result from a variety of activities, including university research programs, medical treatment, and electrical power generation. The radioactivity of low-level wastes is considerably less than that of high-level nuclear wastes associated with irradiated nuclear fuel. Thus, the standards for waste-disposal sites are not as stringent as those for high-level nuclear wastes, but the selection of effective sites requires careful study, particularly in determining site hydrogeology.

The purpose of the program is to develop hydrologic information for use in selecting future sites for burial of low-level nuclear wastes, and to aid in monitoring and managing existing sites. Commercial sites now open are located at Beatty, Nevada; Barnwell, South Carolina; and Richland, Washington.

Activities

- ° Conducts research and field investigation into processes controlling leaching and migration of radionuclides from three existing shallow land-disposal sites: Beatty, Nevada which is open, and Maxey Flats, Kentucky and Sheffield, Illinois, which have been closed.
- ° Develops techniques and guidelines for the selection and design of future sites and for determining remedial measures at existing sites where site performance does not appear to be satisfactory.
- ° Assists other Federal and State agencies in developing and implementing effective low-level waste-management programs.

Recent Accomplishments

- ° Completed detailed hydrogeologic descriptions of five commercial low-level waste sites at West Valley, New York; Barnwell, South Carolina; Maxey Flats, Kentucky; Sheffield, Illinois; and Beatty, Nevada.
- ° Conducted studies at U.S. Department of Energy waste-disposal sites at Idaho Falls, Idaho; Oak Ridge, Tennessee; and Argonne, Illinois.
- ° Demonstrated and documented the usefulness of complex computer models to simulate movement of radionuclides in ground water.
- ° Identified and described in reports the major geologic and hydrologic problems associated with existing disposal sites for low-level wastes.
- ° Provided technical assistance to the Nuclear Regulatory Commission in the preparation of criteria for the selection of low-level-waste burial sites.
- ° Provided technical assistance to the Environmental Protection Agency in the development of standards for release of low-level waste contaminants into the environment.

- ° Provided improved understanding of contaminant transport at U.S. Government low-level waste sites in cooperative investigations with the Department of Energy.
- ° Provided technical assistance to State agencies and compacts in the selection of new sites in accordance with Public Law 99-240--the Low-Level Radioactive Waste Policy Amendments Act of 1985. The Act requires unsited compacts (multi-State regions) or a non-member unsited State to file a complete license application for a low-level radioactive waste disposal facility by January 1, 1992. The U.S. Geological Survey is developing hydrogeologic siting guidelines and criteria, and providing advice and the results of geohydrologic research to Federal Agencies, States, and compacts who are responsible for developing additional sites for the disposal of low-level radioactive waste prior to the 1992 deadline.
- ° Published reports, including:
 - Cahill, J.M., 1982, Hydrology of the low-level radioactive solid-waste burial site and vicinity near Barnwell, South Carolina: U.S. Geological Survey Open-File Report 82-863, 101 p.
 - Foster, J.B., Erickson, J.R., and Healy, R.W., 1984, Hydrogeology of a low-level radioactive waste disposal site near Sheffield, Illinois: U.S. Geological Survey Water Resources Investigations Report 83-4125, 83 p.
 - Prudic, D.E., 1986, Ground-water hydrology and subsurface migration of radionuclides at a commercial radioactive-waste burial site, West Valley, Cattaraugus County, New York: U.S. Geological Survey Professional Paper 1325, 83 p.
 - Zehner, H.H., 1983, Hydrogeologic Investigation of the Maxey Flats active waste burial site, Fleming County, Kentucky: U.S. Geological Survey Open-File Report 83-133, 147 p.

Funding

Source of Funds	Fiscal Year (\$ in millions)				
	1983	1984	1985	1986	1987
Federal funds	2.1	2.4	2.6	2.6	2.6
Other Federal agency funds	1.2	1.2	1.2	1.2	1.0
Total	3.3	3.6	3.8	3.8	3.6

NUCLEAR WASTE DISPOSAL--NEVADA TEST SITE

The Nuclear Waste Policy Act of 1982 defined the procedures and timetable for selecting the Nation's first repository for high-level nuclear waste. One of the sites being considered by the Department of Energy (DOE) is Yucca Mountain, Nevada Test Site (NTS). A brief history of the program is:

- ° 1977--Studies began; screening of potential sites at NTS.
- ° 1979--Focus on Yucca Mountain as potential site.
- ° 1982--Shift of emphasis from saturated zone to unsaturated zone as potential repository horizon.
- ° 1983--Acceleration and expansion of program as a result of passage of the National Waste Policy Act.

The U.S. Geological Survey is principal investigator of earth-science issues during site characterization. The objective of the program is to assist the DOE in developing the technical basis for determining the hydrologic suitability of this site for isolating waste.

Activities

- ° Conducts geohydrologic field, laboratory, and modeling investigations of unsaturated-zone hydrology, saturated-zone hydrology, paleohydrology, and hydrochemistry.
- ° Contributes to the following DOE documents in support of their waste-disposal program:
 - Site Characterization Plan
 - Environmental Assessment
 - Exploratory Shaft Test Plan

Recent Accomplishments

- ° Identified preliminary ground-water flow paths and travel times in the saturated zone. (Czarnecki, J.B., Waddell, R.K., 1985: Finite-element simulation of ground-water flow in the vicinity of Yucca Mountain, Nevada-California: U.S. Geological Survey Water-Resources Investigations Report 84-4349, 38 p.)
- ° Developed conceptual hydrologic model of flow in the unsaturated zone. (Montazer, P., and Wilson, W.E., 1984: Conceptual hydrologic model of flow in the unsaturated zone, Yucca Mountain, Nevada: U.S. Geological Survey Water Resources Investigations Report 84-4345, 55 p.)

- ° Provided an indication of the range of past climate conditions that have existed at the site by making preliminary assessment of Quaternary paleoclimates (Spaulding, G.W., 1983: Vegetation and climates of the last 45,000 years in the vicinity of the Nevada Test Site, south-central Nevada: U.S. Geological Survey Open-File Report 83-535, 199 p.)
- ° Made preliminary assessment of the effect of future climates on hydrologic conditions.
- ° Assisted DOE in the development of program issues and information requirements.
- ° Contributed to the preparation of DOE's preliminary Site Characterization Plan, scheduled to be released for comment in 1987 and 1988.
- ° Contributed to the preparation of DOE's Environmental Assessments released in 1986.
- ° Prepared hydrologic sections of DOE's draft Exploratory Shaft Test Plan, which are needed before in situ tests can proceed.

Funding

Source of funds	Fiscal Year (\$ in millions)				
	1983	1984	1985	1986	1987
Other Federal agency funds	1.3	2.8	3.6	8.3	9.9

OTHER FEDERAL AGENCY ASSISTANCE

The U.S. Geological Survey (USGS) frequently is requested by other Federal agencies to assist them by supplying hydrologic information or expertise pertinent to specific needs of those agencies. The agency requesting the work reimburses the USGS for its services. In fiscal year 1986 about 40 agencies requested assistance as part of the USGS's Other Federal Agency Program.

Activities

The USGS's responses to requests to provide hydrologic assistance to other Federal agencies include the following major sources and types of help:

- ° Department of the Interior - for most of its Bureaus, collects hydrologic data; conducts various types of investigations of the availability and characteristics of ground water and surface water; evaluates the current and potential impacts of water-resources development and hazardous materials on water quality.
- ° Department of Agriculture - investigates hydrology of small watersheds by studying sediment deposits, stream discharge, and quality of water.
- ° Department of Defense:
 - Corps of Engineers - collects hydrologic data, and investigates tidal flows in estuaries, subsidence, streamflow, ground water, sedimentation, and water quality.
 - Military bases - conducts studies related to toxic waste, ground-water contamination, and water supply.
- ° 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 disposal sites; conducts research on the interaction between radioactive materials and various geohydrologic environments.
- ° Nuclear Regulatory Commission - reviews interpretations of hydrologic conditions at sites being evaluated for potential high-level radioactive waste repositories.
- ° Federal Emergency Management Agency - delineates flood plains; determines flood profiles and flood frequencies for flood-insurance programs.
- ° Environmental Protection Agency (EPA) - conducts studies related to energy research and development, municipal waste-disposal sites, relationship of ground water to lakes; collects water-quality information, and provides hydrologic assistance for toxic-waste cleanup actions.

Recent Accomplishments

- ° Published reports describing the hydrology of eastern and western coal areas, as a result of studies requested by the Bureau of Land Management, the Bureau of Mines, and the Office of Surface Mining.
- ° Implemented Memorandums of Understanding (MOU) with the EPA regarding related programs of the USGS, including coordination of information on hydrologic plans, and technology transfer of data and information. Collaborated with the EPA in developing its national ground-water protection strategy.
- ° Participated in "Superfund" activities with the EPA, Corps of Engineers, States, and some local agencies concerning cleanup of hazardous-waste disposal sites.
- ° Prepared a series of hydrologic and geologic reports on National Parks and National Monuments for the National Park Service.
- ° Implemented MOU's with the Bureau of Reclamation to establish a committee for coordination of programs of mutual concern.

Funding

Source of Funds	Fiscal Year (\$ in millions)				
	1983	1984	1985	1986	1987
Other Federal agency funds	31.9	37.9	37.3	54.9	39.8

REAL-TIME WATER RESOURCES DATA

The needs of water-resources management and forecasting agencies for real-time information on reservoir levels, streamflow, and water quality have grown significantly in recent years. Pressures for better monitoring and management of water resources have developed from increased competition for water, the establishment of higher environmental standards, and floods and droughts. Increased efforts are required to meet the real-time data needs of Federal and State agencies.

The purpose of the U.S. Geological Survey's (USGS) Real-Time Data activity is to acquire current information on the condition of water resources by the cost-effective use of new computer, electronic, and satellite-communication technologies to meet the requirements of Federal and State water-management agencies. The activity also improves the reliability and performance of the hydrologic data network.

Activities

- ° Develops new measurement techniques for hydrologic data collection.
- ° Develops an advanced hydrologic data-collection and telemetry system for USGS hydrologic stations.
- ° Continues to establish earth satellite communications technology at USGS hydrologic stations.
- ° Operates a network of satellite receiving stations at selected USGS District offices.

Recent Accomplishments

- ° Established Geostationary Operational Environmental Satellite (GOES) communications at more than 2,000 USGS hydrologic stations, in cooperation with numerous Federal and State agencies.
- ° Established a network of six Direct-Readout Ground Stations at district offices, in cooperation with Federal and State agencies, that have been linked together via the Distributed Information System of the USGS Water Resources Division. The ground stations are located in Arizona, Colorado, Pennsylvania, South Carolina, Texas, and Washington,
- ° Coordinated with other agencies on the collection of real-time data.

Funding

Funding for this activity does not appear as a line item in the USGS budget, but is derived from several sources.

Approximately \$0.3 million of Federal funds will be used in fiscal year 1987 to coordinate real-time data collection activities, develop software, and assist in the procurement of equipment. Each District office arranges with local agencies for the purchase and operation of satellite communications equipment.

REGIONAL AQUIFER SYSTEM ANALYSIS

The Regional Aquifer System Analysis Program (RASA) 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: (1) aquifers that are of regional extent, such as those beneath the Northern Great Plains, or (2) groups of aquifers that share so many characteristics that investigation of a few of these aquifers can establish principles and hydrologic factors controlling the occurrence, movement, and quality of ground water throughout 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 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 pumpage or artificial recharge.

Recent Accomplishments

- ° Identified 28 systems for possible study. As of December 1986, nine RASA studies were completed: Central Midwest, Central Valley (California), Floridan Aquifer, Great Basin, High Plains, Northern Great Plains, Northern Midwest, Snake River Plain, and Southwest Alluvial Valleys. Eleven other studies were underway.
- ° Mapped the volumes of ground water depleted from the High Plains aquifer by irrigation pumpage, and developed a ground-water model to test alternative strategies for mitigating effects of depletion.
- ° Determined that additional development of the Southeastern Carbonate aquifer (Florida and Georgia) is feasible, but that careful management will be needed to avoid encroachment of saline water.
- ° Published more than 400 reports describing the scientific findings of the RASA studies. About 80 reports were in preparation early in 1987.
- ° Calibrated flow-simulation models for the California Central Valley, East Snake River Plain, Floridan, High Plains, Northern Great Plains, and Northern Midwest Aquifer Systems.
- ° Developed simulation models to predict the effects of future pumping.

° Provided ground-water information to Federal, State, and local agencies. For example:

- U.S. Department of Commerce used information in evaluating impacts of water-level declines in the High Plains due to irrigation development.
- Department of Water Resources of Idaho used LANDSAT imagery to map irrigated crop areas, using a method developed during the High Plains and Snake River Plain RASA studies.

° Recent reports include:

- Miller, James, 1986, Hydrogeological framework of the Floridan aquifer system in Florida and in parts of Georgia, South Carolina, and Alabama: U.S. Geological Professional Paper 1403-B, 91 p., 33 plates.
- Luckey, R.R., Gutentag, E.D., Heimes, F.J., and Weeks, J.B., 1986, Digital simulation of ground-water flow in the High Plains aquifers in parts of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming: U.S. Geological Survey Professional Paper 1400-D, 57 p.
- Downey, J.S., 1986, Hydrogeology of bedrock aquifers in the northern Great Plains in parts of Montana, North Dakota, South Dakota, and Wyoming: U.S. Geological Survey Professional Paper 1402-E, 87 p., 3 plates.
- Ryder, P.D., 1985, Hydrology of the Floridan aquifer system in west-central Florida: U.S. Geological Survey Professional Paper 1403-F, 63 p.
- Sun, R.J., 1986, Regional Aquifer-System Analysis Program of the U.S. Geological Survey--Summary of Projects, 1978-84: U.S. Geological Survey Circular 1002, 264 p.

Funding

Source of Funds	Fiscal Year (\$ in millions)				
	1983	1984	1985	1986	1987
Federal funds	14.7	15.2	14.3	14.2	12.2

SNOW AND ICE

Events, such as the severe floods; the potential threat of icebergs to oil-tanker shipping lanes in the water near Valdez, Alaska, due to the retreat of the Columbia Glacier; the advance of Hubbard Glacier and other glaciers; and questions about the effect of sea-ice distribution on world climate, have renewed the interest of the water-resources community in snow and ice research. U.S. Geological Survey (USGS) research on this topic began more than 20 years ago. The purpose of this work is to analyze the natural processes operative in this poorly understood part of the hydrologic cycle and to develop predictive capabilities in assessing the response of snow and ice to meteorologic and hydrologic stresses.

Activities

- ° Utilizes remotely sensed data collected by aircraft and satellite to investigate the thickness and extent of snow and icepacks in polar regions and the contiguous 48 States.
- ° Monitors the movement 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 growth and runoff.
- ° Investigates the flood hazard potential for rain falling on frozen or snow-covered ground.

Recent Accomplishments

- ° Developed numerical modeling techniques which enabled the USGS to predict for the first time the advance and retreat of glaciers. As predicted, observations show that the Columbia Glacier is in retreat and the Hubbard Glacier is advancing.
- ° Published the first comprehensive data-set on Antarctic sea ice and interpretation of its influence on world climate, in cooperation with the National Aeronautics and Space Administration (NASA).
- ° Applied the passive microwave-detection capabilities of NASA's Nimbus-7 satellite to map the water content of snow in the upper Colorado River basin, in order to better predict water availability and flood potential associated with the snowmelt.

Funding

Funding for this activity does not appear as a line item in the USGS budget but is derived from several sources.

In fiscal year 1987, approximately \$0.7 million will be spent on snow and ice studies.

STATE WATER RESOURCES RESEARCH INSTITUTES AND RESEARCH GRANTS

The Secretary of the Interior has designated the U.S. Geological Survey (USGS) as the administering agency for Title I of the Water Resources Research Act of 1984. Previous State Water Resources Research Institute and Research Grant programs were administered by the Office of Water Research and Technology, and subsequently by the Office of Water Policy and the Bureau of Reclamation. Title I authorizes the following programs:

- ° Establishment of up to 57 State Water Resources Research Institutes (Section 104).
- ° Matching grants to non-Federal entities for research in water resources (Section 105).
- ° Grants and contracts for the development of technology to address the Nation's water-resources problems (Section 106).

Activities

- ° Provides matching grants to finance part of the operation of the State Water Resources Research Institutes.
- ° Evaluates the Institutes at least once in each 4-year period.
- ° Defines priority areas of research and technology development for funding under the program.
- ° Solicits, evaluates, and ranks proposals for funding under water-resources research and technology development.
- ° Monitors progress of research and development projects funded under Title I of the Water Resources Research Act.

Recent Accomplishments

- ° Fifty-four Water Resources Research Institutes were granted Federal funds in fiscal year 1985 and in fiscal year 1986.
- ° Three Institutes were evaluated in fiscal year 1985, and 28 were evaluated in fiscal year 1986. The remaining 23 will be evaluated in fiscal year 1987.
- ° Impaneled a committee, comprised of four Institute Directors, two representatives of other academic interest, and three USGS employees, to develop a plan for future operations of the Water Institute Program.
- ° Issued 24 grants in fiscal year 1985, and 43 grants in fiscal year 1986, under the competitive matching-grant program. Published open-file reports that provided abstracts of the research to be conducted under each grant.

Funding

Source of Funds	Fiscal Year (\$ in millions)				
	1983	1984	1985	1986	1987
Federal funds:					
Water Research Institutes ¹	---	6.4	6.3	6.2	5.7
Research Grants	---	---	2.4	4.8	2.0
Total	---	6.4	8.7	11.00	7.7

¹Institutes and Research Grants were matched on a 50-50 basis in fiscal year 1985 and fiscal year 1986. In fiscal year 1987, the Institute Program matches each Federal dollar with 1 1/2 dollars from non-Federal sources.

TOXIC-CHEMICAL WASTE--GROUND-WATER CONTAMINATION

The disposal of toxic wastes and the associated ground-water contamination that may result is considered by many to be the most significant environmental issue of the decade. Instances of ground-water contamination in every State and the closure of hundreds of domestic supply wells as a result of contamination from toxic organic chemicals indicate the extensive social and economic impact that can result from even a relatively small area of ground-water contamination. The purpose of the Toxic Waste--Ground-Water Contamination Program, which began in fiscal year 1982, is to provide earth-sciences information to help in mitigating the effect on ground-water systems of current and future land-based disposal of toxic substances.

Activities

- ° Develops and refines methods to sample and measure hazardous substances in ground water, sediment, and organisms.
- ° Increases understanding of the biological, physical, and chemical processes that affect the movement and fate of hazardous substances in ground-water systems.
- ° Appraises the occurrence of hazardous substances in the Nation's ground waters and how ground-water quality is changing with time.
- ° Conducts interdisciplinary field studies of the impact of contamination by crude oil, gasoline, sewage, wood preservatives, metals, and chlorinated hydrocarbons on the subsurface.
- ° Supports other agencies in fulfilling their hazardous-waste management or regulatory responsibilities.

Recent Accomplishments

- ° Published reports on ground-water quality for the States of Kentucky, Montana, Nebraska, Oregon, Pennsylvania, Wisconsin, and Wyoming.
- ° Published a report providing a methodology to evaluate ground-water quality in relation to land use:
 - Helsel, D.R., and Ragone, S.E., 1984, Evaluation of regional ground-water quality in relation to land use: U.S. Geological Survey Water-Resources Investigations Report 84-4217.
- ° Published reports of research conducted at interdisciplinary field sites where the movement of different types of contaminants are being studied:
 - Hult, M.F., 1984, editor, Ground-water contamination by crude oil at the Bemidji, Minnesota research site: U.S. Geological Survey Toxic Waste--Ground-Water Contamination Study: U.S. Geological Survey Water-Resources Investigations Report 84-4188.

--LeBlanc, D.R., editor, 1984, Movement and fate of solutes in a plume of sewage-contaminated ground water, Cape Cod, Massachusetts: U.S. Geological Survey Toxic Waste--Ground-Water Contamination Program: Open-File Report 84-475.

--Mattraw, H.C., and Franks, B.J., editors, 1984, Movement and fate of creosote waste in ground water, Pensacola, Florida: U.S. Geological Survey Toxic Waste--Ground-Water Contamination Program: Open-File Report 84-466.

° Published the following reports on the earth-science processes affecting the transport of contaminants through the subsurface:

--Baedecker, M.S., and Apgar, M.A., 1984, Hydrogeochemical studies at a landfill in Delaware, in, Groundwater Contamination, Studies in Geophysics: National Academy Press, p. 127-138.

--Davis, J.A., 1984, Complexation of trace metals by absorbed natural organic matter: Geochimica Cosmochimica Acta, v. 48, p. 679-692.

--Gorelick, S.M., Voss, C.I., Gill, P.E., Murray, W., Saunders, M.S., and Wright, M.H., 1984, Aquifer reclamation design: The use of contaminant transport simulation combined with non-linear programming: Water-Resources Research, v. 20-4, p. 415-427.

--Grove, D.B., and Stollenwerk, K.G., 1984, Computer model of one-dimensional equilibrium controlled sorption processes: U.S. Geological Survey Water-Resources Investigation Report 84-4205.

--Konikow, L.F., and Thompson, D.W., 1984, Groundwater contamination and aquifer reclamation at the Rocky Mountain Arsenal, Colorado, in Groundwater Contamination, National Academy Press, Washington, D.C., p. 93-103.

--Stollenwerk, K.G., and Grove, D.B., 1985, Absorption and desorption of hexavalent chromium in an alluvial aquifer near Telluride, Colorado: Journal of Environmental Quality, 14, 150-155.

° Published reports on subsurface waste-injection investigations. For example:

--Hickey, J.J., and Vecchioli, J., 1986, Subsurface injection of liquid waste with emphasis on injection practices in Florida: U.S. Geological Survey Water-Supply Paper 2281.

Funding

Source of Funds	Fiscal Year (\$ in millions)				
	1983	1984	1985	1986	1987
Federal funds ¹	4.4	8.4	9.4	8.9	9.3

¹Toxic-Chemical Waste--Ground-Water Contamination does not appear as a line item in the budget. The activity is funded under Toxic Waste Hydrology.

URBAN HYDROLOGY

The U.S. Geological Survey (USGS) has been studying urban runoff since the 1950s. Since 1971, the USGS has conducted 104 studies, some of which are still continuing. These studies have investigated the effects of urbanization on runoff quantity (especially of peak flows), of sediment transport, and of runoff quality. From 1979 to 1983 the USGS conducted an intensive study of urban runoff quality, in cooperation with the Environmental Protection Agency.

Activities

- ° Acquires and analyzes urban runoff data from a number of communities throughout the United States.
- ° Assembles urban runoff data and documents the data so it is readily available to users.
- ° Analyzes urban runoff data so that estimates of runoff characteristics can be made at ungaged sites and so that the impacts of runoff control measures can be evaluated.

Recent Accomplishments

- ° Installed and supported 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.
- ° Continued national statistical regionalization of urban stormwater quality for stormwater loads, event mean concentrations, and for long-term annual and seasonal characteristics.
- ° Supported the formation of Task Committees by the American Society of Civil Engineers on the USGS's Urban Gaging Networks and Urban Stormwater Detention.
- ° Submitted 11 papers on urban runoff to the Fourth International Conference on Urban Storm Drainage, Switzerland.

Funding

Source of Funds	Fiscal Year (\$ in million)				
	1983	1984	1985	1986	1987
Federal funds	0.3	0.3	0.3	0.2	--
Federal-State Cooperative funds	1.7	0.9	1.0	1.9	1.8
Total	2.0	1.2	1.3	2.1	1.8

VOLCANO HAZARDS

The U.S. Geological Survey has the primary Federal responsibility for investigating volcano hazards. Water-related activities include:

- ° Describe the nature and rates of hydrologic processes involved in cataclysmic events.
- ° Monitor water resources in areas of potential volcanic eruptions.
- ° Define mudflow and debris flow hazards.
- ° Develop information for resource planning and management.

Activities

- ° Maintains a flood-hazard and mudflow-warning system for the Toutle-Cowlitz and Lewis Rivers related to volcanic activities at Mount St. Helens.
- ° 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 reevaluates the stability of the 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 (mudflows from volcanoes) on a variety of volcanoes.
- ° Investigates ground-water and its relation to volcanic processes at Kilauea Volcano, Hawaii.

Recent Accomplishments

- ° Established a computer-enhanced monitoring system for Spirit Lake and other debris-dammed lakes near Mount St. Helens utilizing satellite and radio-telemetry units to transmit real-time water-level data. This system provides immediate warning of any failure of the debris blockages.
- ° 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.
- ◻ Published reports on volcano-hazards investigations. Examples are:
 - Driedger, C.L., and Kennard, P.M., 1986, Ice volumes on Cascade Volcanoes: Mr. Ranier, Mr. Hood, Three Sisters, and Mt. Shasta: U.S. Geological Survey Professional Paper 1365, 36 p., 6 pl., 27 figs.
 - Hupp, C.R., 1984, Dendrogeomorphic evidence of debris flow frequency and magnitude at Mount Shasta, California: Environmental Geology and Water Sciences, v. 6, no.2, p. 121-128.
 - Meyer, William, Sabol, M.A., Glicken, H.X., and Voight, Barry, 1985, 1985, The effects of ground water, slope stability, and seismic hazard on the stability of the South Fork Castle Creek blockage in the Mount St. Helens area, Washington: U.S. Geological Survey Professional Paper 1345.
 - Osterkamp, W.R., Hupp, C.R., and Blodgett, J.C., 1986, Magnitude and frequency of debris flows, and areas of hazard on Mount Shasta, Northern California: U.S. Geological Survey Professional Paper 1396-C, 26 p., 1 pl., 7 figs.

Funding

Source of Funds	Fiscal Year (\$ in millions)				
	1983	1984	1985	1986	1987
Federal funds	3.3	3.3	3.3	3.2	3.2

WATER INFORMATION STORAGE, RETRIEVAL, AND DISSEMINATION

Four programs of the U.S. Geological Survey (USGS) focus on computerized systems that store, retrieve, and disseminate water resources information. The USGS has decentralized its computerized water information operations, shifting from a mainframe database to a network of large minicomputers located in each District office and at other key sites.

- ° The Water Resources Scientific Information Center (WRSIC), established in 1968, provides abstracts and computerized bibliographic information on water-related scientific literature.
- ° The National Water-Data Storage and Retrieval System (WATSTORE), established in 1971, maintains the national water-resources file of data resulting from hydrologic measurements.
- ° The National Water-Data Exchange (NAWDEx), established in 1976, maintains an index of water-data locations and assists organizations to access computerized Federal files of water-resources information.
- ° The National Water Information System (NWIS) was established in 1986 to create a master database incorporating the WRSIC, WATSTORE, and NAWDEX files, and other computerized water-resources information. These revisions to existing systems will improve the efficiency and utilization of computer resources.

Activities

Water Resources Scientific Information Center:

- ° Abstracts, indexes, and classifies the major water-resources literature of the world.
- ° Prepares and issues "Selected Water Resources Abstracts" monthly.
- ° Maintains a worldwide computerized bibliographic information base.
- ° Maintains the "Water Resources Thesaurus."

National Water-Data Storage and Retrieval System:

- ° Maintains computer files on surface-water flows and ground-water levels, water quality, water-well data, and water-use information.
- ° Provides water data to managers and planners.

National Water-Data Exchange:

- ° Operates a national water-data indexing program.
- ° Provides nationwide user assistance in finding water data.
- ° Maintains liaison with water organizations.

- ° Provides support to the Office of Water Data Coordination (OWDC) in cataloging water-data requirements.

National Water Information System:

- ° Develops software systems which link together USGS offices for the processing, storage, retrieval, analysis, and dissemination of water resources information.
- ° Designs and implements a nationwide distributed information system which integrates separate computer files of water data, indexes, and bibliographic citations and abstracts of water-resources literature.

Recent Accomplishments

Water Resources Scientific Information Center:

- ° Expanded bibliographic information base to 180,000 abstracts, and made them available through commercial on-line services.
- ° Initiated Volume 20 of "Selected Water Resources Abstracts" in January 1987.

National Water Data Storage and Retrieval System:

- ° Maintained files containing 220 million values including streamflow, stream sediment, reservoir contents, and ground-water levels; 2.5 million chemical analyses of surface and ground water; and data on 900,000 wells.
- ° Transferred data monthly to the U.S. Environmental Protection Agency's STORET system.
- ° Developed a nationwide telecommunications network for the storage and retrieval of data collected at 59,000 hydrologic stations, including more than 2,000 automated stations that continuously provide real-time data relayed via satellite.
- ° Supplied water information in computer-generated formats such as digital plots, tables, graphs, statistical analyses, and magnetic tape.

National Water Data Exchange:

- ° Increased membership to more than 290 Federal, State, and local governments, and academic and private water-oriented organizations.
- ° Processed approximately 84,000 requests for water information during 1986, through a national network of 76 assistance centers in 45 States, the District of Columbia, and Puerto Rico.
- ° Designed and maintained a Master Water Data Index of 450,000 data-collection sites operated by nearly 450 organizations.

- ° Designed and maintained a Water-Data Sources Directory for more than 750 water-related organizations. Identified 2,200 additional offices to be included.
- ° Maintained the coordination of direct access to the two major water-databases, STORET of the U.S. Environmental Protection Agency, and WATSTORE of the USGS.

National Water Information System:

- ° Received approval to publish the conceptual design for NWIS, and the system's Plan for Design, Development, Implementation, and Operation.
- ° Completed design specification for various subsystems including hydrologic data and index, and tested the first prototype of the Site Index subsystem.
- ° Tested and evaluated database management systems and 32-bit micro-computers.

Funding

Source of Funds	Fiscal Year (\$ in millions)				
	1983	1984	1985	1986	1987
Federal funds					
WRSIC	0.6	0.9	0.9	0.9	0.9
WATSTORE	1.7	2.0	1.8	1.9	1.8
NAWDEX	1.2	1.3	1.3	1.2	1.1
NWIS ¹	0.4	1.3	1.3	2.6	2.8
Total	3.9	5.5	5.3	6.6	6.6

¹Funding for this activity does not appear as a line item in the USGS budget but is derived from several sources.

WATER RESEARCH (NATIONAL RESEARCH PROGRAM)

Hydrologic research increases knowledge and develops methodologies that are used to solve or mitigate critical water problems. The purpose of the National Research Program is to improve the capability of U.S. Geological Survey (USGS) 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 National Research Program is one component of USGS- sponsored water-research activities. Other research is conducted in the Federal-State Cooperative Program and the State Water Resources Research Institutes and Research Grants Programs.

Activities

- ° Conducts research involving about 180 researchers working on 110 projects, in an average year. The general areas of research are:

- Surface-water hydrology
- Ground-water hydrology
- Water chemistry
- Geochemistry
- Sediment transport and geomorphology
- Ecology

The topics of 1987 research include:

- Hydrology of lakes and estuaries
- Sediment transport in streams
- Effects of acid precipitation on watershed chemistry
- Glacier and sea-ice dynamics
- Movement of hazardous substances in surface and ground water

Recent Accomplishments

Published more than 250 reports and abstracts covering a broad scientific spectrum in fiscal year 1986. Examples of the research accomplishments include:

- ° Demonstrated that significant topographically-induced air and vapor circulation can occur in thick unsaturated zones, particularly in arid environments, and that this effect should be accounted for in the analysis of proposed waste repositories in such environments, such as at Yucca Mountain, Nevada. (Weeks, E.P., 1986, Effect of topography on gas flow in unsaturated fractured rock--concepts and observations: Eos, v. 67, no. 44, p. 962-963.)
- ° Demonstrated that San Francisco Bay Estuary has been modified by human activity, with habitats for many fish and waterfowl eliminated, dynamics of plant and animal communities changed, and sediments and organisms contaminated by toxic wastes. (Nichols, F.H., Cloern, J.E., Luoma, S.N., and Peterson, D.H., 1986, The Modification of an Estuary: Science, v. 231, p. 567-573.)

- ° Completed studies of the long-term sediment load and channel changes in the Green River downstream of Flaming Gorge Reservoir, Utah, showing that the mean annual sediment discharge has decreased downstream from the reservoir, that the quasi-equilibrium that existed before the reservoir was created no longer occurs along a majority of the Green River, and that it appears that a century or more will be required for the Green River to adjust to the effects of Flaming Gorge Reservoir (Andrews, E.D., 1986, Downstream effects of Flaming Gorge Reservoir on the Green River, Colorado and Utah: GSA Bulletin, v. 97, p. 1012-1023).
- ° Described reactions carried out by iron-reducing microorganisms which significantly influence the nutrient and iron chemistry of surface and ground water environments. (Lovely, D.R., and Phillips, E.J.P., 1986, Organic matter mineralization with reduction of ferric iron in anaerobic sediments: Applied and Environmental Microbiology, v. 51, p. 683-689. Also Lovely, D.R., and Phillips, E.J.P., 1986, Availability of ferric iron for microbial reduction in bottom sediments of the freshwater tidal Potomac River: Applied and Environmental Microbiology, v.52, p. 751-757.)

Funding

Source of Funds	Fiscal Year (\$ in millions)				
	1983	1984	1985	1986	1987
Federal funds	18.3	19.8	19.8	19.8	20.0
Federal-State Cooperative funds	0.0	0.7	0.7	0.7	0.5
Total	18.3	20.5	20.5	20.5	20.5

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