THE U.S. GEOLOGICAL SURVEY FEDERAL-STATE COOPERATIVE WATER-RESOURCES PROGRAM, FISCAL YEAR 1987

by B. K. Gilbert and W.B. Mann IV

U.S. GEOLOGICAL SURVEY
Open-File Report 88-174

1988

DEPARTMENT OF THE INTERIOR
DONALD PAUL HODEL, Secretary

U.S. GEOLOGICAL SURVEY
Dallas L. Peck, Director

Copies of this report can be purchased from:

Books and Open-File Reports Section
U.S. Geological Survey
Federal Center, Box 25425
Denver, CO 80225

For additional information write to:

Assistant Chief Hydrologist for Operations
U.S. Geological Survey
Water Resources Division
441 National Center
12201 Sunrise Valley Drive
Reston, Virginia 22092

CONTENTS

FIGURES

TABLES

CONVERSION FACTORS

The inch-pound units in this report may be converted to metric (International System) units by using the following factors:

Multiply inch-pound unit	By	To obtain metric unit
mile	1.609	kilometer
foot	0.3048	meter
pound	0.4536	kilogram
square mile	2.590	square kilometer

The U.S. Geological Survey Federal-State Cooperative Water-Resources Program, Fiscal Year 1987

By Bruce K. Gilbert and William B. Mann IV

ABSTRACT

The U.S. Geological Survey's Federal-State Cooperative Water Resources Program (50-50 matching of funds) started in Kansas in 1895. During fiscal year (FY) 1987, hydrologic data collection, investigations, and research are being conducted in every State, Puerto Rico, and several territories in cooperation with 940 State, regional, and local agencies. Federal funding of $55.3 million was matched by cooperating agencies; cooperators also provided $4.6 million unmatched, for a program total of about $115 million.

The Cooperative Program accounted for almost 45 percent of the FY 1987 obligations of the Geological Survey's Water Resources Division. The principal areas of emphasis during the year included ground-water contamination, stream quality, water supply and demand, and hydrologic hazards. This report presents information on program functions and priorities. It also describes data-collection activities, as well as work related to water-resources contamination. Several examples of current (1987) investigations are provided.

INTRODUCTION

The U.S. Geological Survey was established in 1879. Congress in 1888 authorized the Geological Survey to identify irrigable lands and sites appropriate for reservoirs and canals. The initial cooperative water-resources investigation was started with the State of Kansas in 1895. The Congress first appropriated monies for the Federal-State Cooperative Program in the 1906 fiscal year (FY) budget.

During FY 1987 hydrologic data collection, interpretive investigations, and research were conducted by Geological Survey personnel in offices in every State, Puerto Rico, and several territories (fig. 1) in cooperation with 940 local, State, and regional agencies. The Division's programs are supported by direct annual appropriations from Congress (Federal Program), the cost sharing of the Federal-State Cooperative Program (50:50 matching of funds, the Geological Survey part of which is appropriated by Congress), and reimbursable agreements with other Federal agencies (Other Federal Agency Program).

The Federal-State Cooperative Program is unique in that local and State agencies provide at least one-half the funds, but the Geological Survey does most of the work. The major sources of and actual obligations for water-resources investigations during FY 1987 are shown in figure 2. For the Cooperative Program, Federal funding of $55.3 million was matched by cooperating agencies; cooperators also furnished $4.6 million unmatched for a total of $115.2 million. Additional information regarding the Cooperative Program, which provides almost 45 percent of the funding, can be found in Gilbert and Buchanan (1981), and Gilbert and Mann (1987).

In fulfilling its water-resources mission, the Geological Survey performs four principal functions:

o Data collection needed for the continuing determination and evaluation of the quantity, quality, and use of the Nation's water resources.

o Analytical and interpretive appraisals to describe the occurrence, availability, and physical, chemical, and biological characteristics of surface and ground water.

o Research in hydraulics, hydrology, and related scientific and engineering fields.

o Dissemination of water data and the results of investigations and research.

The current and historical information derived from hydrologic data-collection stations are basic and pertinent to the activities of local, Federal, State, and regional agencies, and to public and private entities concerned with water-resources planning, development, management, and conservation. The Geological Survey also conducted during FY 1987 about 900 interpretive and research investigations, of which about 500 are included as part of the Cooperative Program. The interpretive investigations are of areas that range in size from a square mile or less to small basins or counties to a State to multistate regions. These investigations provide information to define, characterize, and evaluate the extent, quality and availability of the water resource.

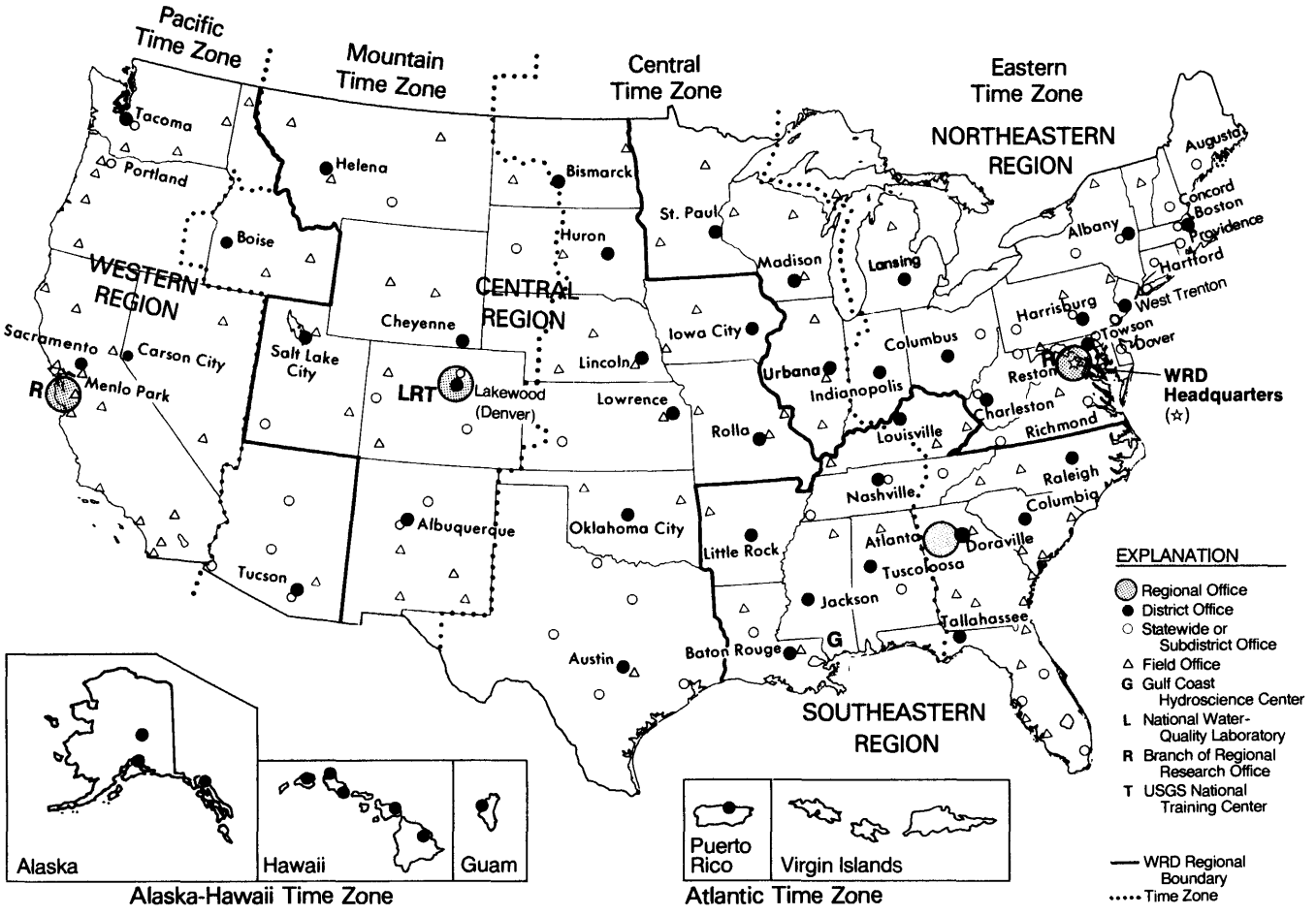

Figure 1.--Location of the principal offices of the U.S. Geological Survey's Water Resources Division, 1987.

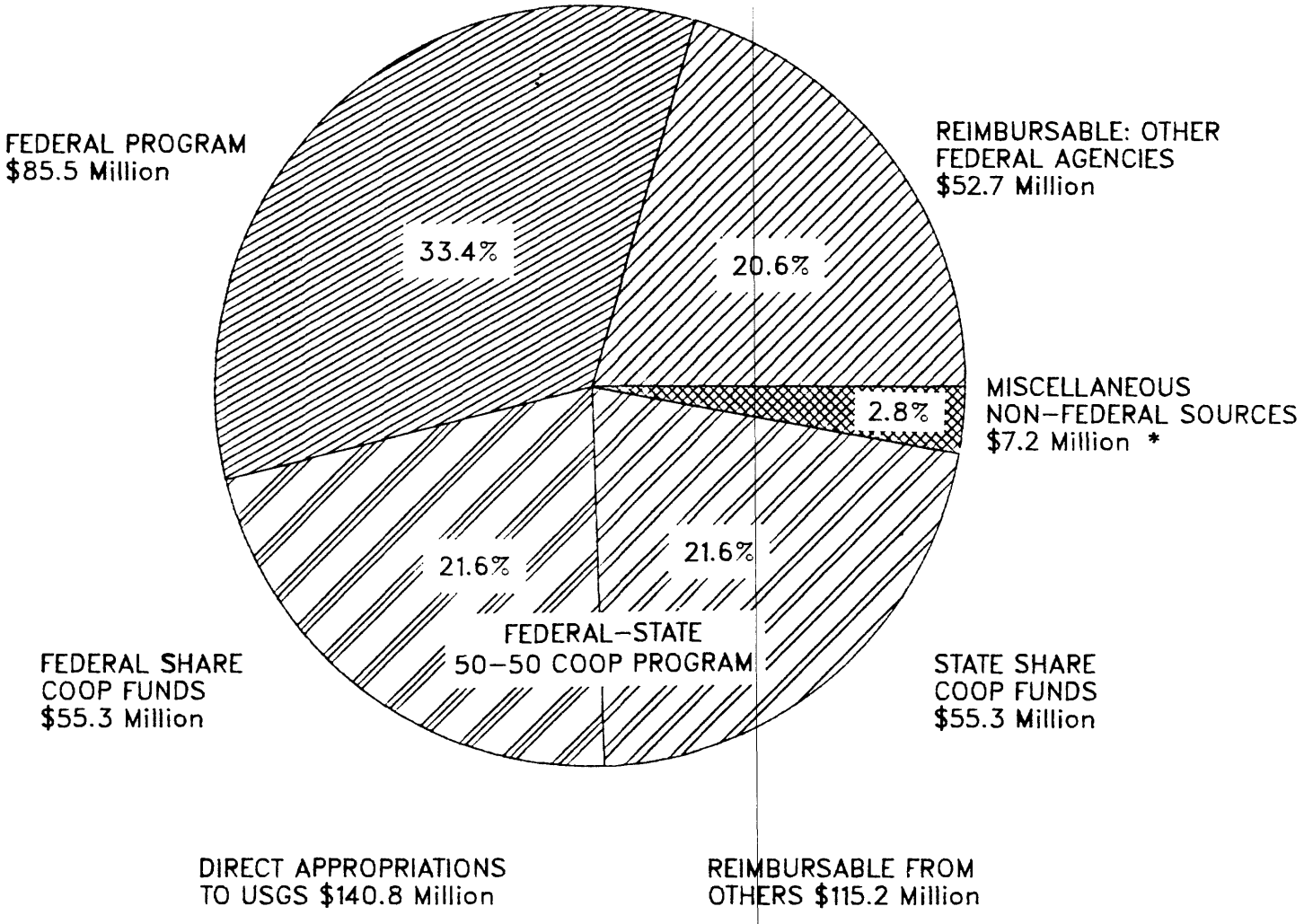

Figure 2.--The fiscal year 1987 actual obligations for the U.S. Geological Survey's Water Resources Division.

FUNCTION OF THE U.S. GEOLOGICAL SURVEY FEDERAL-STATE COOPERATIVE WATER-RESOURCES PROGRAM

Clearly, the Cooperative Program cannot, and does not, exist apart from other activities conducted within the overall water-resources investigations program of the Geological Survey. The sum total of efforts performed in the Federal, the Federal-State Cooperative, and the Other Federal Agency Programs represents a balanced, coordinated, and interactive program of fact-finding, investigations, and research regarding the Nation's water resources. Key hydrologic concerns and issues requiring priority consideration in the selection of new activities, or the retention of ongoing activities, are determined through discussions with State and local cooperators, with Federal agency officials, by guidance from Congress and the Department of the Interior, and through awareness of the concerns of the general public.

The enormity and complexity of appraising the Nation's water resources preclude accomplishing the task by Federal efforts alone. Cooperative planning of data collection and investigations by local, State, and Federal officials permits a more balanced approach to water-related problems. Information developed in the Cooperative Program has relevance to potential and emerging long-term problems, such as water supply, waste disposal, energy development, and environmental protection. Because common analytical methods and techniques are used, the information also is relevant to problems having interstate, regional, or international significance. The information furnishes the basis required to conduct interstate and international compacts, Federal law and court decrees, congressionally mandated studies, regional and national water-resources assessments, and planning activities.

Development, utilization, and conservation of the Nation's water resources require an adequate data base. The continuing Cooperative Program provides more than half of the Nation's data and information base regarding water quantity and responds in a timely manner to the varying and increasing requirements of agencies at all levels of government that have responsibilities for water resources. The Geological Survey and its cooperating agencies work together in a continuing process that leads to adjustments in each year's program. This process is guided by a determination of the key hydrologic problems and issues requiring priority consideration in the selection of new, or the retention of ongoing investigations in the overall program. A growing number of requests for scientific and technical assistance is expected from State agencies responsible for ground-water protection and controlling sources of contamination.

The State offerings reflect the continuing growth in emphasis on water-quality issues, as well as on other concerns regarding the availability and distribution of the resource. The water-quality issues include aquifer contamination, acid rain, river-quality assessment, storm runoff, and the effects of agricultural chemicals and practices. Overall, there is an increasing need for hydrologic information. The operation of data-collection network stations is a continuing activity. Although many data-collection stations are operated on a long-term basis as components of national networks, some are discontinued each year when their purpose has been served; new stations are added in response to changing needs and priorities. Areal water-resources appraisals and research investigations provide information to define, characterize, and evaluate the extent, quality, and availability of the water resource and related processes.

Existing hydrologic data commonly are used in appraisals and studies. However, in many cases it is necessary to collect additional data and information, which complement the available information. All data and analytical studies are made available to users through reports of investigations, the National Water Data Storage and Retrieval System (WATSTORE), the National Water Data Exchange (NAWDEX) Program, and various publications.

Hydrologic Data Collection

The collection of surface-water and ground-water data on a systematic basis through the Federal-State Cooperative Program is a major part of the Geological Survey's coordinated water-resources activities. Table 1 summarizes the numbers of stations operated through funding from the Federal, Cooperative, and Other Federal Agency Programs. The resulting information provides a continuing record of the quantity, quality, and use of the Nation's water resources. The data are available for use by Federal, State, and local agencies in developing, utilizing, conserving, and managing water and related land resources to meet the Nation's need for clean water. The data are also the basis for continuing analytical, interpretive, and predictive studies and appraisals of water resources. The number of continuous and scheduled long-term operation surface-water, ground-water, and water-quality stations operated by the Geological Survey in FY 1987 are shown in figure 3 by sources of support.

In the 1987 fiscal year, the Federal-State Cooperative Program funded totally the operation of 3,158 continuous streamflow-discharge stations (table 1) and funded in combination with other sources another 1,640 continuous streamflow stations (Condes, 1987). The program funded fully or in part the collection of ground-water levels at 20,880 scheduled, long-term sites and 7,421 short-term or project sites, as shown in table 2. The FY 1987 program also provided for collection of water-quality data at a total of 2,001 surface-water stations and a total of 7,597 ground-water stations.

Each year from 1983 through 1987, the Cooperative Program supported data collection at between 28,300 and 30,800 public and privately owned wells where information was collected on ground-water levels. Water-level data are used to assess changes in ground-water storage that can result from natural causes or from man's activities. During the same period, selected water-quality constituents were determined annually from samples collected at 5,000 to 8,500 of these wells. These data are necessary to determine suitability of water for various uses, to identify trends, and to evaluate the effects of stresses on aquifer characteristics. Overall in FY 1987, the Cooperative Program accounted for more than 80 percent of the Geological Survey's activities in ground-water data collection.

The Program has been adjusted at times in response to changing requirements for hydrologic data, as reflected in the summary information of table 2. For example, from fiscal year 1983 to 1987, the number of continuous surface-water discharge stations declined by 27 sites; the total number of surface-water quality stations declined by 366; total ground-water level stations declined by 1,221; and total ground-water quality stations increased by 1,018. These changes have been produced by the need to adapt program content to the availability of funds and evolving priorities, and are composites of increases in some States and decreases in others. Condes (1987) reports that:

Table 1.--Water-data collection activities of the U.S. Geological Survey, fiscal year 1987

Types of Stations 1/	Number of Stations 2/				
	A. Federal Program	B. Federal-State Cooperative Program	C. Other Federal Agency Program	D. Combined Support	Total
SURFACE WATER					
Discharge					
Continuous record	481	3,158	1,575	1,786	7,000
Partial record	99	2,880	273	372	3,624
Stage only--Streams					
Continuous record	13	86	245	104	448
Partial record	1	166	28	34	229
Stage only--Lakes and Reservoirs					
Continuous record	12	274	277	216	779
Partial record	11	177	75	87	350
Quality					
Scheduled, long-term	389	1,109	330	357	2,185
Short-term or project	26	512	116	62	716
GROUND WATER					
Water Levels					
Scheduled, long-term	656	17,089	1,098	3,791	22,634
Short-term or project	1,157	4,202	1,061	3,534	9,954
Quality					
Scheduled, long-term	49	3,053	158	640	3,900
Short-term or project	560	3,475	730	455	5,220

1. Types of Stations

CONTINUOUS RECORD; The station is instrumented to monitor hydrologic conditions continually and, in some instances, to transmit data soon after collection.

PARTIAL RECORD: Hydrologic information is collected only during selected periods, for example, during floods.

SCHEDULED, LONG-TERM: Hydrologic information is collected on a fixed schedule for a long period to detect trends. With respect to surface-water quality and ground-water levels, continuous-recording stations are included in this category.

SHORT-TERM OR PROJECT: Hydrologic information is collected to meet the needs of a specific study. Data supplement those available from scheduled, long-term; continuous-record; and partial-record stations.

2. Number of Stations

COLUMN A - Stations totally supported by funds appropriated to the Geological Survey for the Federal Program.

COLUMN B - Stations partially supported by funds appropriated to the Geological Survey for the Federal-State Cooperative Program.

COLUMN C - Stations totally supported by reimbursements as part of the Other Federal Agency Program.

COLUMN D - Stations supported by a combination of two or more of the above.

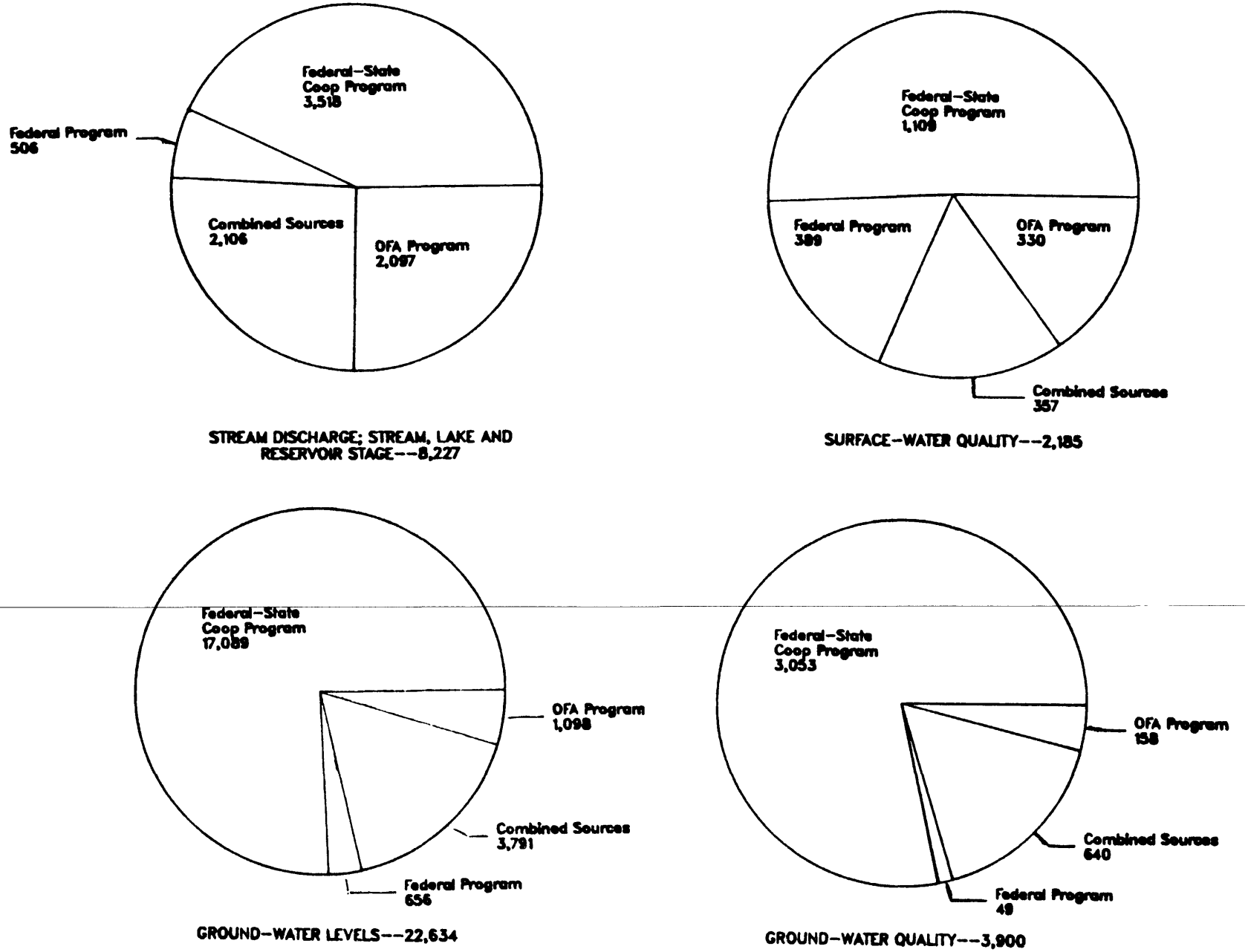

Figure 3.--Number of continuous and scheduled, long-term operation surface-water, ground-water, and water-quality stations, by sources of support, that were operated by the U.S. Geological Survey in fiscal year 1987.

Table 2.--Hydrologic data-collection stations supported fully or in part by the U.S. Geological Survey Federal-State Cooperative Program, fiscal years 1983 through 1987

Types of Stations1/	Fiscal Year				
	1983	1984	1985	1986	1987
SURFACE WATER					
Discharge					
Continuous record	4,825	4,662	4,721	4,866	4,798
Partial record	3,446	3,413	3,646	3,278	3,161
Stage only--Streams					
Continuous record	211	198	220	268	187
Partial record	412	386	448	435	200
Stage only--Lakes and Reservoirs					
Continuous record	578	577	507	458	489
Partial record	332	280	327	316	264
Quality					
Scheduled, long-term	1,878	1,708	1,554	1,378	1,442
Short-term or project	489	645	777	796	559
GROUND WATER					
Water Levels					
Scheduled, long-term	22,267	21,250	22,708	21,673	20,880
Short-term or project	7,255	7,344	8,047	8,220	7,421
Quality					
Scheduled, long-term	2,837	2,876	4,089	4,637	3,693
Short-term or project	3,742	2,085	3,915	3,833	3,904

1. Types of Stations

CONTINUOUS RECORD; The station is instrumented to monitor hydrologic conditions continually and, in some instances, to transmit data soon after collection.
PARTIAL RECORD: Hydrologic information is collected only during selected periods, for example, during floods.
SCHEDULED, LONG-TERM: Hydrologic information is collected on a fixed schedule for a long period to detect trends. With respect to surface-water quality and ground-water levels, continuous-recording stations are included in this category.
SHORT-TERM OR PROJECT: Hydrologic information is collected to meet the needs of a specific study. Data supplement those available from scheduled, long-term; continuous-record; and partial-record stations.

o In Virginia, "215 partial record (surface-water) stations were discontinued between FY 1985 and FY 1987 when a multiyear program to develop State-wide low flow regression equations reached the end of the data-collection stage. In Louisiana, 102 partial record (surface-water) stations were discontinued after an analysis showed that, with the data presently available, regression equations could define flood flows well enough to meet existing needs."

o In Wyoming, "the number of (surface-water quality) sampling stations was reduced when the emphasis changed from analyses for major dissolved constituents to more expensive analyses for pesticides and herbicides. Thus, in order to accommodate to a static level of available funds, the number of sampling stations had to be decreased. In Florida and Alabama, surface-water quality work was reduced as a result of decreased funding from other Federal and local agencies."

o In Iowa, "a major ground-water investigation underway with two Iowa State agencies, called for an increased number of ground-water quality stations. In New Jersey, studies of ground-water quality, in cooperation with the State of New Jersey, required additional stations. In Idaho, the number of ground-water quality stations was reduced when a study in an area along the upper Snake River was completed."

In recent years, satellite-telemetry technology has been used increasingly by the Geological Survey to meet needs for near real-time hydrologic data for flood-forecasting and water-management purposes, and for monitoring the operation of critical data-collection stations. As of FY 1987, largely through reimbursements from other Federal, State, and local agencies, satellite data-relay platforms have been installed in some 2,300 Geological Survey stations and are providing information variously on stream discharge, stream or reservoir stage, selected water-quality characteristics, or precipitation quantity (Condes, 1987). Condes (1987) also reports that about 1,700 of the platforms are operated by the Geological Survey and the remaining 600 are operated by others; his analyses show, too, that more than one-quarter of the platforms receive support from the Federal-State Cooperative Program and approximately two-thirds of the funding is derived from other Federal agencies. It is anticipated that by FY 1989, satellite data-relay platforms will be in operation at as many as 3,000 Geological Survey stations.

Investigations of Water-Resources Contamination

The Survey has included water-quality activities in its programs virtually from the time it was established. By the late 1890's and early 1900's, the Geological Survey was pursuing investigations of stream and ground-water contamination problems. From 1902 through 1913, about 100 reports containing water-quality information were issued (Durum, 1978). Many of the reports containing information on water-resources contamination resulted from investigations in the Federal-State Cooperative Program. Some examples are:

o Lower Michigan mineral waters, a study into the connection between their chemical composition and mode of occurrence (Lane, 1899).

o Investigations on the purification of Boston sewage, made at the Sanitary Research Laboratory and Sewage Experiment Station of the Massachusetts Institute

of Technology, with a history of the sewage-disposal problem (Winslow and Phelps, 1906).

o Stream pollution by acid-iron wastes, a report based on investigations made at Shelby, Ohio (Stabler, 1906).

o A preliminary report on the underground waters of Georgia (McCallie, 1908).

o The pollution of streams by sulphite-pulp waste, a study of possible remedies (Phelps, 1909).

o Geology and underground waters of southern Minnesota (Hall, Meinzer and Fuller, 1911).

o Quality of the water supplies of Kansas, with a preliminary report on stream pollution by mine waters in southeastern Kansas (Parker, 1911).

o Underground water resources of Iowa (Norton, Hendrixson, Simpson, Meinzer, and others, 1912).

o The underground water resources of the Coastal Plain province of Virginia (Sanford, 1913).

Until 10 years ago, most of the Survey's emphasis on contamination concerns was concentrated in the Federal-State Cooperative Program. The effects of urban and agricultural runoff, saltwater intrusion, acid precipitation, industrial and sewage discharges, and the storage of wastes, for example, were topics of local urgency and were being investigated long before emerging as problems of national importance. However, the number of activities supported directly by the Survey and other Federal agencies began to increase in the 1950's and has increased markedly since 1980. In addition to continuing to expand the substantial volume of background data, a variety of work that is underway will enable an improved understanding of the Nation's water quality and the factors affecting it.

The quality of water supplies for domestic, industrial, and agricultural uses can affect human health as well as the economy. Considerable progress has been made in the identification and solution of complex water problems, but many activities continue to have the potential for degrading the quality of ground and surface water. In some places, disposal of toxic wastes has made ground water unsafe for use. At an isolated point source of contamination, such as an industrial disposal pond, the consequences may be severe in magnitude but only local in extent. In some places, however, many separate agricultural and industrial activities located over a large area are contributing to widespread contamination. The Nation's rivers have historically been used for water supply, irrigation, recreation, commerce, production of fish and other aquatic crops, and for dilution and transport of wastes. Not all these uses are compatible, and water managers and legislators are faced with resolving increasing conflicts.

During fiscal years 1977-1986, the Survey had some 437 investigations concerned with water-resources contamination in progress at various times; 244 of these were conducted as part of the Federal-State Cooperative Program. Of the 240 investigations in progress during fiscal year 1986, one-half were supported by the Cooperative Program. A report by Gilbert, Mann, and Emery (1987) identifies these investigations and provides additional information about Survey activities related

to water-resources contamination. Several of the investigations are described in this report in the section entitled "Examples of Current Investigations."

The distribution of investigations and funding during fiscal year 1986, by sources of support, is shown in figure 4. Although most of the investigations were conducted as part of the Cooperative Program, the greatest amount of funding was provided for investigations done under the Other Federal Agency Program. Expenditures for the 240 investigations are estimated to have been approximately $50 million.

The total number of investigations under all programs related to water-resources contamination that were underway each fiscal year, 1977 through 1986 is shown in figure 5.A. The number remained near 100 annually for the first one-half of the decade, but the number began to increase during fiscal year 1982 and reached 240 by fiscal year 1986. The most significant increase took place in the number of ground-water investigations, which increased from about 50 in progress annually during fiscal years 1977 to 1981 to more than 160 during fiscal year 1986.

The number of water-resources contamination investigations that were conducted in the Cooperative Program each fiscal year, 1977 through 1986, is shown in figure 5.B. The annual changes in numbers of investigations follow a similar pattern to those in figure 5.A, except that for the Cooperative Program the increase from 1982 to 1986 is less marked. The increase in the number of ground-water investigations was most significant--from about 30 in progress each year, 1977-1982, to about 85 in 1986.

Approximately 55 percent of the Geological Survey's overall expenditures for water-resources programs are associated with investigations and research, and nearly 40 percent of those funds were spent for work related to surface- and ground-water contamination during fiscal year 1986. The number of investigations conducted by the Geological Survey on water-resources contamination problems continues to increase. In the Federal-State Cooperative Program, for example, the number increased from 121 in FY 1986 to 156 in FY 1987.

The geographic distribution of Cooperative Program investigations in FY 1987 is shown in figure 6. For the Cooperative Program in FY 1987, the most investigations were conducted in Florida, 17; New York, 8; Pennsylvania, 7; and Missouri, New Jersey, and Wisconsin, 6. No Cooperative Program investigations in FY 1987 are shown for Mississippi, Nebraska, New Hampshire, and Vermont. The disparity among the numbers of investigations shown in various locations does not necessarily reflect the relative incidence of water-resources contamination. Many local, State, regional, and Federal agencies, as well as universities and private organizations, conduct hydrologic investigations and research in addition to the Geological Survey.

Investigations such as these provide fundamental information on the extent and effects of contaminants in the water-resource environment, as well as facilitating the development of plans for remedial actions. They can also serve as the basis for pollution-control and waste-reduction efforts. According to the Office of Technology Assessment (U.S. Congress, 1987), a commitment to prevent pollution would prove less costly for industry and government than controlling and cleaning up wastes. Investigations that characterize present levels of contamination are essential for evaluating the effectiveness of each approach and for compliance

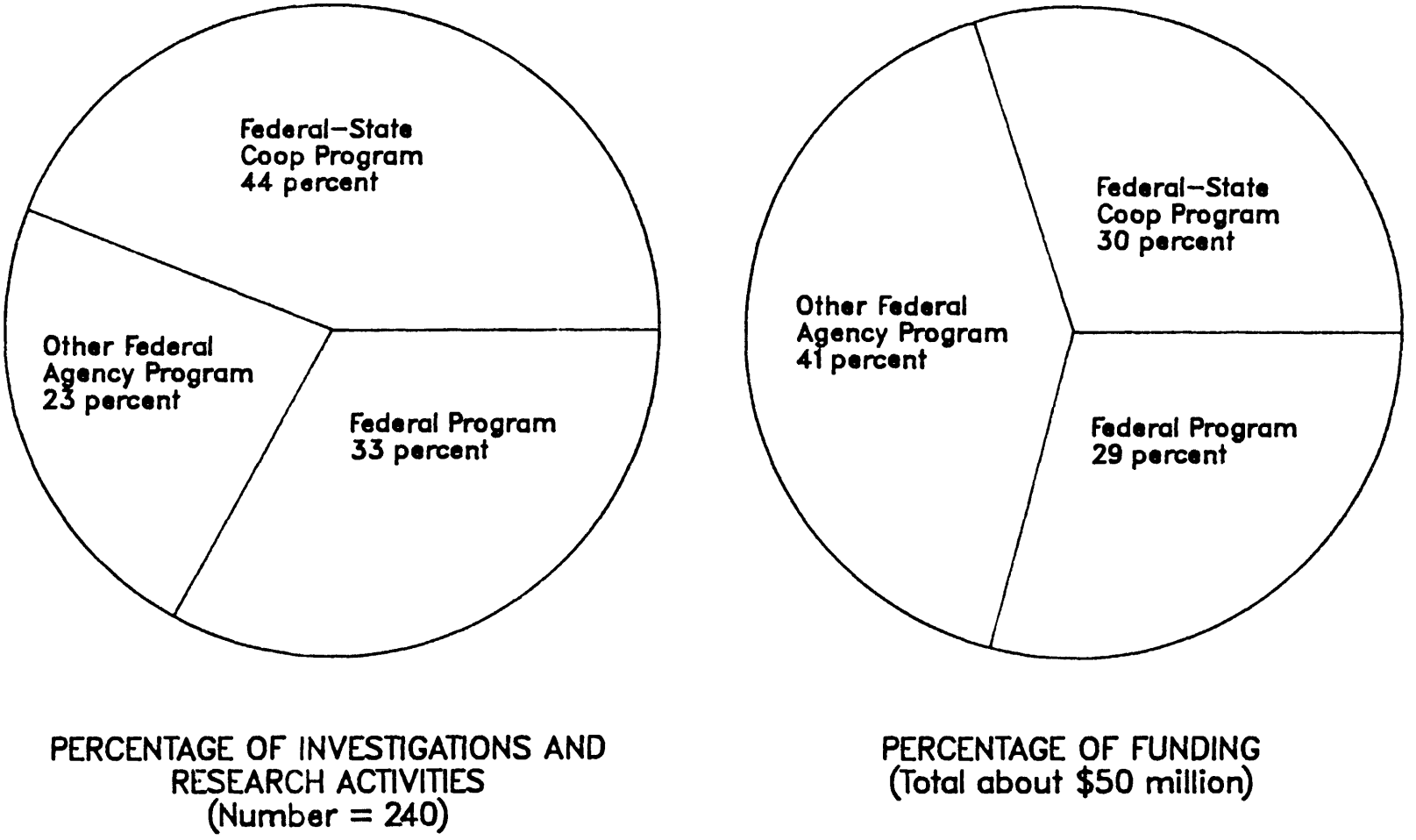

Figure 4.--Distribution of U.S. Geological Survey investigations and research related to water-resources contamination, and funding by sources of support, fiscal year 1986.

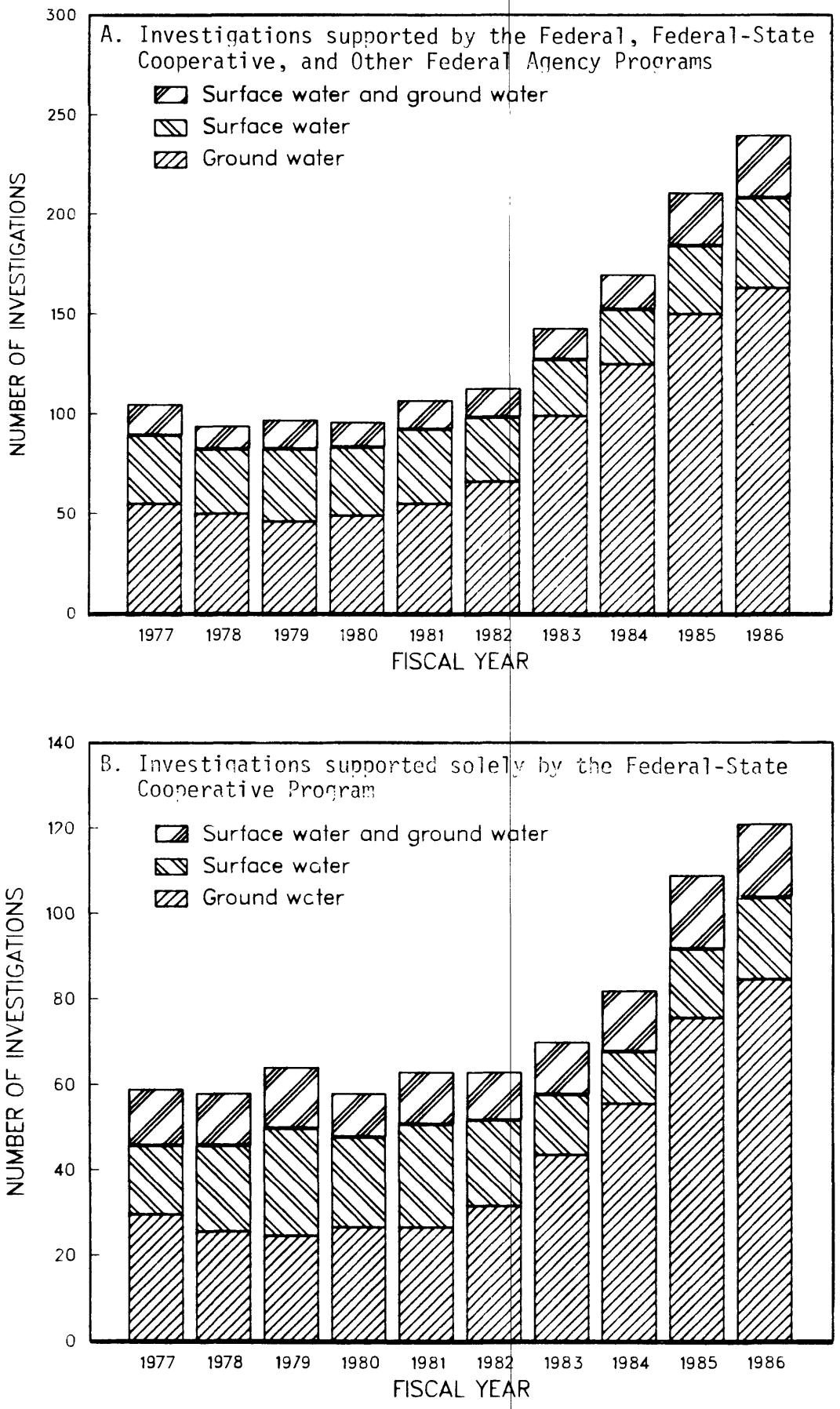

Figure 5.--Number of U.S. Geological Survey investigations related to water-resources contamination that were ongoing each fiscal year, 1977 through 1986.

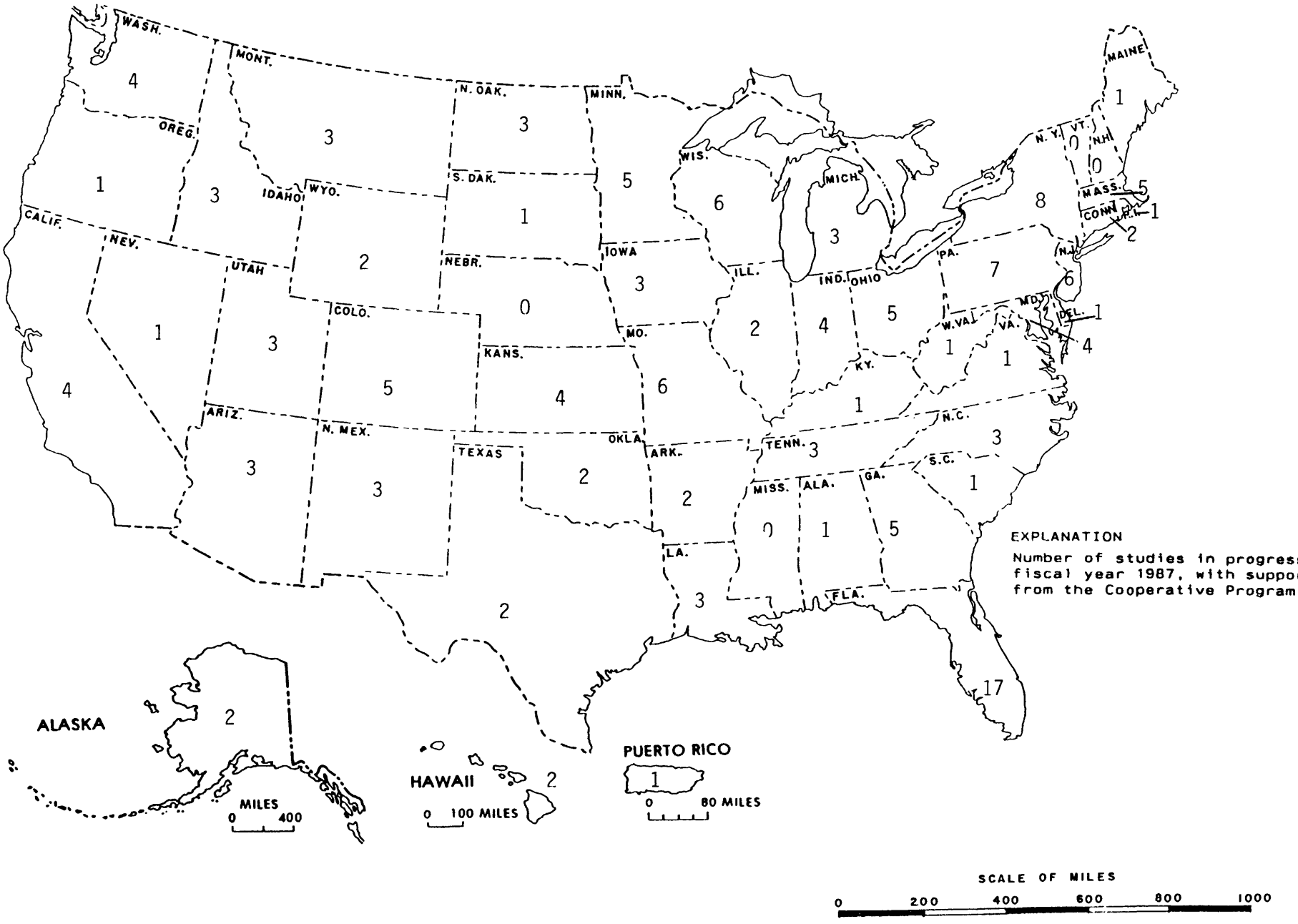

Figure 6.--Distribution of the 156 U.S. Geological Survey investigations and research studies, related to water-resources contamination, that were underway in fiscal year 1987, as part of the Federal-State Cooperative Program.

monitoring. The results may help to reshape the Nation's philosophy regarding environmental protection.

Examples of Current Investigations

Several examples are provided below of investigations conducted as part of the Cooperative Program in FY 1987:

Ground-water contamination, lower Miami Wash and Pinal Creek basins near Globe, Arizona--An investigation by the Geological Survey, in cooperation with the Arizona Department of Health Services and the Salt River Valley Water Users Association, has identified a complex group of contaminants affecting both the surface and ground water near Globe. A plume of contaminated ground water more than 10 miles long and 250 feet thick along Miami Wash and Pinal Creek is extremely acidic, with high concentrations of dissolved metals, calcium and sulfate. The plume is believed to be the result of the intensive copper mining and ore processing in the area during the past 70 years. The findings of the investigation are of special interest not only to local water users but also to those concerned with the quality of the Colorado River, which receives drainage from this hydrologic system.

Geohydrologic investigations of the Sacramento Valley area, California--In cooperation with the California Department of Water Resources, the Geological Survey is developing a geographic information system to store, manipulate, and analyze geohydrologic data for the Sacramento Valley area. This system will include logs from wells and test holes, geologic maps, soil surveys, and pumpage records along with topographic, geologic, and hydrologic data. The resulting information is expected to describe the nature of alluvial materials to a depth of 1,000 feet below land surface. Because most ground water produced in the area comes from this zone, an accurate description of the aquifer's properties is essential to those responsible for water-resources development and management.

Ground-water contamination probability in south Florida--Numerous studies have identified a direct relation between land use and ground-water quality in south Florida where urban and agricultural areas overlie the shallow, unconfined aquifers. These aquifers provide nearly 90 percent of the potable water for the area. The Geological Survey is conducting an investigation in cooperation with the South Florida Water Management District to develop waste-hazard evaluation ratings using a geographic information system as a data-base management tool. The objective of the investigation is to assess the contamination probability of the local aquifer systems. The hazard ratings produced will include consideration of hydrogeologic characteristics, direction of ground-water flow, time of travel, land use, and known sources of contamination. The resulting products will assist the South Florida Water Management District in designing ground-water monitoring networks, siting well fields, and assessing probability of ground-water contamination.

Simulation of ground-water flow in the Brunswick area, Georgia--The Geological Survey, in cooperation with the city of Brunswick, Georgia, and Glynn County, is developing numerical models for simulating ground-water flow in fractured limestone formations. Substantial ground-water withdrawals have resulted in the movement of saline water into the freshwater zones of the Upper Floridan aquifer. The conduits for the saline water are believed to be fracture zones bounded by

northeast-trending faults. A ground-water flow model has been used to evaluate significant changes in the flow system in Brunswick and Glynn County from predevelopment to present-day conditions. The present model will be extended to include the simulation of multiple aquifer layers and lateral movement of the saline water in the Brunswick area.

Improved runoff prediction in Illinois--Understanding the relation between rainfall and resulting runoff is important for accurate flood forecasting. Many computer models have been developed to simulate this relation, but none has been able to completely describe how factors such as land-use patterns, soil properties, and rainfall distribution affect runoff. The Geological Survey, in cooperation with the Illinois Department of Transportation, is using geographic information system technology to improve the way that models handle the various factors involved. Improved model simulations will provide better predictions of runoff and enable forecasters to provide more accurate flood information.

Pesticides in soil and ground water, Iowa River basin, Iowa--Recently established ground-water quality monitoring programs have detected the presence of numerous pesticides in shallow ground-water supplies throughout Iowa. Increasing concern about the leaching of agricultural chemicals into aquifers has sparked the need to understand the movement of these contaminants. Data collected by the State indicate that nearly 56 million pounds of herbicides are applied annually to cultivated fields in Iowa. In cooperation with the University of Iowa Hygienic Laboratory and the Iowa Department of Natural Resources--Geological Survey Bureau, the U.S. Geological Survey is evaluating the movement and distribution of selected pesticides in the cultivated field environment. The specific objectives of the investigation are to determine the distribution of selected pesticides in the soil and the characteristics of pesticide movement from the land surface to shallow ground water.

Effects of pesticides in Tuttle Creek Lake, northeastern Kansas--Agricultural pesticides have been detected in Tuttle Creek Lake, a large multipurpose reservoir on the Big Blue River in northeastern Kansas. The lake is used for recreation, flood control, and maintenance of flow and water quality in the Kansas River. The lake also is being considered as a source of public-water supply. In addition to deleterious effects that might result from pesticides in potential drinking-water supplies, atrazine, an extensively used herbicide, is known to adversely affect phytoplankton. An investigation being conducted by the Geological Survey, in cooperation with the Kansas Department of Health and Environment, is designed to document the occurrence and transport of pesticides in the lake-stream system, which is representative of hydrologic settings in many agricultural areas.

Low-flow characteristics of Kentucky streams--In cooperation with the Kentucky Department of Natural Resources and Environmental Protection Cabinet, the Geological Survey is conducting an investigation of low-flow characteristics of Kentucky streams. The investigation is expected to provide a means of estimating low-flow values for use by the State in the management of its water resources and to indicate where additional gaging stations may be desirable so that more low-flow information can be obtained.

Effects of agricultural best management practices, Patuxent River basin, Maryland--Nutrients in runoff from agricultural areas in the Patuxent River basin markedly affect the water quality of the Chesapeake Bay. Best management practices, proposed by the county Soil Conservation Districts to decrease the nutrients in

runoff, may result in increased infiltration to the ground-water flow system. These practices may increase the concentration of nutrients in shallow ground water, which is the source of base flow to streams and the bay. In cooperation with the Maryland Department of the Environment, the Geological Survey is conducting an investigation to determine the effects of best management practices on ground-water flow and nitrogen concentrations. Numerical models will be developed for flow analyses under actual conditions and under various land-management alternatives.

Flow and transport modeling in the Grand Strand area, South Carolina--The Geological Survey, in cooperation with the Grand Strand Water and Sewer Authority, is currently modeling flow and water quality in the Atlantic Intracoastal Waterway in an area that extends from north of Myrtle Beach, south to Georgetown. The rapidly growing resort area along South Carolina's Grand Strand, an 800 square-mile area centered around the town of Myrtle Beach, faces severe constraints on local water supply and wastewater disposal because of problems with water quality and quantity. The Black Creek aquifer, which has been the primary source of drinking water, has shown increasing concentrations of sodium, fluoride, and dissolved solids. In addition, the ground-water levels have been declining approximately 10 feet per year because of pumping.

Pesticides at North Hollywood dump, Memphis, Tennessee--The Geological Survey, in cooperation with the city of Memphis, is conducting an investigation of hazardous wastes at a closed municipal-industrial landfill. The study area is the North Hollywood dump, which is Tennessee's top-ranking site on the "Superfund" list of the U.S. Environmental Protection Agency. The city of Memphis is particularly concerned with the possible contamination of the underlying aquifer, which provides drinking water for almost 1 million people. Toxic wastes of primary concern at the landfill are residues of pesticide manufacturing. These chemicals have been detected in local soils, sediments, biota, and ground and surface waters. The goal of the investigation is to describe the present extent of contamination at the landfill and to estimate the potential for migration of toxic constituents outside the landfill.

Highway deicing and ground-water quality in Ohio--Since 1940, the use of salt to deice highways has grown steadily. Recent evidence indicates that applied salt tends to accumulate in soil adjacent to highways and to cause detrimental effects on vegetation, wildlife, and water quality. A cooperative project involving the Geological Survey and the Ohio Department of Transportation is studying the long-term effects of salt applications on shallow aquifers underlying highways. The investigation will examine how different application rates alter ground-water quality. Results of the investigation will provide valuable insights for decisions by the State dealing with a balance between highway safety and environmental health.

Radioactivity in ground water, southeastern Pennsylvania--Recently, radioactive substances in ground water, dissolved radium and gaseous radon, have received national attention. In southeastern Pennsylvania, higher than normal concentrations of radioactivity have been detected in wells drawing water from a bedrock (quartzite) aquifer. The Geological Survey, in cooperation with the Pennsylvania Department of Environmental Resources, is mapping the extent and magnitude of the radium and radon anomalies in public water-supply wells and identifying alternative sources of supply where necessary. Results of the investigation will indicate areas of elevated radioactivity for consideration by the State in water-resources planning and development.

PROGRAM PRIORITIES

Program priorities are based on national needs that have been identified by the President and Administration advisors, by the Congress, by the Department of the Interior, by other Federal agencies, and from information the Geological Survey has received from cooperating agencies and other interested parties. Issues that are identified through the National Water Summary (U.S. Geological Survey 1984, 1985, and 1986) are also taken into consideration. As a result, the priorities are developed in response to mutual Federal, regional, State, and local needs.

Health and safety, national defense, economic welfare, and environmental quality are all recognized as public responsibilities and are all related to water resources. Because the availability of water of suitable quality is so vital to the health and well-being of citizens and the economy, there is sufficient universal interest to enable the Geological Survey to fulfill its water-resources mission in partnership with others, and the need is increasing for cooperation and collaboration in focusing efforts on highest priority areas. The data and results of investigations are available to all; the Nation's ability to cope with new and challenging water-resources problems and issues depends largely on the pool of information developed during preceding years.

The issues for FY 1988 (which have not changed greatly since FY 1987) reflect the strong interdependence of the Cooperative Program, the Federal Program, and the Other Federal Agency Program. For example, the National Water-Quality Assessment (NAWQA) Program will build on information derived from data collection and studies conducted within the Cooperative Program. Data-collection efforts supported by the Federal Program and other Federal agencies augment the Cooperative Program network. The National Research Program develops and improves hydrologic principles and methods for use in the Federal-State Cooperative Program, which in turn provides a setting for application of new scientific methods. The issues and their relative importance may be influenced markedly during the next several decades by the effects of climate change on hydrology. Water-quality issues headed the list of Federal-State Cooperative Program priorities in FY 1987, and will do so again in FY 1988, thus continuing the emphasis given during the past several years. Approximately three-fourths of the investigations undertaken in this program will in part address water-quality concerns, and of these, it is estimated that more than one in four will focus on contamination problems.

Major Issues of National Concern

Four issues of national concern have been identified of highest priority in developing the FY 1988 Cooperative Program.

Ground-Water Contamination--There is a continuing need for studies of the movement and fate of contaminants in ground-water systems. Studies will address flow dynamics, solute-transport processes, and the determination of present water quality with which future changes can be compared. Geochemical studies will emphasize processes that influence the suitability of water for use--particularly those uses that could affect human health. These include natural processes that generate undesirable constituents as well as mechanisms related to human activities that act to alter, add, or remove contaminants. Also needed are studies of the

effects of waste disposal, contamination by nonpoint sources, and evaluation of saltwater encroachment.

Stream Quality--There is a continuing need for appraisals of the water quality of stream systems both in areas where contamination has been documented and in areas where contamination may or may not be a problem. Particular emphasis will be given to the occurrence and movement of toxic substances, and the effects of contamination on the stream environment. Investigations are needed of stream quality and sediment chemistry as related to land use and land-use changes, stream biota, ground-water contribution of contaminants, and overland runoff. Cooperative investigations supporting and complementing the NAWQA Program will be given high priority in program formulation. Such investigations might include expansion of data bases on chemical properties, particularly toxic substances, and on the processes governing erosion, sediment transport and deposition; measurement of the effects of land-use changes, including urban development; studies of the effects on land and water resources of suspended and deposited sediments; understanding the transport of toxic substances and other constituents sorbed or attached to sediment; and identifying the nonpoint source component of surface-water quality loads transported by streams in different geographic settings.

Water Supply and Demand--Increasing diversion, withdrawal, and use of water places stress on the quantity and quality of water supplies, thereby raising costs of delivery and treatment, and presenting ever more difficult problems of allocation and quality management. Information defining present water use is required to quantify such stresses over time and space. Topical studies are needed to improve estimates of water use in categories outlined in the National Water-Use Program. Emphasis also will be placed on the identification of aquifers that are major sources for water supply. Flow-system simulation is essential to anticipate stress response, especially for stream-aquifer systems. Topics for study will include streamflow response to drought conditions, and system response both to projected uses and supply-augmentation schemes.

Hydrologic Hazards--Economic losses from floods, mudflows, debris flows, sedimentation, and other hydrologic hazards amount to billions of dollars annually. These hazards are related not only to meteorological conditions, but to such phenomena as landslides, volcanic eruptions, and earthquakes. Studies are needed to define the magnitude and probability of occurrence of hazardous hydrologic events and to improve understanding of the processes that cause them. For example, the relations between climatic and hydrologic trends need to be better understood to determine the relation of changing lake levels to possible climatic changes.

Major Issues of Regional Concern

Three additional issues, the importance of which may differ depending on regional interests, also are considered to have high priority:

Hydrologic Effects of Fossil Fuel and Mineral Extraction--The mineral extractive industries, oil and gas production and processing, solid-fuel mining and processing (such as coal and oil shale), and metallic and nonmetallic mining, greatly affect hydrologic systems. Effects may relate to a wide spectrum of hydrologic phenomena, including interaction of subsurface fluids having different chemical and physical characteristics, large-scale aquifer dewatering to permit mining,

disruption of surface drainage, and disturbance of geochemical equilibria. Investigations will include studies of the hydrologic affects of land reclamation, mining, and waste disposal.

Wetlands, Lakes and Estuaries--Wetlands, lakes, and estuaries deserve special attention because of their importance as water supplies, and to waste disposal, recreation, and fish and wildlife resources. These areas are especially sensitive to human encroachment. Studies will address the availability, movement, and quality of water, and will emphasize physical, chemical, and biological processes.

Acid Rain--Studies of the effects of the chemistry of precipitation on stream quality and the interaction of acid rain with biological systems will receive priority attention in terranes that have limited ability to buffer ground and surface waters, and in urban settings that produce large loads of atmospheric pollutants.

SUMMARY

The U.S. Geological Survey's Federal-State Cooperative Water-Resources Program (50:50 matching of funds) has responded to national needs for hydrologic information since 1895. During 1987, water-resources data collection, investigations, and research were conducted in cooperation with 940 local, State, and regional agencies in every State, Puerto Rico, and several territories. Total funding for the program in FY 1987 amounted to about $115 million, and comprised about 45 percent of the total obligations for the Geological Survey's Water Resources Division. The Cooperative Program provides much of the information required by those responsible for water-resources planning and management, water-supply development, and environmental improvement.

Investigations of water-resources contamination also have been conducted in this program since the late 1890's. The effects on water quality of agricultural and urban runoff, saltwater intrusion, and liquid- and solid-waste disposal, for example, were topics included in Cooperative Program investigations well in advance of being recognized as problems of national concern. In FY 1986, the Geological Survey had in progress about 240 investigations concerned with water-resources contamination. The Cooperative Program accounted for 120 of these. In FY 1987, the number of contamination investigations supported by the Cooperative Program increased to 156.

The Federal-State Cooperative program content continues to evolve in response to priorities identified in consultation with Federal agencies, cooperators, and other interested parties. The principal areas of emphasis during FY 1987 included ground-water contamination, stream quality, water supply and demand, and hydrologic hazards. Hydrologic data-collection efforts continue to expand the substantial volume of background information, and the variety of research and investigations being conducted enable an improved understanding of, and approach to, the Nation's critical water problems.

REFERENCES CITED

Condes de la Torre, Alberto, 1987, Operation of hydrologic data collection stations by the U.S. Geological Survey in 1987: U.S. Geological Survey Open-File Report 87-563, 42 p.

Durum, W. H., 1978, Historical profile of quality of water laboratories and activities, 1879-1973, Part 2, History of water quality activities: U.S. Geological Survey Open-File Report 78-432, 152 p.

Gilbert, B. K., and Buchanan, T. J., 1981, The U.S. Geological Survey Federal-State Cooperative Water-Resources Program: U.S. Geological Survey Open-File Report 81-691, 27 p.

Gilbert, B. K., and Mann, W. B., IV, 1987, The U.S. Geological Survey Federal-State Cooperative Water-Resources Program, fiscal year 1986: U.S. Geological Survey Open-File Report 87-27, 38 p.

Gilbert, B. K., Mann, W. B., IV, and Emery, P. A., 1987, Some aspects of U.S. Geological Survey activities related to the effects of contamination on water resources: U.S. Geological Survey Open-File Report 87-574, 63 p.

Hall, C. W., Meinzer, O. E., and Fuller, M. L., 1911, Geology and underground waters of southern Minnesota: U.S. Geological Survey Water-Supply Paper 256, 406 p.

Lane, A. C., 1899, Lower Michigan mineral waters, a study into the connection between their chemical composition and mode of occurrence: U.S. Geological Survey Water-Supply Paper 31, 97 p.

McCallie, S. W., 1908, A preliminary report on the underground waters of Georgia: Georgia Geological Survey Bulletin 15, 370 p.

Norton, W. H., Hendrixson, W. S., Simpson, H. E., Meinzer, O. E., and others, 1912, Underground water resources of Iowa: U.S. Geological Survey Water-Supply Paper 293, 994 p.

Parker, H. N., 1911, Quality of the water supplies of Kansas, with a preliminary report on stream pollution by mine waters in southeastern Kansas, by E. H. S. Bailey: U.S. Geological Survey Water-Supply Paper 273, 375 p.

Phelps, E. B., 1909, The pollution of streams by sulphite-pulp waste, a study of possible remedies: U.S. Geological Survey Water-Supply Paper 226, 37 p.

Sanford, Samuel, 1913, The underground water resources of the Coastal Plain province of Virginia: Virginia Geological Survey Bulletin 5, 361 p.

Stabler, Herman, 1906, Stream pollution by acid-iron wastes, a report based on investigations made at Shelby, Ohio: U.S. Geological Survey Water-Supply Paper 186, 36 p.

U.S. Congress, Office of Technology Assessment, 1987, From pollution to prevention--A progress report on waste reduction: Special report OTA-ITE-347, 54 p.

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

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

U.S. Geological Survey, 1986, National water summary 1985--Hydrologic events and surface-water resources: U.S. Geological Survey Water-Supply Paper 2300, 506 p.

Winslow, C. E. A., and Phelps, E. B., 1906, Investigations on the purification of Boston sewage, made at the Sanitary Research Laboratory and Sewage Experiment Station of the Massachusetts Institute of Technology, with a history of the sewage-disposal problem: U.S. Geological Survey Water-Supply Paper 185, 163 p.

APPENDIX

COOPERATORS BY STATE, FISCAL YEAR 1987

Alabama:
- Alabama Department of--
  - Environmental Management
  - Highways
- Alabama Surface Mining Commission
- Alabaster, City of
- Anniston, City of
- Arab Water Works
- Autauga County Commission
- Birmingham, City of
- Calhoun County Commission
- Coffee County Commission
- Dauphin Island Water Authority
- Geological Survey of Alabama
- Harvest - Monrovia Water and Fire Protection Authority
- Heflin, City of
- Huntsville, City of, Public Works
- Jefferson County Commission
- Mobile, City of
- Montgomery, City of, Water Works and Sanitary Sewer Board
- Reece City, Town of
- Southside Water Works
- Tuscaloosa, City of
- University of Alabama

Alaska:
- Alaska Department of--
  - Fish and Game
  - Military and Veterans Affairs, Division of Emergency Services
  - Natural Resources, Division of--
    - Geological and Geophysical Surveys
    - Technical Services
  - Transportation and Public Facilities
- Alaska Power Authority
- Anchorage, Municipality of--
  - Department of Health and Human Services
  - Department of Solid Waste Services
  - Water and Wastewater Service
- Fairbanks North Star Borough
- Juneau, City and Borough of
- Kenai Peninsula Borough
- Matanuska - Susitna Borough
- Sitka, City and Borough of

Arizona:
- Arizona Department of Water Resources
- Arizona Municipal Water Users Association
- Arizona State Land Department
- Gila Valley Irrigation District
- Maricopa County--
  - Flood Control District
  - Municipal Water Conservation District No. 1
- Metropolitan Water District of Southern California

Arizona--Continued
- Pima County Flood Control District
- Safford, City of
- Salt River Valley Water Users Association
- San Carlos Irrigation and Drainage District
- Scottsdale, City of
- Show Low Irrigation Company
- The Tohono O'Odham Nation
- Tucson, City of
- University of Arizona, Board of Regents
- Yuma, City of

Arkansas:
- Arkansas Department of--
  - Pollution Control and Ecology
  - Highway and Transportation
- Arkansas Game and Fish Commission, Fisheries Division
- Arkansas Geological Commission
- AR-OK Arkansas River Compact Commission
- Arkansas Soil and Water Conservation Commission
- Independence County

California:
- Alameda County --
  - Flood Control and Water Conservation District (Hayward)
  - Flood Control and Water Conservation District, Zone 7 (Pleasanton)
  - Water District
- Antelope Valley - East Kern Water Agency
- California Coastal Conservancy
- California Department of --
  - Boating and Waterways
  - Parks and Recreation
  - Water Resources --
    - Central District (Sacramento)
    - Northern District (Red Bluff)
    - San Joaquin District (Fresno)
- Carpinteria County Water District
- Casitas Municipal Water District
- Coachella Valley Water District
- Contra Costa County --
  - Department of Health Services
  - Flood Control and Water Conservation District
- Crestline - Lake Arrowhead Water Agency
- Desert Water Agency
- East Bay Municipal Utility District
- East Valley Water District
- El Dorado County
- Fresno Metropolitan Flood Control District
- Georgetown Divide Public Utility District
- Goleta County Water District
- Humboldt Bay Municipal Water District
- Imperial County Department of Public Works
- Imperial Irrigation District
- Indian Wells Valley Water District

California--Continued
Inyo County Water Department
Kings River Conservation District
Los Angeles Department of Water and Power
Los Penasquitos Lagoon Foundation
Madera Irrigation District
Marin County Department of Public Works
Marin Water Municipal District
Merced, City of
Merced Irrigation District
Mojave Water Agency
Montecito Water District
Monterey County Flood Control and Water Conservation District
Monterey Peninsula Municipal Water District
Oakdale - South San Joaquin Irrigation District
Orange County--
Environmental Management Agency
Water District
Oroville - Wyandotte Irrigation District
Rainbow Municipal Water District
Rancho California Water District
Regional Water Quality - Lahonton Region
Riverside County Flood Control and Water Conservation District
Sacramento Department of Health Services
Sacramento Municipal Utility District
Sacramento Regional County Sanitation District, Department of Public Works
San Benito County Water Conservation and Flood Control District
San Bernardino County Flood Control District
San Bernardino Valley Municipal Water District
San Diego City Water Utilities
San Diego County, Department of--
Planning and Land Use
Public Works
San Francisco, City and County of, Public Utilities Commission
San Francisco Water Department
San Luis Obispo County, County Government Center
San Mateo County--
Department of Public Works
Santa Barbara, City of, Department of Public Works
Santa Barbara County--
Flood Control and Water Conservation District
Water Agency
Santa Clara Valley Water District
Santa Cruz County--
Flood Control and Water Conservation District
Santa Maria Valley Water Conservation District
Santa Ynez River Water Conservation District
Scotts Valley Water District
Siskiyou County Flood Control and Water Conservation District
Sonoma County--
Planning Department
Water Agency

California--Continued
Tahoe Regional Planning Agency
Terra Bella Irrigation District
Tulare County Flood Control District
Turlock Irrigation District
United Water Conservation District
University of California--Riverside
Cooperative Extension
Ventura County Public Works Agency
California State Water Resources Control Board
Western Municipal Water District
Westlands Water District
Woodbridge Irrigation District
Yolo County Flood Control and Water Conservation District
Yuba County Water Agency

Colorado:
Arkansas River Compact Administration
Arvada, City of
Aspen, City of
Aurora, City of
Boulder, City of
Boulder County Department of Public Works
Breckenridge, Town of
Castle Rock, Town of
Cherokee Water and Sanitation District
Cherry Creek Basin Authority
Colorado Department of--
Health
Natural Resources
Colorado Division of Mined Lands Reclamation
Colorado Division of Water Resources, Office of the State Engineer
Colorado Geological Survey
Colorado River Water Conservation District
Colorado Springs, City of--
Department of Public Utilities
Office of the City Manager
Delta County Board of County Commissioners
Denver Board of Water Commissioners
Denver Regional Council of Governments
Eagle County Board of Commissioners
Englewood, City of, Wastewater Treatment Plant
Evergreen Metropolitan District
Fort Collins, City of
Fountain Valley Authority
Fruita, City of
Garfield County
Glendale, City of
Glenwood Springs, City of
Grand County Board of Commissioners
Kiowa-Bijou Ground Water Management District
Larimer-Weld Regional Council of Governments

Colorado--Continued
Longmont, City of
Lost Creek Ground Water Management District
Lower Fountain Water-Quality Management Assoc.
Metropolitan Denver Sewage Disposal District No. 1
Mineral County
Moffat County
Northern Colorado Water Conservancy District
North La Junta Water Conservation District
Pikes Peak Area Council of Governments
Pikes Peak Regional Building Department
Pitkin County Board of Commissioners
Pueblo, City of, Board of Water Works
Pueblo Civil Defense Agency
Pueblo West Metropolitan District
Purgatoire River Water Conservancy District
Rio Blanco County
Rio Grande Water Conservation District
Southeastern Colorado Water Conservancy District
Southwestern Colorado Water Conservancy District
St. Charles Mesa Water District
Steamboat Springs, City of
Thornton, City of
Trinchera Conservancy District
Uncompahgre Valley Water Users Association
Upper Arkansas River Water Conservancy District
Upper Black Squirrel Ground Water Management District
Upper Yampa Water Conservancy District
Urban Drainage and Flood Control District
Water Users No. 1 (Rangely)
Yellow Jacket Water Conservancy District

Connecticut:
Connecticut Department of Environmental Protection
Fairfield, Town of, Conservation Commission
New Britain, City of--
Board of Water Commissioners
South Central Connecticut Regional Water Authority
Torrington, City of

Delaware:
Department of Natural Resources and Environmental Control
Geological Survey

District of Columbia:
Department of Public Works
Metropolitan Washington Council of Governments

Florida:
Boca Raton, City of
Bradenton, City of
Brevard County Board of County Commissioners

Florida:--Continued
Broward County--
Environmental Quality Control Board
Water Resources Management Division
Cape Coral, City of
Cocoa, City of
Collier County
Collier Mosquito Control District
Cottondale, City of
Englewood Water District Board of Supervisors
Escambia County, Board of County Commissioners
Escambia County Utilities Authority
Florida Department of--
Environmental Regulation, Bureau of Water Resource Management
Natural Resources, Division of Marine Resources
Transportation
Florida Division of Recreation and Parks (Hope Sound and Tallahassee)
Florida Institute of Phosphate Research
Florida Keys Aqueduct Authority
Fort Lauderdale, City of
Fort Walton Beach, City of
Game and Freshwater Fish Commission
Hallendale, City of
Highland Beach, Town of
Hillsborough County
Hollywood, City of
Indian River County
Jacksonville, City of--
Department of Health and Environmental Services
Department of Planning
Water Service Division
Jacksonville Beach, City of
Jacksonville Electric Authority
Research and Environmental Affairs
Lake County, Board of County Commissioners
Lakeland, City of
Lee County, Board of County Commissioners
Leon County
Leon County Department of Public Works
Loxahatchee River Environmental Control District
Madison, City of
Manatee County, Board of County Commissioners
Marion County, Board of County Commissioners
Metropolitan Dade County, Department of Environmental Resources Management
Miami-Dade Water and Sewer Authority
Northwest Florida Water Management District
Orange County, Board of County Commissioners
Palm Beach County, Board of County Commissioners
Palm Beach County Solid Waste Authority
Perry, City of
Petersburg, City of
Pinellas County

Florida--Continued
- Polk County, Board of County Commissioners
- Pompano Beach, City of, Water and Sewer Department
- Quincy, City of
- Reedy Creek Improvement District
- Sanibel, City of
- Sarasota, City of
- Sarasota County
- South Dade Soil and Water Conservation District
- South Florida Water Management District
- Southwest Florida Regional Planning Council
- Southwest Florida Water Management District
- St. Johns County
- St. Johns River Water Management District
- Stuart, City of
- Sumter County, Recreation and Water Conservation and Control Authority
- Suwannee River Authority (Trenton)
- Suwannee River Water Management District
- Tallahassee, City of
  - Electric Department
  - Streets and Drainage
  - Underground Utilities
  - Water Quality Laboratory
- Tampa, City of
- Tampa Port Authority
- University of Florida, Center for Wetlands
- Walton County
- West Coast Regional Water Supply Authority

Georgia:
- Albany, City of
- Albany Water, Gas, and Light Commission
- Bibb County, Board of County Commissioners
- Brunswick, City of
- Clayton County Water Authority
- Consolidated Government of Columbus
- Covington, City of
- Georgia Department of--
  - Natural Resources--
    - Environmental Protection Division, Water Management Branch
    - Environmental Protection Division, Water Quality Support Program
    - Geological Survey
  - Transportation, Materials and Research
- Gwinnett County
- Helena, City of
- Macon-Bibb County Water and Sewage Authority
- Moultrie, City of
- Thomaston, City of
- Thomasville, City of
- Valdosta, City of

Hawaii:
- Hawaii Department of--
  - Land and Natural Resources--
    - Division of Water and Land Development
  - Transportation
- Honolulu, City and County--
  - Board of Water Supply
  - Department of Public Works

Idaho:
- Boise, City of
- Burley Irrigation District
- College of Southern Idaho
- Idaho Department of--
  - Fish and Game
  - Health and Welfare
  - Water Resources
- Idaho Falls, City of
- Shoshone County
- Sun Valley Water and Sewer District
- SW Irrigation District
- Teton County, Board of County Commissioners
- The Shoshone Bannock Tribes, Fort Hall Indian Reservation
- Water District No. 1--Idaho Falls

Illinois:
- Bloomington and Normal Sanitary District
- Cook County Forest Preserve District
- Decatur, City of
- De Kalb, City of
- Du Page County --
  - Forest Preserve
  - Public Works
- Illinois Department of--
  - Energy and Natural Resources, State Water Survey Division
  - Transportation, Division of Water Resources
- Illinois Environmental Protection Agency, Division of Water Pollution Control
- Metropolitan Sanitary District of Greater Chicago
- Springfield, City of

Indiana:
- Carmel, Town of
- Elkhart Water Works
- Indiana Department of--
  - Environmental Management
  - Highways
  - Natural Resources, Division of Water
- Indianapolis Department of Public Works

Iowa:
- Cedar Rapids, City of
- Charles City, City of
- Clear Lake, City of
- Des Moines Water Works
- Fort Dodge, City of
- Iowa Department of--
  - Natural Resources--Des Moines
  - Natural Resources--Iowa City
    - Geological Survey Bureau
  - Transportation, Highway Division
- Iowa State University
- Marshalltown, City of--
  - Water Pollution Control Plant
  - Sewage Disposal Plant
- Sioux City, City of
- University of Iowa--
  - Institute of Hydraulic Research
  - University Hygenic Laboratory
  - University Physical Plant
- Union Electric Company
- Waterloo Sewage Disposal Plant

Kansas:
- Arkansas River Compact Administration
- Equus Beds Groundwater Management District No. 2
- Hays, City of
- Kansas Corporation Commission
- Kansas Department of--
  - Health and Environment
  - Transportation
- Kansas Geological Survey
- Kansas State Board of Agriculture, Division of Water Resources
- Kansas State University
- Kansas Water Office
- Northwest Kansas Groundwater District No. 4
- Olathe, City of
- Pawnee Watershed
- Sedgwick County Department of Environmental Resources
- Southwest Kansas Ground Water Management District No. 3
- Western Kansas Ground Water Management District No. 1

Kentucky:
- Elizabethtown, City of
- Jefferson County Public Works and Transportation Department
- Hardin County Water District
- Kentucky Department of--
  - Natural Resources and Environmental Protection

Kentucky:--Continued
- Kentucky Geological Survey
- University of Louisville

Louisiana:
- Avoyelles Parish
- Capital-Area Groundwater Conservation Commission
- East Baton Rouge Parish
- Jefferson Parish Department of Public Utilities
- Louisiana Department of--
  - Natural Resources--
    - Environmental Quality
  - Transportation and Development--
    - Materials Lab
    - Office of Public Works
  - Wildlife and Fisheries
- Sabine River Compact Administration
- Slidell, City of

Maine:
- Androscoggin Valley Regional Planning Commission
- Cobbossee Watershed District
- Maine Department of--
  - Conservation, Geological Survey
  - Environmental Protection
  - Inland Fisheries and Wildlife
- North Kennebec Valley Regional Planning Commission

Maryland:
- Anne Arundel County Planning and Zoning Office
- Baltimore County--
  - Department of Permits and Licenses
  - Department of Public Works
  - Office of Planning and Zoning
- Calvert County Courthouse
- Caroline County Courthouse
- Howard County Department of Public Works
- Maryland Department of Environment
- Maryland Geological Survey
- Maryland State Highway Administration
- Maryland Water Resources Administration
- Montgomery County--
  - Department of Environmental Protection, Division of Environmental Planning and Monitoring
  - Storm Water Management
- Poolesville, Town of
- St. Marys County Commissioner
- Upper Potomac River Commission
- Washington Suburban Sanitary Commission

Massachusetts:
- Barnstable County Commissioners
- Brewster, Town of
- Harwich, Town of
- Massachusetts Department of--
  - Environmental Management--
    - Division of Water Resources
  - Environmental Quality Engineering--
    - Division of Water Pollution Control
    - Division of Water Supply
  - Fisheries, Wildlife and Environmental Law Enforcement
    - Division of Fisheries and Wildlife
- Massachusetts Hazardous Waste Facility, Site Safety Council
- Metropolitan District Commission, Water Division

Michigan:
- Ann Arbor, City of
- Battle Creek, City of
- Cadillac, City of, Wastewater Treatment Plant
- Clare, City of
- Coldwater, City of, Board of Public Utilities
- Elsie, Village of
- Flint, City of, Department of Public Works and Utilities
- Genesee County Drain Commission, Division of Water and Waste Services
- Grand Traverse County Board of Commissioners
- Huron-Clinton Metropolitan Authority
- Imlay, City of
- Kalamazoo, City of, Department of Public Utilities
- Kalamazoo County Board of Commissioners
- Lansing, City of, Board of Water and Light, Water and Stream Division
- Macomb County
- Mason, City of
- Michigan Department of--
  - Agriculture, Soil and Water Conservation Division
  - Natural Resources
  - Transportation
- Oakland County Drain Commission
- Otsego County Road Commission
- Portage, City of
- Wayne County Environmental Health Division
- Ypsilanti, City of

Minnesota:
- Beltrami County Soil and Water Conservation District
- Elm Creek Conservation Commission
- Fond du Lac Reservation Business Commission
- Leech Lake Reservation Business Committee
- Lower Red River Watershed Management District
- Metropolitan Waste Control Commission

Minnesota--Continued
- Mille Lac Reservation Business Commission
- Minneapolis Water Works
- Minnesota Department of--
  - Natural Resources, Division of Waters
  - Transportation
- Minnesota Geological Survey
- Red Lake Tribal Reservation Business Commission
- Rochester Public Utilities
- St. Paul Water Utility, Water Purification Plant
- University of Minnesota, Department of Soil Science
- Wes Min Resource, Conservation and Development Association
- White Earth Reservation Business Commission

Mississippi:
- Gulf Regional Planning Commission
- Harrison County--
  - Board of Supervisors
  - Development Commission
- Jackson, City of
- Jackson County--
  - Board of Supervisors
  - Port Authority
- Mississippi Department of--
  - Highways
  - Natural Resources--
    - Bureau of Geology
    - Bureau of Land and Water Resources
    - Bureau of Pollution Control
- Pat Harrison Waterway District
- Pearl River Basin Development District
- Pearl River Valley Water Supply District

Missouri:
- Little River Drainage District
- Missouri Department of--
  - Conservation
  - Health
  - Natural Resources--
    - Division of Environmental Quality, Lab Service Program
    - Division of Geology and Land Survey
    - Land Reclamation Commission
- Missouri Highway and Transportation Commission
- Springfield City Utilities Engineering Department

Montana:
- Daniels County
- Fort Peck Tribes
- Helena, City of
- Montana Bureau of Mines and Geology
- Montana Department of--
  - Fish, Wildlife, and Parks
  - Health and Environmental Sciences
  - Highways
  - Natural Resources and Conservation
  - State Lands
- Montana State University
- Salish and Kootenai Tribes of Flathead Reservation
- University of Montana

Nebraska:
- Central Platte Natural Resources District
- Kansas-Nebraska Big Blue River Compact Administration
- Lincoln, City of
- Little Blue Natural Resources District
- Nebraska Department of--
  - Environmental Control
  - Water Resources
- University of Nebraska, Conservation and Survey Division

Nevada:
- Carson City, Department of Public Works
- Clark County --
  - Public Works Department
  - Regional Flood Control District
- Douglas County Department of Public Works
- Elko County
- Las Vegas Valley Water District
- Mackay School of Mines
- Nevada Bureau of Mines and Geology
- Nevada Department of--
  - Conservation and Natural Resources--
    - Division of Environmental Protection
    - Division of Water Resources
  - Transportation
- Nevada Senate Interim Finance Committee
- Nye County
- South Lake Tahoe, California, City of
- South Lake Tahoe, California, Public Utility District
- Summit Lake Paiute Tribe
- Tahoe Regional Planning Agency
- University of Nevada-Reno

New Hampshire:
- New Hampshire Department of Resources and Economic Development

New Jersey:
- Bergen County Department of Public Works
- Brick Township Municipal Utilities Authority
- Camden County Board of Chosen Freeholders
- Cape May, City of
- Delaware River Basin Commission
- Gloucester County Improvement Authority
- Greenwich, Township of
- New Jersey Department of Environmental Protection, Division of Water Resources
- North Jersey District Water Supply Commission
- Passaic Valley Water Commission
- Somerset County Board of Chosen Freeholders
- Township of Lower, Municipal Utilities Authority
- West Windsor Township
- Wildwood, City of

New Mexico:
- Alamogordo, City of
- Albuquerque, City of
- Albuquerque Metropolitan Arroyo Flood Control Authority
- Canadian River Municipal Water Authority
- Costilla Creek Compact Commission
- El Paso Water Utilities Public Service Board
- Gallup, City of
- Highlands University
- Las Cruces, City of
- Las Vegas, City of
- Los Alamos County
- Navajo Indian Nation, Navajo Tribal Council
- New Mexico Bureau of Mines and Mineral Resources
- New Mexico Department of Highways
- New Mexico Environmental Improvement Division
- New Mexico Interstate Stream Commission
- Office of State Engineer
- Pecos River Commission
- Pueblo of Acoma
- Pueblo of Laguna
- Pueblo of Zuni
- Raton, City of
- Rio Grande Compact Commission
- San Juan County
- Santa Fe Metropolitan Water Board
- Santa Rosa, City of
- Vermejo Conservancy District

New York:
- Amherst, Town of, Engineering Department
- Auburn, City of

New York--Continued
Chautauqua County Department of Planning and Development
Cheektowaga, Town of
Cornell University--
Department of Natural Resources
Department of Utilities
Dutchess County Environmental Management Council
Hudson-Black River Regulating District
Monroe County Department of Health
Nassau, County of
Department of Health
Department of Public Works (Bellmore and Mineola)
New York City--
Department of Environmental Protection, Air and Water Resources-Energy
New York State Department of--
Environmental Conservation--
Division of Water
Transportation, Bridge and Construction Bureau
New York State Energy Research and Development Authority
New York State Power Authority
Nyack, Village of, Board of Water Commissioners
Onondaga, County of--
Department of Drainage
Water Authority
Orange County Department of Public Works
Schuyler County
Suffolk, County of--
Department of Health Services
Water Authority
Tompkins County Department of Planning
Ulster County Legislators
Westchester, County of--
Department of Planning
Department of Public Works

North Carolina:
Bethel, Town of
Brevard, City of
Chapel Hill, Town of
Charlotte, City of
Durham City Department of Water Resources
Greensboro City Department of Public Works
Guilford, County Soil and Water Conservation District
Jacksonville, City of
North Carolina State Department of--
Human Resources
Natural Resources and Community Development
Transportation, Division of Highways
North Carolina State University

North Carolina--Continued
Orange County
Orange Water and Sewer Authority
Raleigh, City of
Rocky Mount, City of

North Dakota:
Dickinson, City of
Lower Heart River Water Resources District
North Dakota Geological Survey
North Dakota State University
Oliver County Board of Commissioners
Public Service Commission
State Water Commission

Ohio:
Akron, City of
Canton, City Water Department
Columbus, City of
Eastgate Development and Transportation Agency
Freemont, City of
Geauga County Planning Commission
Lucas County
Miami Conservancy District
Northwood, City of
Ohio Department of--
Natural Resources
Transportation
Ohio Air Quality Development Authority
Ohio Environmental Protection Agency
Ohio State University
Ohio Water Development Authority
Oregon, City of
Richwood, Village of
Ross County
Sandusky County
Seneca Soil and Water District
Williams County
Wood County

Oklahoma:
Ada, City of
Altus, City of
Central Oklahoma Master Conservancy District
Fort Cobb Reservoir Master Conservancy District
Foss Reservoir Master Conservancy District
Lawton, City of
Lugert-Altus Irrigation District
Mountain Park Master Conservancy District
Wood County

Oklahoma--Continued
- Oklahoma City, City of
- Oklahoma Geological Survey, University of Oklahoma
- Oklahoma State Health Department
- Oklahoma Water Resources Board
- Tulsa, City of

Oregon:
- Confederated Tribes of--
  - Umatilla Indian Reservation
  - Warm Springs Indian Reservation
- Coos Bay-North Bend Water Board
- Douglas County Department of Public Works
- Eugene City Water and Electric Board
- McMinnville City Water and Light Department
- Oregon Department of--
  - Fish and Wildlife
  - Transporation, Highway Division
  - Water Resources
- Portland City Water Bureau

Pennsylvania:
- Allentown, City of
- Bethlehem, City of
- Chester County Water Resources Authority
- Delaware River Basin Commission
- Erie County Department of Health
- Harrisburg City Department of Public Works
- Indiana County
- Lancaster County Planning Commission
- Letort Regional Authority
- Media Borough Water Department
- Neshaminy Water Resources Authority
- New York State Department of Environmental Conservation
- Philadelphia City Water Department
- Pennsylvania State--
  - Bureau of Forestry
  - Mining and Reclamation Bureau
  - Office of Resources Management, Bureau of Water Resources Management
  - Topographic and Geologic Survey Bureau
  - Water Quality Management Bureau
- Susquehanna River Basin Commission
- University Area Joint Authority
- Williamsport, City of

Rhode Island:
- Narragansett Bay Water Quality Commission
- New Shoreham, Town of
- Rhode Island State Department of Environmental Management,
  - Division of Water Resources
- State Water Resources Board

South Carolina:
- Charleston Commission of Public Works
- Cooper River Water Users Association
- Grand Strand Water and Sewer Authority
- Myrtle Beach, City of
- Newberry, City of
- South Carolina State--
  - Department of Highways and Public Transportation
  - Geological Survey
  - Health and Environmental Control
  - Public Service Authority
  - Sea Grant Consortium
  - Water Resources Commission
  - Wildlife and Marine Resources Department
- Spartanburg Water System
- Spartanburg Sanitary Sewer District
- University of South Carolina
- Waccamaw Regional Planning and Development Commission
- Western Carolina Regional Sewer Authority

South Dakota:
- East Dakota Water Development District
- Oglala Sioux Tribe
- Rapid City, City of
- Sioux Falls, City of
- Sisston-Wahpeton Sioux Tribe
- South Dakota Department of--
  - Game, Fish, and Parks, Division of Wildlife
  - Transportation
  - Water and Natural Resources--
    - Geological Survey Division
    - Water Rights Division
    - Water Quality Division
- South Dakota School of Mines and Technology
- Watertown, City of
- West Dakota Water Development District

Tennessee:
- Alcoa, City of
- Bartlett, City of
- Benton, Town of
- Dickson, City of
- Eastside Utility District
- German Town, City of
- Government of Nashville and Davidson County
- Hyson Utility District
- Jackson, City of
- Lawrenceburg, City of
- Lincoln County Board of Public Utilities
- Memphis, City of--
  - Light, Gas, and Water Division
  - Public Works Division

Tennessee--Continued
- Murfreesboro Water and Sewer Department
- North Stewart County Utility District
- Shelby County Public Works
- Spring Hill, Town of
- Tennessee Department of--
  - Conservation, Geology Division
  - Health and Environment--
    - Divison of Superfund
    - Office of Groundwater Protection
    - Office of Surface Mining and Reclamation
    - Office of Water Management
  - Transportation, Division of Structures
- Tennessee Tech University
- Tennessee Wildlife Resources Agency
- University of Tennessee, Water Resources Research Center
- Webb Creek Utility District
- West Overton Utility District

Texas:
- Abilene City Water Utilities
- Arlington City Public Utilities
- Austin City Public Works Department
- Bexar-Medina-Atascosa Counties, Water Improvement District No. 1
- Brazos River Authority
- Carrollton, City of
- Coastal Industrial Water Authority
- Colorado River Municipal Water District
- Corpus Christi City Public Works
- Dallas, City of --
  - Public Works
  - Water Utilities
- Dallas-Ft. Worth Airport
- Edwards Underground Water District
- El Paso City Public Service Board
- Fort Bend County
- Fort Stockton, City of
- Franklin County Water District
- Gainesville, City of
- Galveston County
- Garland City Public Works Department
- Georgetown, City of
- Graham, City of
- Greenbelt Municipal and Industrial Water Authority
- Guadalupe-Blanco River Authority
- Harris County Flood Control District
- Harris-Galveston Coastal Subsidence District
- Houston City Public Works Department

Texas--Continued
- Lower Colorado River Authority
- Lower Neches Valley Authority
- Lubbock City Water Utilities
- Nacogdoches, City of
- North Central Texas Municipal Water Authority
- Northeast Texas Municipal Water Authority
- Orange County
- Pecos River Commission
- Red Bluff Water Power Control District
- Runaway Bay, City of
- Sabine River Authority
- Sabine River Compact Administration
- San Angelo, City of
- San Antonio, City of--
  - Department of Environmental Management
  - Public Service Board
  - Water Board
- San Antonio River Authority
- San Jacinto River Authority
- Tarrant County Water Control and Improvement District No. 1
- Texas --
  - Department of Highways
  - Water Commission
  - Water Development Board
- Titus County Fresh Water Supply District No. 1
- Trinity River Authority
- Upper Guadalupe River Authority
- Upper Neches River Municipal Waste Authority
- Upper Trinity Basin Water Quality Compact
- West Central Texas Municipal Water District
- Wichita County Water Improvement District No. 2
- Wichita Falls City Public Works

Utah:
- Bear River Commission
- Salt Lake, County of--
  - Board of County Commissioners
  - Division of Flood Control and Water Quality
- Utah Department of--
  - Health --
    - Division of Environmental Health
  - Natural Resources--
    - Oil, Gas, and Mining Division
    - Water Resources Division
    - Water Rights Division
    - Wildlife Resources Division
  - Transportation
- Utah Geological and Mineral Survey

Vermont:
Vermont Department of--
Water Resources and Environmental Engineering

Virginia:
Accomack County
Alexandria City Department of Transportation and Environmental Services
Clarke, County of
James City, County of--
Department of Public Works
Service Authority
Lord Fairfax Planning District Commission
Newport News City Department of Public Utilities
Northampton County
Northern Virginia Planning District Commission
Prince William Health District
Roanoke City Utilities and Operations
Southeastern Public Service Authority of Virginia
Southeastern Virginia Planning District Commission
University of Virginia, Department of Environmental Sciences
Virginia Beach, City of
Virginia Commonwealth University
Virginia Department of--
Highways and Transportation
Mines, Minerals and Energy--
Division of Mined Land Reclamation
Williamsburg, City of
York County

Washington:
Bellevue City Public Works Department
Centralia City Light Department
Chelan County Public Utilities District #1
Cowlitz County Board of Commissioners
Douglas County Public Utilities District #1
Hoh Indian Tribe
King County Department of Public Works
Lewis County Board of Commissioners
Municipality of Metropolitan Seattle
Pend Oreille County
Pierce County Department of Emergency Management
Public Utility District No. 1 of Kitsap County
Pullman, City of
Puyallup Indian Nation
Quinault Indian Business Committee
San Juan County Board of Commissioners
Seattle, City of--
Department of Lighting
Department of Parks and Recreation
Skagit County Department of Public Works
Snohomish County
South King County Regional Water Association

Washington--Continued
Tacoma, City of--
Public Works Department
Washington Department of--
Ecology
Emergency Management
Fisheries
Natural Resources
Transportation
Whatcom County Department of Public Works
Yakima Tribal Council

West Virginia:
Marshall County Commission
Morgantown City Water Commission
Office of Community and Industrial Development
Washington Public Service District
West Virginia Department of--
Energy
Highways
Natural Resources--
Division of Water Resources
West Virginia Geological and Economic Survey

Wisconsin:
Bad River Tribal Council
Beaver Dam, City of
Chippewa County Land Conservation Department
Dane, County of--
Department of Public Works
Regional Planning Commission
Delavan Lake Sanitary District
Delavan, Town of
Fond du Lac, City of
Forest County Potawatomi Community
Fowler Lake Management District
Fox Valley Water Quality Planning Agency
Green Lake Sanitary District
Hillsboro, City of
Hills Lake Management District
Lac Courte Oreilles Governing Board
Little Muskego Lake District
Madison Metropolitan Sewage District
Medford, City of
Menominee Indian Tribe of Wisconsin
Middletown, City of
Morris Lake Management District
Noquebay Lake District
Norway - Wind Lake, Town of
Ocohomowoc Lake, Village of
Okauchee Lake Management District
Oneida Tribe of Indians

Wisconsin--Continued
- Park Lake Management District
- Peshtigo, City of
- Powers Lake, District of
- Rock County
- Sand Lake, Town of
- Slinger Village Wastewater Treatment Plant
- St. Croix Tribal Council
- Southeastern Wisconsin Regional Planning Commission
- Stockbridge - Munsee Tribal Council
- Thorp, City of
- University of Wisconsin -- Extension, Geological and Natural History Survey
- Waupun, City of
- Wisconsin Department of--
  - Natural Resources
  - Transportation --
    - Division of Highways
- Wolf Lake Management District

Wyoming:
- Cheyenne, City of
- Evanston, City of
- Sublette County
- Uinta County County Commissioners
- Wyoming Department of--
  - Agriculture
  - Economic Planning and Stabilization Board
  - Environmental Quality
  - Highways

Wyoming--Continued
- Wyoming State --
  - Attorney General
  - State Engineer
  - Water Development Commission
  - Water Research Center

Commonwealth and Territories:
- Government of --
  - American Samoa
  - Guam
  - Northern Mariana Islands
- Federated States of Micronesia--
  - Kosrae
  - Pohnpei
  - Truk
  - Yap
- Puerto Rico:
  - Aqueduct and Sewer Authority
  - Electric Power Authority
  - Environmental Quality Board
  - Industrial Development Company
- Puerto Rico Department of--
  - Agriculture
  - Natural Resources
  - Transportation and Public Works
- University of Puerto Rico, Center for Energy and Environmental Research
- Republic of Palau

★ U.S. GOVERNMENT PRINTING OFFICE: 1988—201-985/83959