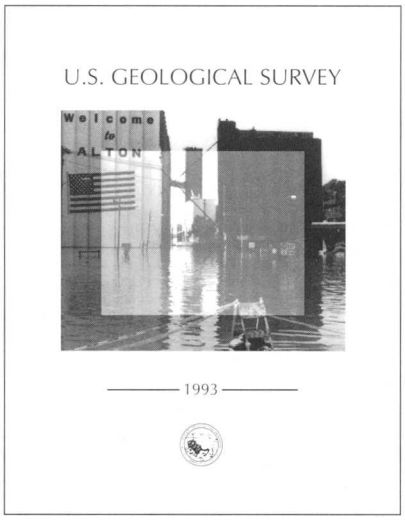
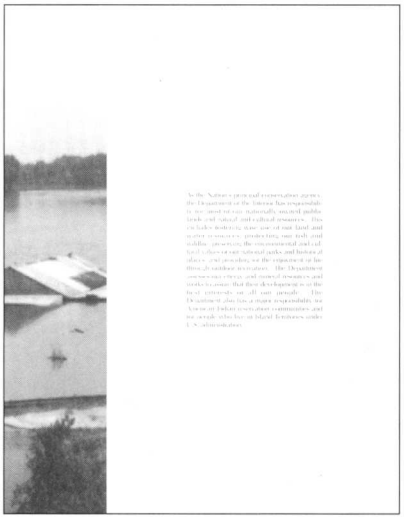
U.S. GEOLOGICAL SURVEY

1993



Front Cover: Downtown Alton, Ill., in the midst of the Mississippi River flood of 1993. USGS hydrologists measured Mississippi River waters in flood stage at 42 sites on 33 streams in the Mississippi basin, in seven of the nine States that were affected by the flood. Other aspects of the flood being studied by USGS hydrologists include structural impacts of the flood on several bridges, concentrations and loads of agricultural chemicals and their impact on water quality, cutoff of a meander at Miller City, Ill., sediment concentrations and loads, and impacts of reservoirs on peak flows.



Back cover: Farm building under water just west of the canal that bypasses, on the Illinois side, the Chain of Rocks segment of the Mississippi River north of St. Louis, Mo.

Design and layout by
Maura Jean Hogan, 1993.

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U.S. Geological Survey Yearbook Fiscal Year 1993

At Work Across the Nation

U.S. DEPARTMENT OF THE INTERIOR
BRUCE BABBITT, *Secretary*

U.S. GEOLOGICAL SURVEY
Robert M. Hirsch *Acting Director*

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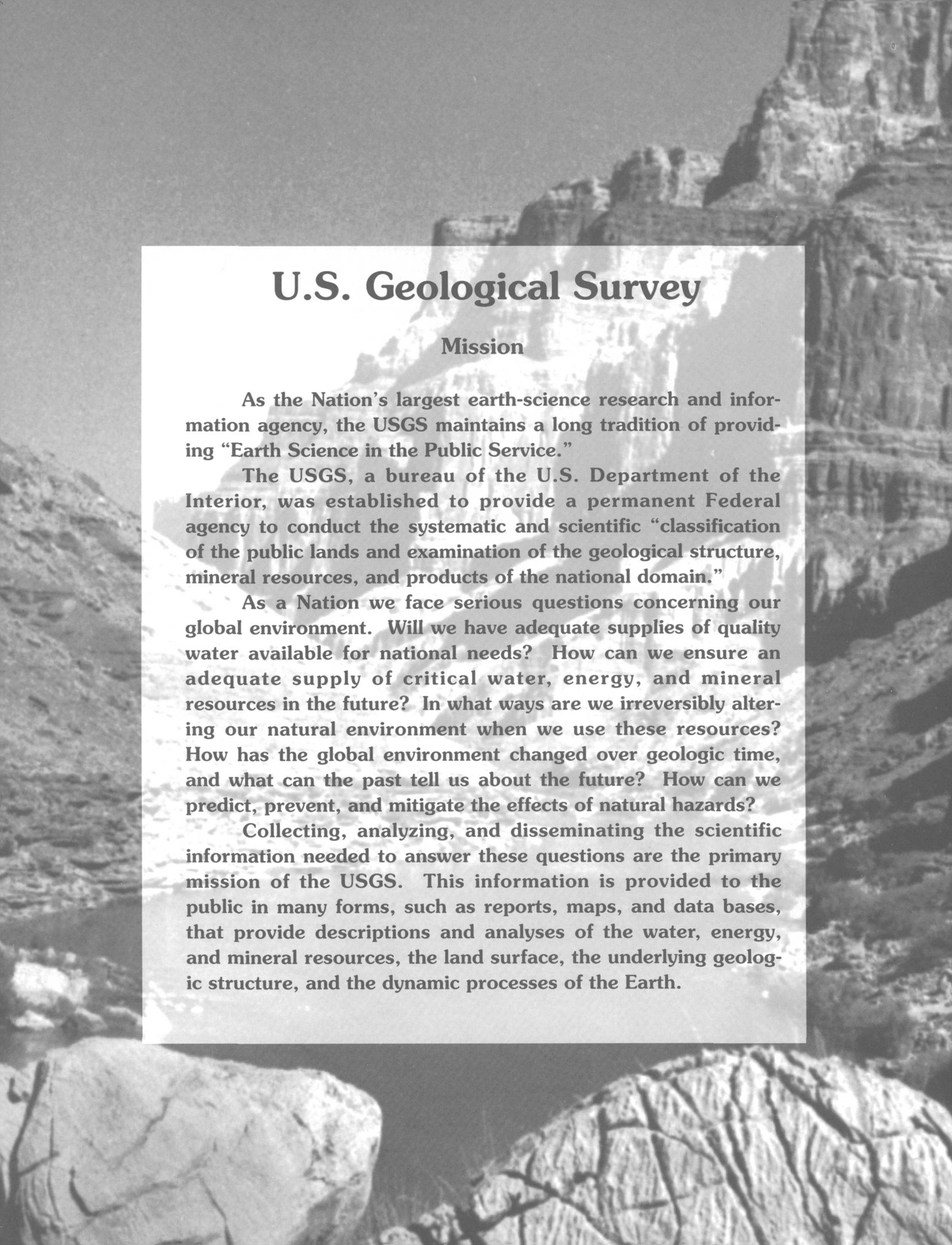


U.S. Geological Survey

Mission

As the Nation's largest earth-science research and information agency, the USGS maintains a long tradition of providing "Earth Science in the Public Service."

The USGS, a bureau of the U.S. Department of the Interior, was established to provide a permanent Federal agency to conduct the systematic and scientific "classification of the public lands and examination of the geological structure, mineral resources, and products of the national domain."

As a Nation we face serious questions concerning our global environment. Will we have adequate supplies of quality water available for national needs? How can we ensure an adequate supply of critical water, energy, and mineral resources in the future? In what ways are we irreversibly altering our natural environment when we use these resources? How has the global environment changed over geologic time, and what can the past tell us about the future? How can we predict, prevent, and mitigate the effects of natural hazards?

Collecting, analyzing, and disseminating the scientific information needed to answer these questions are the primary mission of the USGS. This information is provided to the public in many forms, such as reports, maps, and data bases, that provide descriptions and analyses of the water, energy, and mineral resources, the land surface, the underlying geologic structure, and the dynamic processes of the Earth.

Message from the Acting Director

The need for earth science has never been more paramount. The devastating flooding of the Mississippi River this past year, strikingly portrayed on the cover and discussed in detail in this report (p. 37–42), was a sobering reminder of nature's elemental power. As a Nation, we face many environmental and economic challenges, such as natural hazards, that can be addressed effectively only through science. Water quality, resource assessments, climate change, and toxic wastes are all critical issues that can best be dealt with when approached from a sound scientific base. The goal of the U.S. Geological Survey is to provide hydrologic, geologic, and topographic information and understanding that contribute to the wise management of the Nation's natural resources and that promote the health, safety, and well-being of all Americans. FY 1993 has proven to be a particularly challenging one for the USGS. We entered into a time of transition from the long-term leadership of Director Dallas Peck and Associate Director Doyle Frederick to the appointment of a new director. We thank Dallas and Doyle for their many years of service and for their support during the transition.

As part of our transition efforts, we established a team of employees to examine USGS organization and programs and to develop a range of options for the incoming director. That team developed a revitalized vision for the USGS that will, under the guidance of our new director, move us positively and creatively into the 21st century. The vision of the transition team is that the USGS will continue its leadership in earth science for sustained global health, welfare, and prosperity. While the transition team was undertaking its important task, the dedicated employees of the USGS continued working diligently to address the many scientific challenges before them.

Much scientific good news from recent years came to fruition in many areas this fiscal year. The initiation of the National Water Quality Assessment program in 1986 signaled a profound change in our approach to water-quality studies. This perennial effort will give managers and policymakers consistent information on the status and trends of the quality of the Nation's vital water resources. This year we designated 20 new study units in 36 States for the second leg of what will ultimately be 60 study units that, in aggregate, will provide us with an overview of water quality in many of the Nation's most important river basins and aquifers. This year also saw the release of early findings from the National Synthesis component of the NAWQA Program. In response to questions raised during reauthorization hearings for the Clean Water Act, the NAWQA Program provided information on the magnitude and extent of point and nonpoint sources of contamination in different parts of the Nation and their relations to different natural and human factors (p. 48,49). The results are an example of the type of information that NAWQA is providing that will be useful for making decisions about water-quality policies and programs at the national level.

We have moved aggressively into digital mapping and are making critical strides in building the National Spatial Data Infrastructure (p. 4–6), a key component of the information superhighway envisioned by Vice President Gore. Through our long-standing partnerships throughout the mapping world, we have been at the forefront of the transition from traditional paper maps to the exciting vistas of computer-generated maps.

We are reaping continued benefits from our intensive effort to map and explore the near-shore and offshore sea floor of the continental United States and the U.S. Exclusive Economic Zone. Boston Harbor, cited by the Environmental Protection Agency as the most contaminated harbor in the country, is benefiting from a cleanup effort that has as a key element scientific information from the USGS on the transport and accumulation of contaminated sediments in the bay area (p. 17–19). This type of information will be needed as the Nation deals with many coastal areas where the discharge of wastes into the ocean presents serious environmental and economic consequences.

In global change research, we are looking at the global carbon cycle and trying to determine the sources and sinks of this critical component in global climate and ecosystems. A key aspect of our global change research is reconstructing past climate "snapshots" in order to have a basis for distinguishing those changes caused by human activities from those caused by natural climate variation (p. 60–65). Reconstruction of these paleoclimates give scientists the means to test their climate models and improve their ability to predict future climate change.

These highlights are only a few of our many accomplishments during the past fiscal year. The year also saw the publication of the first standard USGS map produced by using fully automated computer technology. We developed a framework for assessing the economic benefits of new geologic map information in making land-management decisions. The EROS Data Center in Sioux Falls, S.Dak., which holds more than 2 million satellite images, was designated as the world data center for satellite images by the International Council of Scientific Unions. We identified high concentrations of agricultural chemicals in the Mississippi River in the aftermath of the river's historic flooding, which dispelled previous notions about the dilution of herbicides in a large river system. Water managers in the Delaware River basin area are now using USGS information on the potential impacts of climate change on the river basin to more effectively balance water-supply storage against the movement of the salt front in the Delaware River. In conjunction with the National Science Foundation and the University of Colorado, we now operate the Nation's only ice-core repository in Denver, Colo., where scientists store and examine glacier ice to unlock information about ancient climates.

We are poised at a crucial and exciting threshold. Just as the need for science has never been more paramount, so, too, is the need to work effectively with other organizations to ensure that we meet the needs of the customers we serve, be they another government entity, an academic institution, or the public, whose taxes pay for our programs. The underlying theme of this annual report is that the USGS is at work across the Nation and around the world, conducting cooperative research and investigations in the earth sciences and disseminating traditional and innovative information products. Without the more than 1,200 other Federal, State, and local agencies that are our cooperators, the hundreds of academic institutions with which we interact each year, and the millions of people who rely on the USGS for maps, reports, data, and information, we would not and could not exist.

It has been my personal and professional pleasure to serve as Acting Director of the U.S. Geological Survey. It has been my good fortune to have had a very able Acting Associate Director, Bonnie McGregor, to share with me in the challenges and rewards of leading the USGS during the last 6 months. I have been repeatedly impressed with the breadth and caliber of science that is the constant climate of the USGS, and I commend each and every employee for their dedication. In concert with our many cooperators and colleagues, we are each day at work at the fundamental business of understanding our Earth and communicating that understanding to the public we serve. We look forward to the completion of the transition to new leadership for the USGS and to our continued commitment to provide the scientific foundation to help the Nation make wise decisions that provide for a safe environment and a strong economy. Enjoy reading the accomplishments of this, our 114th year of providing "earth science in the public service."

Robert M. Hirsch

Robert M. Hirsch
Acting Director, U.S. Geological Survey

[Editor's note: Gordon P. Eaton was sworn in as the 12th Director of the U.S. Geological Survey by Secretary of the Interior Bruce Babbitt on March 14, 1994.]

At Work Across the Nation in Mapping Activities

Mission

Through its National Mapping Program, the USGS provides accurate and up-to-date basic cartographic information for the United States in forms that can be readily applied to present-day problems. Maps, digital data, aerial photographs, satellite images, and geodetic control information represent some of the cartographic products available. Topographic maps at various scales, which illustrate detailed and precisely referenced information about natural and manmade features on the Earth's surface, continue to be important products.

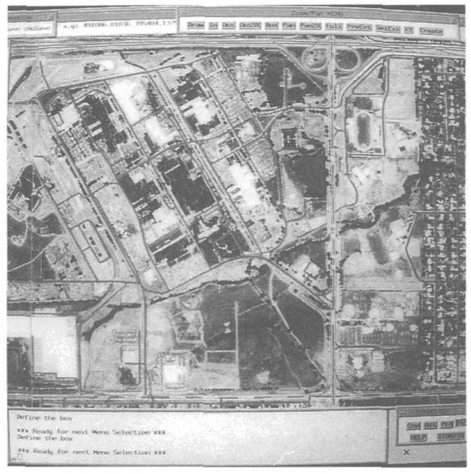
These maps provide basic cartographic information that is needed by Federal, State, and local government agencies in dealing with key issues ranging from satisfying energy demands to conserving natural resources, from identifying environmental problems to developing acceptable solutions, and from locating commercial facilities to designing public works.

In addition to maps, cartographic data in computer-readable form are becoming increasingly important. These data are used in computer-based resource and geographic information systems to evaluate alternative management plans and to study the effects of different management policies.

National Map and Digital Data Production

The USGS continues to fulfill its responsibility to produce, revise, and distribute America's topographic maps, which are available to the public through a national network of earth-science information offices and over 3,000 commercial map dealers. The recent explosive growth of geographic information system (GIS) technology has placed unprecedented demands on the USGS for map data in computer-readable files. To accelerate the creation of a national, electronically retrievable cartographic data base, the USGS is working in partnership arrangements with public and private organizations to reduce Federal data-acquisition costs, minimize duplication of effort, and share "coverage," as in the mapping of a specific State.

Although certain segments of the public will always need printed maps (for example, recreational users, small businesses, and local government offices), demand will increase for specific types of USGS cartographic data in computer-readable formats. For example, aerial photographs used in map revision are electronically scanned, combined with digital terrain elevation data, and corrected for feature displacements due to variations in land elevation. Known as digital orthophotoquads, these information-age tools have significantly shortened the USGS map-making and map-revision cycles and are drawing substantial interest from GIS users. Other computer-data products available from the USGS include digital files of map lines, elevation, land use and land cover, and geographic names.



Digital image of the Denver Federal Center.

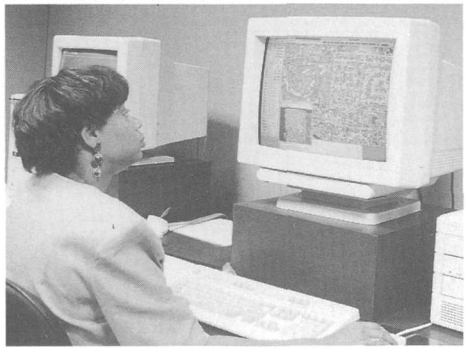
Map Revision and Product Generation

Providing the public with the fundamental topographic mapping information required to inventory, analyze, and develop informed plans concerning the Nation's lands and natural resources is a primary mission of the USGS. Primary topographic mapping products depict transportation routes, surface hydrography, terrain data, cultural features, and boundary and Public Land Survey System (PLSS) information, all of which are vital data for a variety of planning and management applications. The USGS's topographic maps and resulting digital line graphs are the most comprehensive set of base cartographic information available to the Nation's resource managers and scientific community.

In response to the exponential growth in demand for its products, the USGS has developed a three-pronged approach to meeting the diverse needs of its customers:

- Printed maps: The traditional map user remains a valued customer. The USGS sold approximately 5.5 million maps during FY 1993. Demand should remain stable into the 21st century.
- Digital line graphs (DLG): DLG's are topographic maps in digital form and reflect the same level of information shown on printed maps. DLG's are often the foundation on which geographic information system (GIS) users orient other types of data.
- Digital orthophoto quadrangles (DOQ): The goals of the National Aerial Photography Program (NAPP) are to complete conterminous aerial photographic coverage of the United States and to provide cyclic updates every 5 years. The DOQ process brings spatially corrected photographic images acquired by the NAPP into computers, where the data can be combined with other digital map data (such as roads, boundaries, and hydrography). DOQ's provide an economic,

The Public Land Survey System (PLSS) was established by the Second Continental Congress in 1785 to facilitate the orderly settlement of that part of the United States acquired by the Federal Government by cession from the States, by treaty, and by purchase. The PLSS currently provides the basic ownership (cadastral) reference system for all States except for 18 Eastern States, Texas, and Hawaii. Public lands are subdivided by a rectangular system of surveys established and regulated by the Bureau of Land Management. The standard format for subdivision is by townships measuring 6 miles on a side; townships are further subdivided into 36 1-mile-square numbered sections.



A CTL staffer at work in the Cartographic Technology Laboratory.

high-resolution image base for use in map revision.

A major revision program known as the digital revision and product generation (RevPG) system will provide current, reliable information to its users. The primary components of the system are customized commercial GIS software and distributed workstation technologies.

During FY 1993, the RevPG system was used to revise the first topographic maps that used DOQ's as the primary source of information. The RevPG process provides users with a DOQ on which to delineate discipline-specific information. It creates updated DLG's for the National Digital Cartographic Data Base, which are valuable for the spatial integrity and multiple-user versatility that they provide, and can also be used to produce an updated printed map from the revised DLG's. The RevPG process provides a mechanism through which the Nation's spatial data user community can acquire cartographic information in an effective, efficient manner.

Randle W. Olsen
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Cartographic Technology Laboratory Opens

The Cartographic Technology Laboratory (CTL) opened in April 1993 to enable USGS cartographers and researchers to develop advanced digital cartographic production processes and applications. Located in the National Center in Reston, Va., the CTL houses the latest in digital cartographic hardware and software.

The CTL promotes mapping research and modernization efforts by pursuing advanced developmental and applications projects in spatial data collection and analysis. Projects currently under development include the National Advanced Remote Sensing and Applications Project, an exhibit of USGS data sets for the Washington, D.C., area, and three-dimensional visualization of the Earth's surface.

The CTL supports research and development in image-processing techniques, digital revision, product generation, digital line graph-enhanced data format, softcopy stereo extraction and analysis, land-use and land-cover production, evaluation of other mapping organization digital spatial data, and geographic information systems applications. The CTL also supports production activities of the Mapping Applications Center.

The CTL staff demonstrates software and production techniques developed by the USGS and makes commercial software and data products available for use. These products range from software available on personal computers to those used on complex workstations.

The CTL provides briefings and demonstrations of production capabilities and developmental activities to visitors and employees. In 1993, visitors to the

The Mapping Applications Center, one of five such centers in the USGS, manages the National Digital Cartographic Data Base and the National Mapping Program's map printing operations, using advanced technology to create new map production techniques, processes, and products.

CTL came from the Department of the Interior, other Federal agencies, State and local governments, universities, and the private sector. International mapping agency representatives from more than 10 countries also visited the CTL.

Another feature of the CTL is the "Demonstration of the Week," at which different products and projects are displayed and demonstrated. These short, informal demonstrations are open to all USGS employees. The most popular demonstrations in 1993 were the Softcopy stereo workstation, the digital line graph-enhanced production system, the Orange County, Calif., fly-through, and the revision and product generation system.

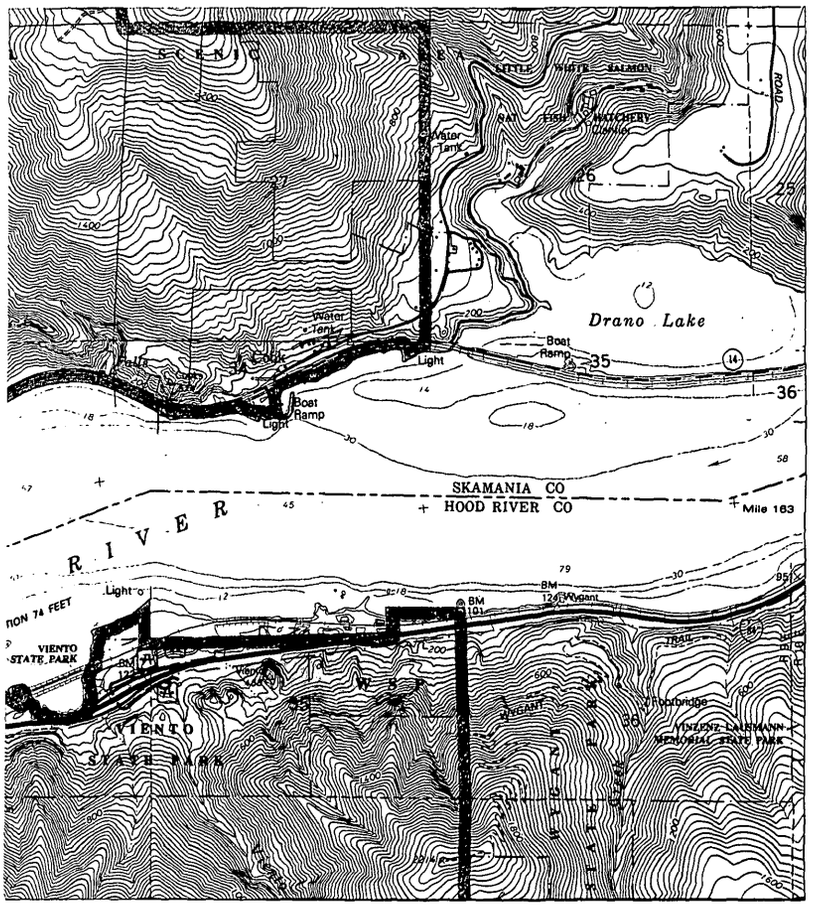
Paul M. Young

is a cartographer who has been with the USGS since 1986 developing new computer systems and production techniques used in the collection of digital cartographic data

Forest Service and the USGS Join Efforts to Produce a Single-Edition Map

A new map of the Mt. Defiance area of Oregon and Washington is the first of an agreed-upon series of 1:24,000-scale maps that, in addition to portraying the usual information shown on USGS maps, highlights areas containing national forest lands. This single-edition map was produced under the provisions of an interagency agreement between the USGS and the U.S. Forest Service (USFS).

The 1:24,000-scale (1 inch=2,000 feet) Mt. Defiance map shows areas straddling the Columbia River, including the Gifford Pinchot National Forest to the north and the Mt. Hood National Forest to the south. The Mt. Defiance map portrays traditional USGS map features such as roads and trails, streams and lakes, cultural features, contours, boundaries, geographic names, and Public Land Survey section lines and numbers. It also portrays USFS road classifications, which distinguish among paved, gravel, and dirt improved roads; private or local government-owned lands within USFS boundaries; designated numbering of USFS roads; more detailed USFS administrative boundaries; and international



This map is an excerpt from the first primary-series topographic quadrangle map to be produced under an interagency agreement between the USGS and the USFS that results in a single-edition map meeting the needs of both agencies. The USFS and the USGS are cooperating in the revision of full-color primary-series topographic maps that use common product standards for format, accuracy, content, and symbolization.

The USGS is responsible for producing topographic maps and digital data throughout the United States. In the 48 contiguous States and Hawaii, the USGS produces primary-series 7.5-minute 1:24,000-scale topographic maps and associated digital line graph data. In Alaska, the primary series maps are produced in the 15-minute format at 1:63,360 scale.

For more information about the CTL, contact:

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U.S. Geological Survey
Reston, VA 22092

symbols for selected features such as trailheads, picnic areas, and campgrounds.

This jointly produced map series reduces duplication of efforts between the agencies. In addition, traditional users of USGS maps should find the additional features useful for recreational purposes. The road classification system will allow people to decide, for example, whether to take a passenger car into remote areas. The detailed road numbering will aid in location with respect to the map. Shaded inholdings indicate potential access restrictions on assumed public lands. International symbols highlight recreational facilities or other points of interest.

Traditional customers of USFS versions of the maps will find the multicolored lithographed maps to be more useful than typical black-and-white reproductions. In addition, the maps will be available from USGS map sales outlets, including the network of official USGS map dealers located near most of the national forests.

For more information about the USGS-USFS joint effort, contact:

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Research and Technology

Cartographic and geographic research supports the day-to-day operations of the National Mapping Program, from data collection to map and digital data production, which entails designing and developing advanced mapping technology needed for creating and updating mapping products. New technologies that are explored and evaluated may enhance and improve the efficiency of the production process.

Geographic and spatial information analysis is the applied research function that addresses analytical techniques and applications of data in geographic information systems (GIS) to support land, natural resource, and natural hazards management. Research conducted to develop and test new and innovative theories and techniques to manage spatial data includes investigating new methods for modeling, analyzing, and visualizing spatial data in GIS's and in automated cartography, image processing, and land characterization.

The USGS coordinates the National Mapping Program at the Federal and State levels, including remote-sensing activities and development and promulgation of cartographic and earth-science data standards that enable multipurpose use and exchange of digital cartographic data. Governmentwide leadership in ensuring coordinated planning and execution of Federal mapping efforts is carried out through the Federal Geographic Data Committee, chaired by the USGS. [Editor's note: In FY 1994, the Secretary of the Interior assumed chairmanship of the committee.]

Building the National Spatial Data Infrastructure and Fostering Partnerships

Geographic data sets can be used to help rebuild the Nation's infrastructure. Working cooperatively, more than 95 Federal agencies use geographic data in applications such as managing land ownership and use, locating sites from which to provide services, routing vehicles, maintaining public works, and marketing resources and products.

The Office of Management and Budget has called for "development of a national digital spatial information resource, with the involvement of Federal, State, and local governments, and the private sector." This information resource has become known as the national spatial data infrastructure or NSDI.

The Office of Management and Budget's Circular A–16 provides a framework for Federal leadership in developing the NSDI. The circular also establishes the Federal Geographic Data Committee (FGDC) to promote the coordinated development and dissemination of geographic data. The FGDC is working in four areas: linking communities, developing common procedures, creating partnerships, and developing a long-term strategic plan. Different Federal agencies lead coordination activities for 10 specific categories of data.

For example, the U.S. Forest Service (USFS) of the U.S. Department of Agriculture is responsible for vegetation data, and the USGS is responsible for base cartographic and geologic data.

As this plan develops, standards are needed to improve the effectiveness with which geographic data users communicate and share data. The FGDC is working on standards in three areas: metadata (information for documenting data), transfer (the Spatial Data Transfer Standard) (see p. 7), and data content. Several partnership programs are underway within the National Mapping Program to expand the resource base for cartographic data.

One critical aspect of NSDI will be a first-ever, comprehensive data base of Federal land ownership. A major cooperative effort is underway among Federal and State agencies to provide a nationwide data base of Federal land ownership information for quick analyses and emergency preparedness. The data are being compiled at 1:2,000,000 scale (1 inch=32 miles). Many Federal and State agencies are contributing information to update and expand the information in the existing 1:2,000,000-scale digital line graph (DLG) series. Transportation information is being supplied by State departments of transportation, the Department of Transportation's National Highway Planning Network Database, and the Federal Railroad Administration. Hydrologic information is being provided by the USGS and the U.S. Army Corps of Engineers. All Federal agencies are contributing information in a variety of formats (data bases, maps, plats, annotated charts) to delineate their land holdings or administrative responsibilities. The USGS will compile this information and plans to complete the 1:2,000,000-scale Federal lands data base by the end of FY 1994.

Another area of rapidly expanding cooperation within the Federal Government—and with State and local agencies—has been the relatively new national digital orthophotography program. Four Federal agencies—the USGS, the Soil Conservation Service, the Agricultural Stabilization and Conservation Service, and the USFS—have formed a partnership to assemble a nationwide data base of digital orthophoto quadrangles (DOQ). One interesting development of the new program is the extent of user interest that has blossomed among State agencies. Initially proposed by the USGS to Federal land management agencies, the program immediately attracted the interest of similar State agencies and has grown from $350,000 in FY 1990 to current estimates of $5 million in cooperative funding during FY 1994. In addition to providing funding support, many States have independently produced DOQ's for their own needs and are seeking to contribute those products to the USGS National Mapping Program.

The Federal partnership aspect of the DOQ program was developed by using the National Aerial Photography Program (NAPP) as a guide. A steering committee made up of members from the Departments of Agriculture and Interior and the Tennessee Valley Authority guides the program overall. The USGS administers the NAPP under the joint committee's direction. In addition to the Federal partnership, many State contributions to the NAPP over the years have increased the number of photographs collected each year. The USGS expects similar results from the DOQ program, in which State contributions are expected to

ACTION: ***In partnership with State and local governments and private companies, we will create a National Spatial Data Infrastructure.***

Dozens of agencies collect spatial data—for example, geophysical, environmental, land use, and transportation data. They spend $1 billion to $3 billion a year on these efforts. The Administration will develop a National Spatial Data Infrastructure (NSDI) to integrate all of these data sources into a single digital resource accessible to anyone who has a personal computer. This resource will help land developers and conservationists, transportation planners and those concerned with mineral resources, and farmers and city water departments.

Because of the value of the data, it will be possible to attract private-sector funding for their collection, processing, and distribution. The Federal Geographic Data Committee, which operates under the auspices of the Office of Management and Budget, plans to raise enough non-Federal funding to pay for at least 50 percent of the project's costs. It will set the standards for data collection and processing by all agencies to ensure that the NSDI can be developed as economically as possible.

—From Red Tape to Results: Creating A Government That Works Better & Costs Less: Report of the National Performance Review
By Vice President Al Gore

Digital line graph (DLG): A selected category of base cartographic data in a topologically structured vector format; includes transportation networks, elevation contours, boundaries, and cultural features.

Digital elevation model (DEM): An array of elevations, usually at regularly spaced intervals, for a number of ground positions; shows three-dimensional differences in elevations of the Earth's surface.

Digital orthophoto quadrangle (DOQ): A raster-scanned aerial photograph, orthographically rectified to remove distortions caused by camera height and angle and by terrain; has the same geometric fidelity as a map.

more than double the volume of DOQ production that would have been produced solely through Federal appropriations in FY 1994.

State contributions are expected to more than double the volume of DOQ production. . .

Innovative partnerships are another mechanism receiving considerable attention. Such partnerships are opportunities for the USGS to acquire digital cartographic data for the public domain from entities such as public utilities and land management organizations, which are collecting data independently for their own purposes. Through these partnerships, the USGS could supplement other organizations' data collection activities and thereby bring those data into conformance with national standards. If data have already been collected, the USGS may acquire data that can be modified to meet national standards. USGS Program Announcement #7885 (released December 18, 1992) solicited technical and cost proposals for cooperative DLG production from non-Federal agencies and private firms that collect base-category data from USGS primary-scale maps to meet their own needs. After comprehensive technical evaluations and program negotiations, three organizations have entered into partnerships totaling nearly $500,000 of support. An expanded program announcement (#8039) for FY 1994 entertains proposals for cooperative production of digital elevation model (DEM) and DOQ data in addition to DLG's and makes provision for the USGS to evaluate existing digital elevation data and DOQ's for possible inclusion in the NSDI.

Since its inception, the USGS has had cooperative agreements with other organizations, including States and local governments. Traditionally, these agreements have been cost-sharing arrangements in which the other agency contributed 50 percent of the cost and the USGS performed the work. State contributions declined during the late 1980's, partly as a reflection of the approaching completion of once-over coverage of the Nation by primary-scale maps. However, contributions have been steadily rising since 1990, owing largely to increasing State interest in digital data production. In FY 1993, agreements with 30 States produced nearly $3 million in cooperative funding.

The USGS expects to expand its partnerships and innovative relationships in the development of the NSDI. Sharing data and the resources to convert those data into maps and digital products is crucial to supporting the escalating demand for spatial data products. Partnerships offer the best chance for maintaining quality standards, responding to user needs, and expanding the base cartographic data in the NSDI.

Michael A. Kelley
is responsible for the planning and management of map and digital data production in the National Mapping Division

Michael A. Domaratz
is executive secretary of the Federal Geographic Data Committee, an interagency group working with the non-Federal community to establish the NSDI

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Coordination and Standards

Do You Know Your Seven-Digit FIPS Code?

The tenth update to the Federal Information Processing Standard (FIPS) 55 file was completed during the fall of 1993. The file, entitled "Codes for Named Populated Places, Primary County Divisions and Other Locational Entities of the United States, Its Posessions, and Associated Areas," provides a unique seven-digit code for approximately 195,800 populated places, townships, American Indian-Alaska Native areas, census county divisions, census-designated areas, and other locational entities of the 50 States, the District of Columbia, and outlying areas. This code consists of a two-digit numeric FIPS State code (as specified in FIPS 5) and a five-digit numeric FIPS place code.

Some of the data included for each entity in the file (in addition to its name and FIPS State and place codes) are the State postal abbreviation, the name and

FIPS 6 code for each county in which the entity is located, a class code that identifies the type of entity, the ZIP code, and a cross reference to the code issued by the U.S. General Services Administration. The "part of code" and "other name code" fields provide identification of relationships among entities.

Additional data are included for each entity that represents a county, primary county division, incorporated place, census-designated place, or American Indian-Alaska Native area. For these entities, the congressional district in which each is located is identified; the area is shown for any entity located in a metropolitan statistical area or primary statistical area. The code assigned by the U.S. Bureau of the Census is listed for incorporated places, census-designated places, and American Indian-Alaska Native area.

The data are used in a variety of applications, including public and private accounting and procurement systems, and are available for a fee in hard copy or on magnetic tape as FIPS Publication 55–3 from the National Technical Information Service.

Key to Sharing Digital Data

An essential component of data sharing is a mechanism by which data can be transferred from one computer system to another without distortion or loss. The Spatial Data Transfer Standard (SDTS), being coordinated and promoted by the USGS at the direction of the National Institute of Standards and Technology (NIST), provides just such a mechanism. The standard consists of specifications for the organization and structure of digital data transfer, definitions of spatial features and attributes, and encoding instructions for data transfer.

The SDTS was approved in July 1992 as FIPS 173. Effective February 15, 1993, the SDTS became mandatory for Federal agencies 1 year from that date. The SDTS is also available for use by State and local governments and the private sector. Efforts are now underway to approve FIPS 173 as an American National Standards Institute (ANSI) standard. The USGS is actively promoting the use of the SDTS by conducting workshops and training, as well as by developing practical user guides and software, a spatial feature and attribute dictionary, and a spatial data transfer processor.

Effective February 15, 1993, the SDTS became mandatory for Federal agencies 1 year from that date.

As with all FIPS, the SDTS now enters a required 5-year maintenance cycle. During this cycle, the USGS will provide the capability for the spatial data community to review the contents of the SDTS in order to suggest changes to the standard. The SDTS has a modular design that allows modifications and enhancements to be made with relative ease.

The SDTS is implemented through the use of profiles, or subsets, of the SDTS designed to handle a specific type of data. Defining a profile allows the elimination of numerous options and thus simplifies the encoding and decoding process. The first of these profiles is the Topological Vector Profile (TVP), which will standardize the distribution of topologically structural vector data, one of the more common types of spatial data currently created by Federal agencies. Two prominent data sets covered by this profile are the U.S. Bureau of the Census TIGER data and USGS digital line graphs (DLG). The TVP was finalized in 1992 and forwarded to NIST for approval as a new part of FIPS 173 in February 1993. A second SDTS subset, the Raster Profile, is currently in a test and demonstration period to allow the user community to evaluate and comment on its contents. This profile was forwarded to NIST for approval as another part of FIPS 173 by the end of 1993.

Additional profiles being considered for development include one for network data structures, one for computer-aided design/computer-aided manufacturing (CAD/CAM) graphics, and one for data that replace or modify an existing data

	Topological Vector Profile (TVP)	Georeferenced Raster Profile (GRP)
Status	NIST formal review period ended October 25, 1993	Test period ended November 19, 1993
Data structure	Vector	Raster
Spatial objects	Points Nodes Chains Polygons	Pixels Grid cells
Characteristics	Full-area topology Coordinates limited to geographic, Universal Transverse Mercator, or State Plane	Supports image compression Data must be georeferenced
Examples of supported data	DLG–3 DLG–E TIGER GRASS ARC/INFO	DEM Images DOQ Grids

set (a "transaction" profile). The USGS is actively working with States and local communities to identify requirements for SDTS profiles to support municipal and utility requirements. Information for profile development needs is being requested from State and local governments and the private sector through professional societies.

User guides and other training materials for the SDTS are currently being developed to increase knowledge and understanding of the SDTS within the user community. The USGS will use these materials in workshops and other presentations to promote the use of the SDTS.

Although the vendor community will play a large role in software development, the USGS is producing publicly available software tools to support encoding and decoding of SDTS data. The first of these tools—as ISO 8211/FIPS 123 Function Library—is already available. In addition, the USGS is designing a processing system to support SDTS transfers of its own digital spatial data, such as DLG's and digital elevation models. DLG data will be made available in the SDTS TVP by January 1994.

The SDTS contains a standard model for a spatial features data dictionary as well as a list of terms and definitions for entities and attributes. The features and attributes glossary, which provides a foundation for standardizing spatial features, currently contains a limited set of hydrographic and topographic terms. Because of increased efforts to share and integrate spatial data, the glossary must be expanded to include terms and definitions for additional categories of data. The NIST has established a FIPS Spatial Features Register at the USGS to allow the periodic addition, modification, or deletion of spatial features. A plan to maintain the register and to identify sponsoring groups for appropriate categories of spatial features is being developed with input from the Federal Geographic Data Committee (FGDC).

Longer term goals for SDTS activities include maintenance of FIPS 173 to ensure that it continues to meet data exchange requirements for spatial data and continued cooperation with the spatial data community to address national and international implementation needs.

The USGS is working closely with the FGDC and relevant professional societies to ensure that everyone has an opportunity to be actively involved in the development and promotion of the SDTS. To encourage widespread use of the SDTS, the USGS is developing additional agreements to increase participation and support.

For more information on the SDTS, contact:

Mail SDTS Task Force
U.S. Geological Survey
526 National Center
Reston, VA 22092

Internet sdts@usgs.gov

Kathryn C. Wortman
manages the SDTS maintenance authority and a program of developmental data standards and technology assessment for the USGS

National Map and Digital Data Cooperative Program

The advent of geographic information system (GIS) technology has created an enormous demand for accurate digital spatial data. To better meet the growing demand for data, the USGS established the National Map and Digital Data Cooperative program. The production of spatial data with partners from State and local government agencies, public utilities, and the private sector will enable the USGS to fulfill more product needs, accelerate the growth of the national data base, and reduce costs and duplication.

To facilitate the development of production partnerships, the USGS is first identifying geographic areas where more than one type of geographic data is required. These high-demand areas then are targeted for the development of partnerships among several agencies. Typically, traditional funded or unfunded agreements are used. Funded agreements involve a transfer of funds; unfunded agreements usually involve the transfer of materials or the exchange of services.

In the past, these agreements were typically developed with Federal, State, and local government agencies only. However, in FY 1993, the USGS obtained the legislative authority to participate in production partnerships with the nongovernmental community. Under this innovative partnership program, the USGS seeks nonproprietary data produced by public utilities, State and local governments, and the private sector that are derived from USGS source materials. Proposals submitted by these organizations may request the purchase of existing data for a fair and reasonable price or the funding of future data production. In the latter case, the USGS would provide funds to cover the incremental cost of producing the data to its standards. In either case, USGS contributions may not exceed 50 percent of production costs.

Program announcements for the innovative partnership program will appear periodically in the *Commerce Business Daily* to specify product types sought—currently digital line graph (DLG) data, digital elevation model (DEM) data, and digital orthophoto quadrangle (DOQ) data—and deadlines for proposal submission. Although these program announcements currently have a specific proposal submission period, eventually there will be an open program announcement to which proposals may be submitted at any time.

Some traditional agreements developed in 1993 include a joint funding agreement with the State of Minnesota for the production of DOQ's for a major portion of the State and a cost-share agreement with the National Park Service for the production of DLG's and DEM's. Under innovative partnerships, the USGS will provide support to Ohio State University for the production of DLG's; to Graphics Information Technologies, Inc., for the purchase of existing Public Land Survey System data from several States; and to the State of Maine for the purchase of DLG's. Total non-National Mapping program contributions toward cooperative agreements in FY 1993 will exceed $3 million.

Gregory Snyder
is a staff cartographer involved in interagency coordination and base cartographic user needs assessments

Mary Griffeth
is a staff cartographer providing cooperative program and policy support to USGS regional mapping center personnel

For more information on the National Map and Digital Data Cooperative program, contact:

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How Does Land Use Affect Water Quality in an Urban Watershed?

The Difficult Run watershed is approximately 59 square miles in size and drains an area of northern Virginia that, like many tributaries to the Potomac River in the Washington, D.C., area, has seen commercial and residential development in recent decades. Through agreements with the Northern Virginia Soil and Water Conservation District, the Soil Conservation Service, and other Federal and local government agencies, the Difficult Run environmental quality research project will establish a data base for continued environmental analysis by local government, citizen and environmental action and volunteer organizations, and local university and high school students.

GeoData are digital cartographic and geographic base data that have been collected, processed, and archived in the National Digital Cartographic Data Base for distribution to users in government agencies, the private sector, and the public. These data include elevation, planimetric, land-use and land-cover, orthophoto, and geographic names information in digital form, as well as comparable digital information contributed by other mapping organizations.

The project will examine the relationship between land-use change in the Difficult Run watershed and the quality of water in the basin. The base layers (hydrography, watershed and subwatershed boundaries, terrain elevation and slope) for the entire watershed have been derived from USGS GeoData products and will be used in water-quality sampling. Land-use information (past and current) will be gathered for the watershed. A geographic information system (GIS) will be used to portray Difficult Run's streamflow and water quality. Once the methods of sampling, land-cover mapping, and initial hydrologic modeling have been developed, university and advanced high school students will take over the project and will use GIS to continue the study. Any trends between land-use change and water quality indicated by the data will be documented in maps, videotapes, and reports.

John W. Jones
is a geographer in the USGS's GIS Research Laboratory who trains researchers in the use of GIS and conducts both basic and applied research using GIS, image processing, and related technologies

For more information on the Difficult Run study, contact:

Telephone (703) 648–5543
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Are We Meeting Customer Needs for Base Cartography?

The transition from hard-copy map use to digital spatial data has prompted the need for a survey to determine whether USGS products contain the appropriate base cartographic information needed to satisfy the Nation's spatial data community. To be completed in 1994, the assessment is being conducted in three phases.

The preliminary phase will consist of interactive sessions, led by a facilitator, with representative digital line graph (DLG) user groups from the public and private sectors. These sessions will give users an opportunity to voice their concerns on DLG format and content. Several sessions were conducted in 1993 at open meetings of the Subcommittee on Base Cartographic Data and at regional State Mapping Advisory Committee meetings.

During the second phase, the information gathered in the interactive sessions will be analyzed independently by several reviewers. Preliminary analyses have shown that users are most concerned with cartographic feature content, geometric and feature classification, positional accuracy, currency, topology, and distribution media. Additionally, those data categories of greatest interest include hypsography (elevation of the Earth's surface with reference to sea level) and road networks.

In the final phase of the assessment, the analyses of data obtained from the interactive sessions will be used to develop a questionnaire. Questionnaire responses will be cross-tabulated to define user needs by organization and industry. The results of the assessment may be used to modify DLG content standards. Other factors to be considered before making changes to standards include availability of funding and technological constraints. This assessment will provide an initial baseline for digital data to support informed decisionmaking by a variety of users in the public and private sectors.

Gregory Snyder
is a staff cartographer involved in interagency coordination and base cartographic data market research

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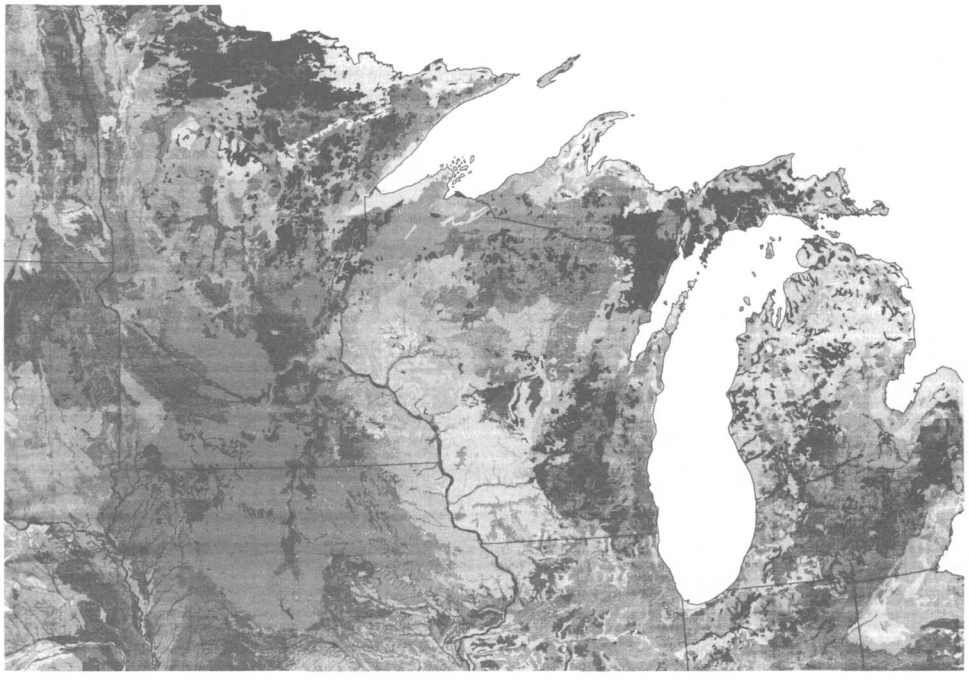
Soil Mapping Developed at the EROS Data Center to Help Scientists

The EROS Data Center (EDC), the Federal archive for remotely sensed data maintained by the USGS in Sioux Falls, S. Dak., has developed a new means of soil mapping on a continental scale that promises to help scientists understand the Earth's carbon cycle and its effects on phenomena such as global warming.

Using the State soil geographic (STATSGO) data base developed by the Soil Conservation Service (SCS), EDC and SCS scientists have used the STATSGO data in a geographic information system to produce maps of specific soil properties.



Upper Midwestern portion of the soil organic carbon map of the Eastern United States (shown here in black and white).

The data base consists of digital maps and associated data on soil properties. Map units that represent groupings of soils at a landscape level were compiled on USGS 1:250,000-scale base maps (1 inch≈4 miles). The map units are described as a set of soil phases. For each phase, a set of layer records represents a generalized profile of soil properties with depth. The map of soil carbon for the Eastern United States, for example, is based on estimates of the organic matter and bulk density for each layer. Average values per unit area (kilograms per square meter) are used to color the map (shown here in black and white). The total amount of soil organic carbon for the States shown is estimated to be 42.8 billion metric tons.

Using this data base and geographic information systems, scientists will be better able to assess how soils will respond to changes in climate.

Norman Bliss
has been developing soil data bases at the EROS Data Center in Sioux Falls, S. Dak., since 1985

Sharon Waltman
is a soil scientist with the U.S. Department of Agriculture's Soil Conservation Service

Jesse Nelson
is a graduate student at South Dakota State University

Monitoring Changes to Wetland Areas in the United States

The USGS is participating with the Wetlands Subcommittee of the Federal Geographic Data Committee to resolve inconsistencies among several wetlands classification reports produced by Federal agencies. The USGS assembled 10 data overlays for Wicomico County, Md., from various Federal and State agencies and placed them onto a geographic information system (GIS) for analysis and evaluation. A user interface was designed that allows the operator to analyze the data and make direct comparisons among data sets. More than 900 special plots (plus tabular reports) were produced on a GIS to identify and measure patterns of inconsistency in the data.

A progress report issued in the fall of 1993 describing the results of the Maryland case study showed that there are major disagreements between the data sets used in wetland identification. In the case of the Maryland data, the greatest inconsistencies were in the forested wetland area. Because the inconsistencies appear to be somewhat systematic, a better understanding of the strengths and weaknesses of the various programs may allow users to use the data

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For more information on wetlands monitoring, contact:

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more intelligently. Additional counties in various types of ecosystems will subsequently be studied nationwide.

Russell D. Berry
is a research cartographer using GIS technology to help solve wetland resource problems across the country

Information and Data Systems

The USGS, through its Earth Science Information Center (ESIC) network, provides a national clearinghouse service for cartographic, geographic, earth-science, and remotely sensed information and responds to national requirements to deliver this information to a community of Federal, State, and local government agencies and general public users. Functions performed include acquiring, archiving, managing, replicating, and distributing cartographic, geologic, hydrologic, and geographic information in many forms and responding to requests for earth-science information. In addition, a centralized facility in Denver, Colo., warehouses and distributes published USGS products, including 5.5 million maps in FY 1993.

In addition to providing product information and distribution services, the USGS manages cartographic, remotely sensed, and other earth-science data in digital and cartographic data bases. The USGS supports several major national data bases. The National Digital Cartographic Data Base organizes and manages the primary- and intermediate-scale digital map data files and digital orthophoto quadrangles. The geographic names information system is an automated data system that cites locations and descriptions for nearly 2 million proper names of places, features, and areas in the United States. The map separates tracking system is used to manage the inventory of original graphics from which the USGS's primary topographic base maps are printed. The Main Image File at the EROS Data Center is an electronic catalog of nearly 10 million aerial photographs and satellite images.

For more information on the global land-cover characteristics data base, contact:

Telephone (605) 594–6066
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Building a Global Land-Cover Characteristics Data Base

As part of the USGS Global Change Research program, the Earth Resources Observation Systems (EROS) Data Center (EDC) and the Center for Advanced Land Management Information Technologies (CALMIT) have analyzed advanced very high resolution radiometer (AVHRR) and other data over time to characterize land cover to meet the needs of global change researchers.

The methods involved clustering a 1990 set of 28-day maximum composite images of the conterminous United States into 70 spectral-temporal classes and subsequently stratifying, refining, and labeling them with ancillary data. The result is a 159-class land-cover characteristics data base, available from the EDC on CD-ROM, that allows users to tailor data to the unique requirements of a variety of applications and to develop custom products. The map inserted at the back of this report is one product that was developed by using these data. It shows seasonal land-cover regions for the conterminous United States. These regions have unique combinations of vegetation mosaics, seasonal properties (onset, peak, and length of green period), and annual net primary production and are grouped into general land-cover types. Increasing color intensity within each group corresponds to increasing relative primary production.

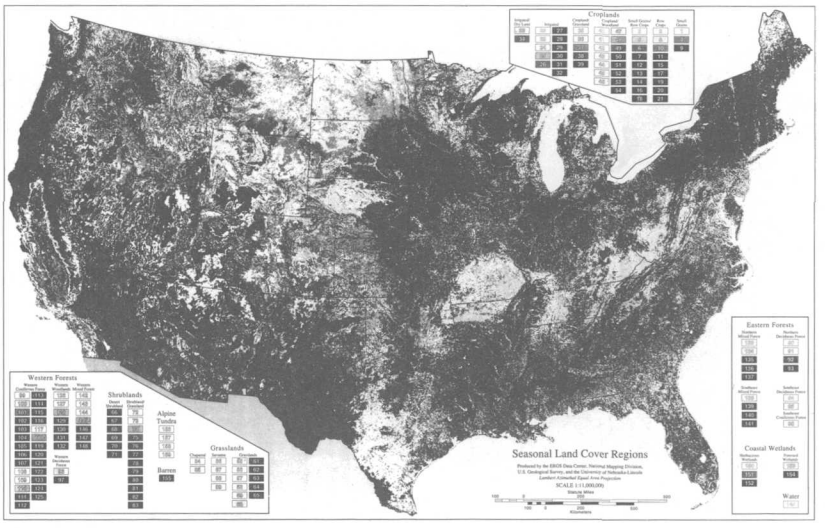
Advanced very high resolution radiometer (AVHRR) is a sensor on board National Oceanic and Atmospheric Administration polar orbiting meteorological satellites. The data from AVHRR sensors have a nominal resolution of 1.1 kilometer, represent five bands of reflected and emitted electromagnetic energy, and cover the entire Earth's surface each day. These data provide a unique means of monitoring and mapping the condition and dynamics of global vegetation.

In cooperation with the U.S. Forest Service (USFS), EDC is conducting an accuracy assessment of the land-cover classification system. Field personnel are visiting 3,500 randomly selected sites throughout the United States and gathering land-cover information.

The Environmental Protection Agency, the USFS, the International Geosphere-Biosphere Programme, and the United Nations Environment Programme-Global Resources Information Database initiated the development of a Western Hemisphere land-cover data base in late 1993; completion of a preliminary data base is scheduled for late 1994. Plans will continue, continent by continent, to characterize the remaining land masses. Priorities for the eventual completion of the effort will depend on recommendations from the scientific community.

Thomas R. Loveland

has been involved in remote-sensing research at the EROS Data Center in Sioux Falls, S. Dak., for more than 14 years



This map represents seasonal regions of the conterminous United States and was developed through the analysis of March–October 1990 1-km AVHRR imagery, digital elevation, ecoregions, and climate data. The complete land characteristics data base, available on CD-ROM, can be tailored to classification legends or parameters required for specific applications.

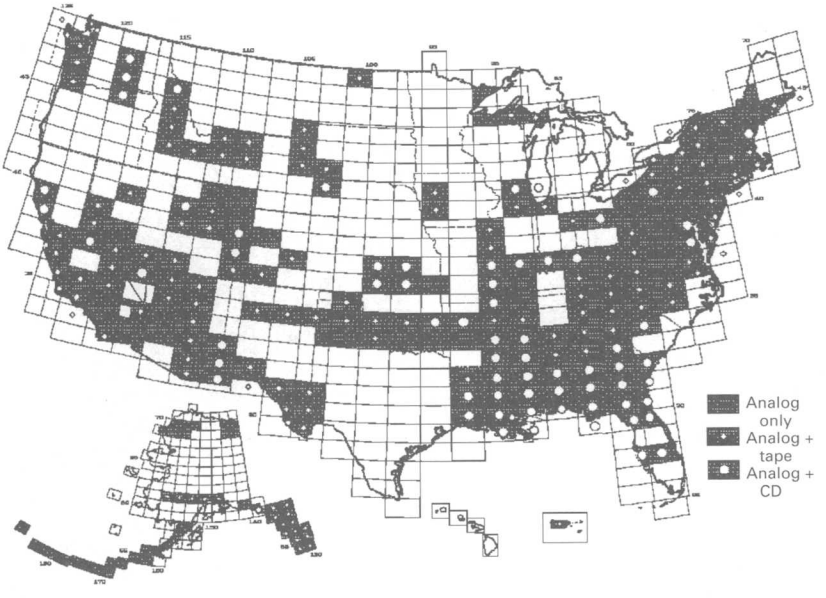
To order CD-ROM, contact:

Telephone: (605) 594–6507
Mail: Customer Services,
USGS, EROS Data Center,
Sioux Falls, SD 57198

Side-Looking Airborne Radar Program

Side-looking airborne radar (SLAR) data have been acquired for over 40 percent of the United States. The USGS began collecting SLAR data in 1980 as a result of a congressional request "to begin the use of side-looking airborne radar imagery for topographic and geologic mapping, and geologic research surveys in promising areas." Each data-collection mission is designed around local geology and specific earth-science research criteria for the area. Because SLAR can penetrate most clouds, it has great value as an almost all-weather imaging system. SLAR data are available both in stereographic strip form and mosaicked onto 1:250,000-scale USGS quadrangles. Since 1986, computer-compatible digital tapes have also been available. All data acquired since 1990 are also available on CD-ROM.

During FY 1993, SLAR data for eight quadrangles were acquired, processed, and delivered to the USGS by a contractor. Data conversion from high-density digital tape to more useful 9-track



USGS SLAR data holdings available from the EROS Data Center.

For more information on SLAR, contact:

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computer-compatible tape (CCT) was completed for 36 previously imaged quadrangles in the Appalachian region. The conversion of 165 quadrangles from CCT's to longer lasting, more accessible CD-ROM's was initiated.

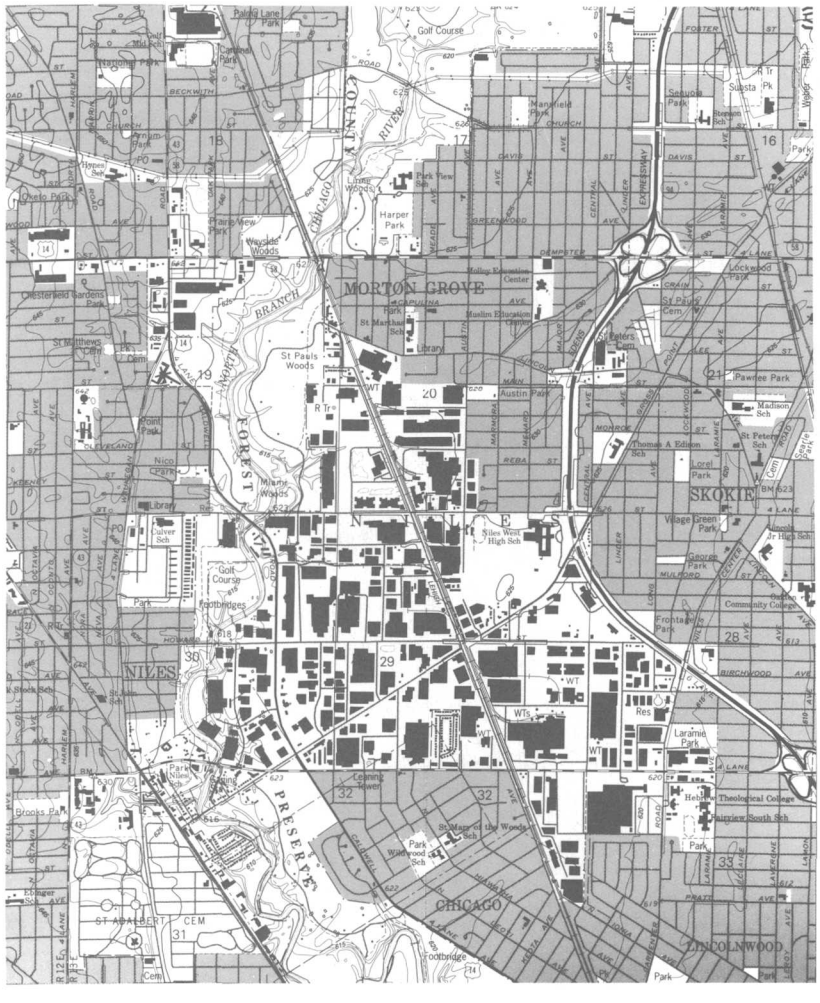
James W. Schoonmaker
is a civil engineer specializing in surveying, mapping, and remote sensing since 1971

Advanced Cartographic Systems

The USGS is modernizing its production, management, and user service technologies for the National Mapping Program. Traditional map-production techniques cannot provide timely products that meet user requirements for computer-assisted applications. Map users are also requiring a wider variety of source material such as those available from advanced remote-sensing and satellite technologies. Advanced Cartographic Systems is a multiyear effort that is replacing outdated graphic mapping equipment with more efficient, advanced computer-assisted cartographic systems and developing innovative applications capable of producing cartographic and image data in both graphic and digital form. The automated production equipment and specialized facilities acquired under this program also provide the USGS with improved ability and greater flexibility for supporting civilian government agency use of remote-sensing capabilities for national concerns such as predicting, detecting, and monitoring natural events and disasters, monitoring environmental conditions and effects, and managing resources.

National Advanced Remote Sensing Applications

During FY 1993, USGS activities supporting the coordinated civilian use of advanced cartographic capabilities were moved into a new facility in Reston, Va. Initial implementation of the national advanced remote sensing applications project (which deals



This map of Park Ridge, Ill., is an excerpt of the first topographic quadrangle map produced and published by the USGS using fully automated digital technology. The map was produced by using digital orthophoto quadrangles from orthorectified aerial photography and digital line graph data scan digitized from the original graphic map separates. The graphic data on the map were plotted by using automated computer technology; only the type was placed manually. The techniques and equipment used to produce this map were developed by the USGS Advanced Cartographic System's development program. The processes used will increase the efficiency of USGS map production and shorten the map-updating cycle. They will also result in digital imagery and cartographic data that can be used in computerized geographic information systems to support complex land and resource management analysis and decisionmaking.

primarily with classified materials) was completed, enhancing USGS ability to conduct prototype scientific investigations of natural phenomena and to look into expanding its support of the Federal Emergency Management Agency.

Initial map production using the advanced technologies introduced with Advanced Cartographic Systems began during 1993. The first digitally produced quadrangle map is of Park Ridge, Ill., a suburban area north of Chicago. The map was produced by using digital orthophoto quadrangles as the primary source for revision of digital line graph data that had been scan digitized from the original graphic map separates. After revision, symbols were added to the digital data by means of automated computer technology. These processes will increase the efficiency of USGS map production and shorten the map updating cycle. As byproducts of these advanced cartographic systems processes, digital imagery and cartographic data will be available for use in computerized geographic information systems to support complex land and resource management analysis and decisionmaking.

Thomas M. McCulloch
has been developing advanced systems for the USGS for the past 7 years

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At Work Across the Nation in Geologic Studies

Mission

The Geologic Division evaluates the Nation's geologic structure and the geologic processes that have shaped it, assesses the Nation's mineral and energy resources, and identifies and investigates geologic hazards.

- Investigations of geologic hazards provide information for predicting and delineating hazards from earthquakes and volcanoes and for identifying engineering problems related to ground-failure hazards.

- Regional geologic studies provide geologic maps and regional syntheses of detailed geologic data essential to mineral, energy, and hazard assessments and to land-use decisions such as landfill siting and selection of transportation routes.

- Offshore geologic studies characterize the marine Federal lands, identifying and describing the mineral and petroleum resources of the offshore areas of the U.S., including the Exclusive Economic Zone, an area one-third larger than the land area of the United States.

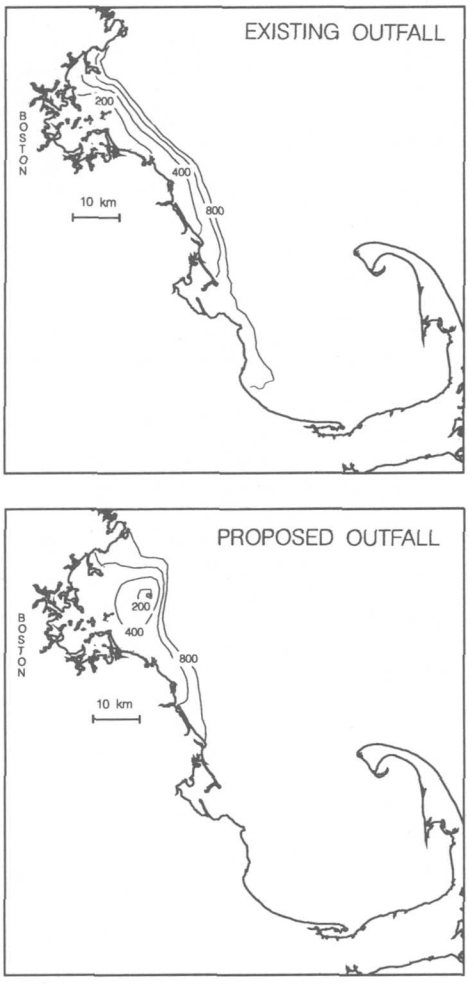
- Mineral resource investigations assess the distribution, quantity, and quality of the Nation's mineral resources and their environmental implications that are required for making land-use decisions by Federal, State, and local land-management agencies.

- Surveys of energy resources provide assessments of the Nation's coal, petroleum, uranium, and geothermal resources and enhance capabilities to explore for and develop new sources of energy.

Marine and Coastal Geologic Surveys

As onshore resources are depleted and as the population continues to shift toward the coasts, more societal pressure will be placed on the Nation's already severely stressed coastal and marine environments. These stresses will increase further as the Nation turns to the coasts and oceans in its search for new sources of minerals and energy, for increased food production, for recreation, and for safe disposal sites for waste materials. Increased use of coasts and oceans in turn increases the potential risk to people and property from natural hazards such as coastal erosion, landslides, earthquakes, and severe storms. Much multidisciplinary information is needed to manage the development of the ocean's vast resources in a safe and environmentally sound manner.

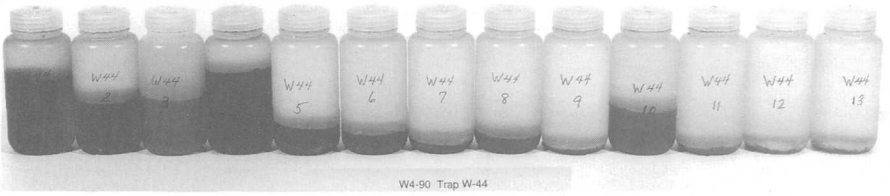
The USGS Marine and Coastal Geologic Surveys program provides data, analysis, and information on issues of national, regional, and local concern in marine and coastal areas; it is the seaward extension of the USGS's onshore geologic investigations. The program covers coastal wetlands, beaches, and estuaries and Federal lands contained in the U.S. Exclusive Economic Zone (EEZ) in the Atlantic, Pacific, and Arctic Oceans and the Gulf of Mexico, which are 30 percent larger than the land area of the continental United States. Research topics include determining the geologic framework of coasts and oceans, mapping the EEZ by using sidescan sonar, identifying and quantifying the processes responsible for transporting and depositing sediments, and characterizing offshore hazards and resources.

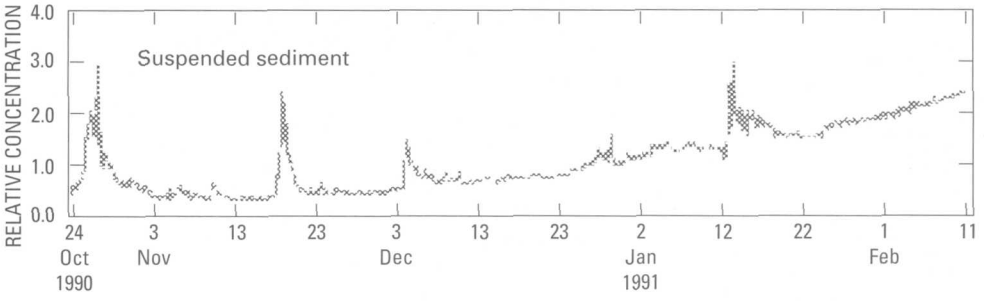


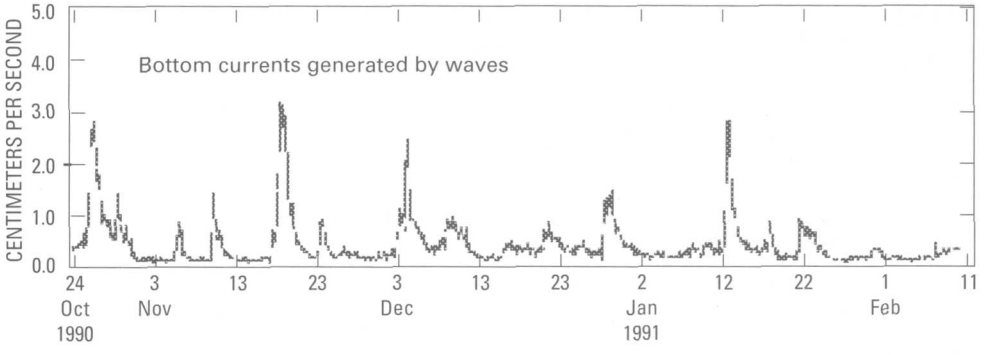
Effluent dilutions for the existing outfall in Massachusetts Bay and the proposed outfall simulated for the period from December 1, 1990, to March 29, 1991 (typical unstratified conditions) and assuming conservative behavior of the effluent.

Contamination in Boston Harbor and Massachusetts Bay

Boston Harbor, cited in the late 1980's by the U.S. Environmental Protection Agency as the most contaminated harbor in the United States, is presently benefiting from a $4.8 billion cleanup effort that involves elimination of sludge discharge, construction of a secondary sewage treatment plant, and relocation of a sewage effluent outfall from its present position at the harbor mouth to a point 9 miles into Massachusetts Bay. The USGS is conducting a research program in cooperation with State agencies in Massachusetts and scientists from universities and the Woods Hole Oceanographic Institution to provide basic scientific information on the transport and accumulation of contaminated sediments in the bay area. Not only is this information critical to making management and engineering decisions, but it also contributes to evaluating the cleanup effort. Such information is needed in many coastal areas around the United States where the







(Top) Sample bottles from a sediment trap located 4 meters (13 feet) above the bottom of Massachusetts Bay. Each bottle represents accumulations during about 9 days during the period from October 1990 to February 1991. (Middle) Suspended sediment concentration based on light transmission shows peaks in turbidity that correlate well with sample bottles. (The upward trend beginning in December was caused by algae fouling the lenses of the turbidity sensor.) (Bottom) There is a clear correlation between the four most intense periods of wave activity and the peaks in suspended sediment shown by the upper graph and the bottles. This correlation indicates that waves are the major cause of resuspension. The samples in bottles are also used to measure attributes (such as sediment characteristics and contaminant levels) during stormy and calm periods.

discharge of wastes into the ocean conflicts with other uses of the marine environment, such as recreation, fishing, and transportation.

Three-dimensional computer modeling of circulation in Massachusetts Bay, which is a major component of the USGS effort, not only has provided insight to scientists but also has played a key role in the debate about whether to complete the new outfall that redirects treated sewage effluent from the presently contaminated harbor to a location 9 miles into Massachusetts Bay. When the model was tested under winter conditions, it showed excellent agreement between what was observed and what was predicted for currents in Massachusetts Bay. The model results, which have been presented at a number of public forums, in court, and for a television documentary, have been used to compare effluent dilution at the present outfall site and the proposed site. The model shows that the present outfall maintains significant concentrations of effluent throughout Boston Harbor and southward along the shore of Massachusetts Bay. Effluent at equivalent concentrations from the deeper offshore outfall does not reach Boston Harbor and affects much less of the Massachusetts Bay shoreline.

The amounts of heavy metals in bottom sediment and suspended matter in western Massachusetts Bay have also been established and provide a baseline for evaluating changes that may result from the new ocean outfall. Maps showing grain sizes of the sea floor in Boston Harbor and Massachusetts Bay have been generated by using sidescan sonar, seismic reflection, bottom photography, and sediment sampling. Because contaminants are commonly bound to fine-grained particles, maps that show particle sizes can be used to indicate where contaminants are most likely to accumulate. These maps have been used by State agencies to design baywide programs to monitor and

evaluate the environmental impacts of the new outfall.

Field measurements conducted around the future outfall site to determine the fate of particles show that surface waves during major winter storms are the principal agents in resuspending sediment. A time-series sediment trap used at a long-term instrumented mooring in Massachusetts Bay demonstrates the correlation between bottom currents caused by surface waves and sediment resuspension and provides material from individual storms for analysis. Fine particles that settle in western Massachusetts Bay during relatively tranquil summer periods may be eroded and redistributed to deeper waters of Stellwagen Basin during winter storms. Knowledge of these processes is critical to evaluating the long-term impacts of pollutants in this coastal area.

The USGS Massachusetts Bay studies are providing information that is applicable to other coastal regions and may serve as a model for studies to assess the environmental consequences of waste disposal and contaminant accumulation in the coastal ocean areas.

Michael Bothner and Bradford Butman
have studied the geochemistry of shallow marine sediments for more than a decade

Richard P. Signell
is a physical oceanographer specializing in numerical models of circulation

Massachusetts Bay Program

A long-term objective of the USGS Massachusetts Bay program is to develop the ability to predict patterns of sediment and contaminant transport and accumulation on a regional basis. The program addresses fundamental questions such as (1) what is the texture and structure of the sea-floor environment in the harbor and bay, (2) how are water and materials transported throughout the system, and (3) where do sediments and associated contaminants accumulate and at what rate? To answer these questions, the USGS study of the bay includes:

- Regional mapping of sediment types and areas of erosion and deposition.
- Chemical analyses of sediment to determine present levels of contaminants.
- Direct measurement of ocean currents and computer modeling of regional circulation.
- Assembly of existing information to describe the spatial distributions and temporal trends in sediment and contaminant conditions.
- Long-term monitoring of ocean conditions and sediment properties to evaluate seasonal and annual variability and the infrequent catastrophic events that may be responsible for most sediment transport.

Surprising News of Recent Faulting in South San Francisco Bay

The USGS began acquiring ultra-high-resolution seismic reflection profiles in San Francisco Bay in 1992 as part of a long-term study of the geology and environment of the Nation's largest urban estuary. In cooperation with scientists from four Japanese universities, the USGS acquired profiles by sharing the use of a Japanese sonar system, which is capable of obtaining unusually precise records from layers as thin as 18 centimeters (7 inches) in the upper 20 meters (66 feet) of soft bay mud. Japanese scientists have used this instrument to study a large and active fault in Japan, called the Median Tectonic Line, and were interested in acquiring data on other strike-slip faults such as the Hayward fault, which crosses the San Pablo Bay area of north San Francisco Bay.

As part of the cooperative study, the USGS extended its surveys into south-central San Francisco Bay. Previous airborne surveys of the magnetic field of the bay had shown that long linear aeromagnetic anomalies were known to cross this part of the bay from northwest to southeast. USGS researchers suggested in the late 1970's that the anomalies delineate fault zones. These faults are exposed on the peninsula beneath the city of San Francisco in a mass of rock called the Franciscan Formation along the Hunters Point-Fort Point shear zone. Because the faults separate bodies of rock that are more than 65 million years old, they were thought to be old and inactive. The new seismic profiles confirmed earlier speculation that the faults extend offshore along the linear magnetic anomalies but also show that some faulting occurred less than 10,000 years ago.

Two major fault zones have been identified, each 2 to 3 kilometers (1.3–1.8 miles) wide and consisting of dozens of strands (a fault strand is a short segment

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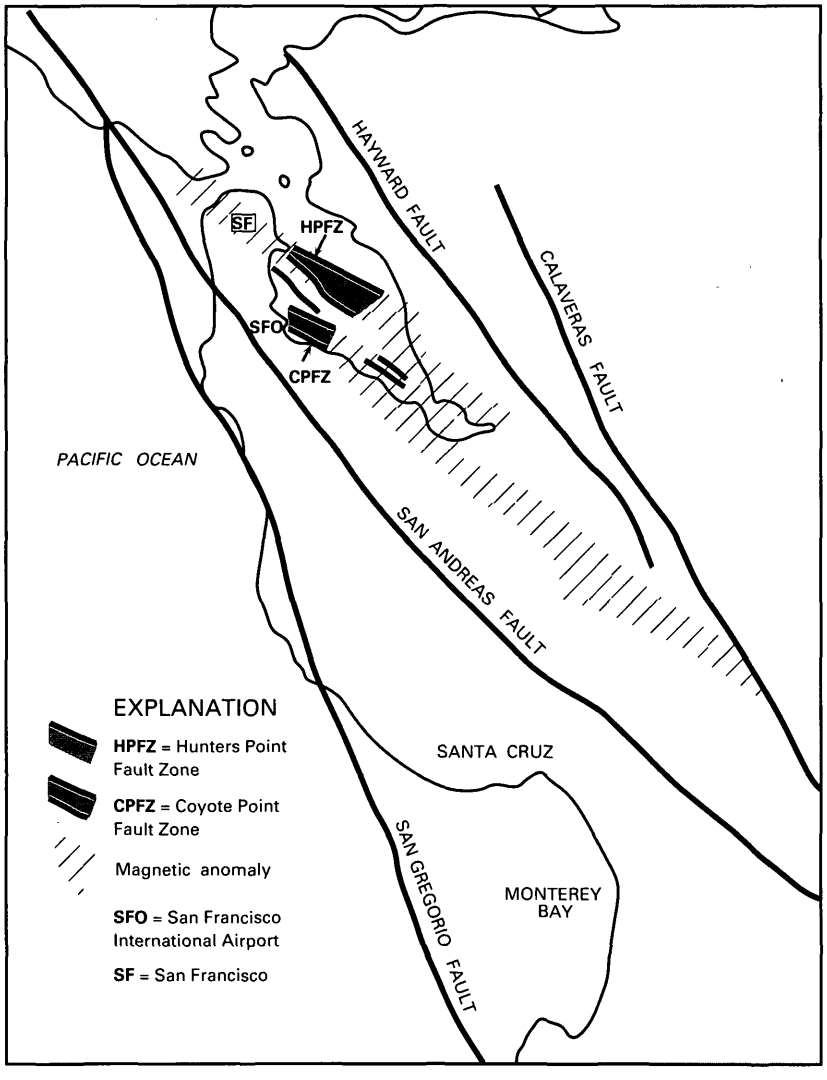

of a fault). The northern fault zone, called the Hunters Point fault zone, is known to extend about 5 kilometers (3 miles) from the shear zones exposed on Hunters Point to the central part of the bay, but it may be longer; the shallow depth of the bay to the southeast prevented surveying there. The area will be surveyed this year by using a shallow-draft vessel on loan from San Francisco State University. The Hunters Point fault zone may be as long as 120 kilometers (75 miles) (as long as the adjacent Hayward fault) if it follows the regional extension of a pronounced magnetic anomaly. The second fault zone, called the Coyote Point fault zone, extends from the end of the runways of San Francisco International Airport to the southeast past Coyote Point and may extend into the shallow part of the bay or beyond. Separating the two fault zones is a large suspected fold and thrust structure called the San Bruno Shoal anticline, which has uplifted the bay floor to less than a meter (3 feet) deep in the center of south San Francisco Bay.

A month after the surveys, the USGS began collecting a series of cores in the south-central bay to date the layers that have been offset by fault movement. Colleagues at Stanford University and the Lawrence Berkeley Laboratory have been assisting USGS scientists in dating shells found in some layers by means of a precise carbon-14 dating technique. The preliminary results indicate that all the faults in the bay offset layers that were deposited 5,000 years ago and that some of the faults offset beds deposited only 1,600 years ago. At least two fault strands offset the bay floor, an indication that faulting may have been active within the past 1,000 years, but further studies are needed to determine the actual age of faulting.

Because of the young age of the faulting and the proximity of the faults to large urban areas and critical infrastructure, the USGS has held a series of briefings with officials from the airport, city emergency and transportation services, and others to advise them of the newly mapped faults. Future plans include a cooperative study with the State transportation agency to assist in the analysis of deep borings (to bedrock) that will be collected near the bay bridges. USGS scientists have recently finished an extensive survey of the rest of the south San Francisco Bay. Other USGS scientists will extend the fault studies on land across the San Francisco Peninsula and into the Pacific Ocean. They hope to find the area where the San Andreas fault intersects these newly delineated faults, near the epicenter of the great 1906 San Francisco earthquake.

For more information about the Marine and Coastal Surveys program, contact Janet Morton at:

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Internet janet@oemg.er.usgs.gov

For more information about the San Francisco Bay study, contact:

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Internet mmarlow@usgs.gov

Michael S. Marlow
has published extensively on tectonic processes at continental margins

Gary M. Mann
studies the deformation caused by strike-slip faulting in young rocks in the Pacific Northwest and in San Francisco Bay

Roberto J. Anima
specializes in combining high-resolution geophysical methods with sedimentology to study the shallow structural framework of San Francisco Bay

The U.S. Energy Mix

The energy consumption of the United States continues to grow at a steady pace. Ninety-nine percent of the energy used in this country is based on natural, nonrenewable resources—91 percent on fossil fuels, including coal, oil, and natural gas, and 8 percent on nuclear power. The remaining 1 percent comes from hydroelectric, solar, and wind power and other renewable sources. The mix of energy used by the United States is the foundation of the Nation's infrastructure and economy and significantly influences the environment. The USGS Energy Program provides fundamental scientific knowledge on the abundance of energy resources and the environmental consequences of their use, information that is vital in order to effect any substantial changes in the energy mix of the Nation.

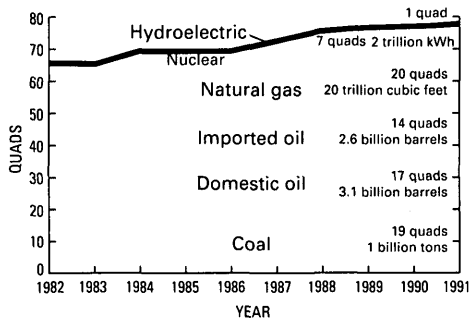
New Energy Assessment Underway

The USGS, in cooperation with the Minerals Management Service (MMS), is currently conducting a new assessment of U.S. oil and gas resources. The USGS assesses all onshore lands and State offshore waters; the MMS assesses Federal offshore waters. The assessment provides an independent, scientifically based set of hypotheses concerning the amounts of oil and gas that could be added to U.S. reserves. The new assessment includes (1) undiscovered, conventionally recoverable oil and natural gas; (2) selected recoverable, unconventional resources of oil and natural gas; and (3) reserve appreciation (field growth). The USGS assessment will be completed by January 1995; results will be published early in 1996.

All results of the new assessment will be released in digital form, including on CD-ROM's. The geographic information system approach—being used for the first time in this assessment—allows results to be identified in relation to specific geologic provinces and geographic areas. For example, resource estimates will be available for individual Federal land-management areas, sedimentary basins, or States. This capability will make it easier for Federal land-management agencies, State agencies, and industry to use the assessment results. Moreover, it will provide a base of digital information that will be the foundation of continuing USGS efforts to improve assessment results.

Energy Resources and the Economy

The bulk of domestic energy consumption comprises oil-based fuels. Domestic oil production satisfies only about half of the Nation's oil appetite, however, and domestic oil production is declining at an alarming rate. Imported oil accounts for a significant proportion of the national trade deficit. Natural gas and coal are alternatives to oil-based fuel and are considered to be abundant in the United States. Scientists do not have a comprehensive understanding of the geological occurrences of natural gas, however, and this lack of knowledge inhibits exploration and development of domestic natural gas resources. Domestic coal resources also are thought to be vast, but a comprehensive understanding of the quantity and quality of minable coal has still not been achieved. Moreover, the use of coal poses potential environmental hazards that must be addressed if coal is to remain a viable energy resource in coming decades. USGS scientists conduct scientifically based assessments of specific energy resources, including oil, natural gas, coal, uranium, and oil shale. In addition, they evaluate the Nation's energy mix on a regular basis. World assessments of oil, natural gas, and coal provide a global perspective for national energy needs. Scientifically based information from these assessments is used by decisionmakers in Federal and State agencies as well as in the private sector.



U.S. energy consumption from 1982 through 1991 (in common units of quads, where 1 quad equals one quadrillion British thermal units or 10^{15} Btu and kWh is kilowatt hours).

Energy Resources and the Environment

Reducing the emission of greenhouse gases and toxic elements into the atmosphere is of foremost importance to the Nation and the world. Research in coal quality and oil geochemistry provides the basic information needed to select fuels that are more environmentally benign. This information can also be used

Coal-Quality Data Base Sets Standards

The Environmental Protection Agency has recently designated the USGS coal-quality data base as the sole data base on which policy recommendations concerning trace-metal emissions from coal-burning powerplants will be made. The electric power industry also has recognized the uniqueness of this data base and the high quality of information it contains. Representatives of the Electric Power Research Institute, the Edison Electric Institute, and the Utility Air Regulations Group recently expressed a strong desire to work cooperatively with the USGS to expand the coverage of the coal-quality data base. These developments establish the USGS coal-quality data base as the primary source of independent scientific data recognized and used by both regulators and industry to address air-quality issues.

to predict the occurrence of relatively clean fossil fuels and to develop technology for removing hazardous elements from fuels before use.

Increased use of natural gas in place of coal and oil-based fuels would significantly reduce the amounts of greenhouse gases and hazardous elements released to the atmosphere. Expanded research on natural gas will build a comprehensive understanding of this vital resource. Research topics of particular interest include the volume and distribution of economically and technically recoverable domestic natural gas resources and the earth-science background needed for the optimal development of those resources. The results of this research will establish a scientific basis for evaluating the environmental impacts of various energy-use scenarios and will provide predictive models to use in exploring for environmentally benign energy resources. An added benefit is an improved understanding of geological constraints in designing technology for removing harmful elements from fossil fuels before use.

For more information about the Energy Resources Surveys program, contact David Houseknecht at:

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Internet dhousekn@usgs.gov

Energy Resources and Cooperation

The USGS is a partner with the Minerals Management Service and the Bureau of Mines in oil and gas assessment activities and coal assessment activities, respectively. Because a large proportion of undiscovered energy resources resides on federally managed lands, the USGS maintains formal liaisons with the U.S. Forest Service and with other Department of the Interior bureaus, including the Bureau of Land Management, the National Park Service, and the Bureau of Indian Affairs. Results of energy-resource assessments are shared with the Bureau of Mines and incorporated into the National Energy Strategy, largely through cooperation among various agencies in the U.S. Department of Energy, including the Energy Information Administration, the Office of Oil and Gas Exploration and Development, and the Office of Basic Energy Sciences. Similarly, the environmental impact assessments conducted by the USGS are cooperative ventures with the Bureau of Reclamation, the Bureau of Mines, and the Environmental Protection Agency. Interaction with agencies in every State having oil, natural gas, or coal potential is an essential part of most Energy Program research.

David Houseknecht
coordinates the USGS Energy Resource Surveys program and has published extensively on various aspects of petroleum geology

Reducing Hazards from Landslides

Landslides are among our Nation's most costly and destructive geologic hazards, causing billions of dollars of economic losses and significant loss of life. In some areas, expanding urban development onto landslide-prone hillsides has increased the number of landslide disasters and escalated costs of Federal disaster relief. An understanding of landslide processes and their consequent hazards can lead to nationwide reduction of landslide losses through proper planning and effective engineering.

Practical Planning for Hawaiian Landslides

In the aftermath of a severe rainstorm that struck Honolulu, Hawaii, on December 31, 1987, and caused massive debris flows and landslides, the USGS began a multiyear project that was completed in 1993 and that provided practical information to local officials on how

to deal with such landslide disasters. The study, which was conducted by USGS geologists and hydrologists in cooperation with the city and county of Honolulu, developed new scientific techniques to analyze debris flows and landslides and methods of applying these techniques in ways that are helpful to local planners and officials.

Debris-flow investigations focused on identifying when and where these rapid and potentially fatal slope movements are likely to occur and established the rainfall thresholds required to trigger them. These thresholds are now the basis for a public warning system like the one currently operating in the San Francisco Bay region. Areas susceptible to debris flows were mapped by using a newly developed computer-based digital method. Information on volumes, travel characteristics, and more than 1,500 source locations of past debris flows was combined to create computer models of potential debris flows that were routed through a digital model of the landscape. The computer generated numerous such simulations in order to systematically delineate areas of hazard. In combination with the rainfall thresholds, the resulting hazard-zone map, released in FY 1993, provides local officials with information needed for effective planning and emergency response over a 180-square-kilometer (70-square-mile) area around Honolulu.

These thresholds are now the basis for a public warning system like the one currently operating in the San Francisco Bay region.

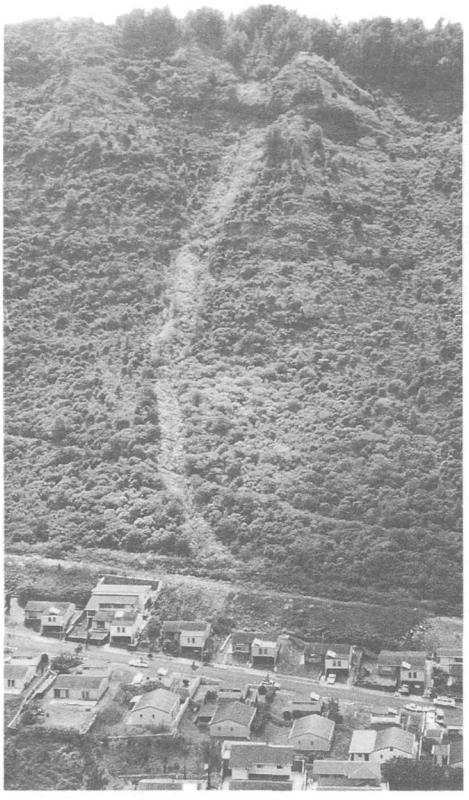
Several larger, slow-moving landslides also were reactivated by the 1987–88 storm; these slides have been damaging several residential areas intermittently for more than 30 years. Scientists made detailed maps of landslide features and related damage in high-priority areas. These maps provided city and county officials with the first systematic portrayal of the underlying cause of damage in apparently unrelated areas and supplied the basis for remedial efforts. Sophisticated analysis and computer modeling of this detailed mapping revealed that movement of the entire landslide mass is being driven by only a part of the landslide. This seemingly simple result has far-reaching implications. Stabilizing only the part of the landslide that is driving the whole mass is much more economical than stabilizing the entire landslide area. This modeling will provide the basis for innovative strategies to stabilize landslides in areas that have proven difficult to control by conventional methods.

This cooperative project in Hawaii has combined the very best aspects of basic scientific research on landslide

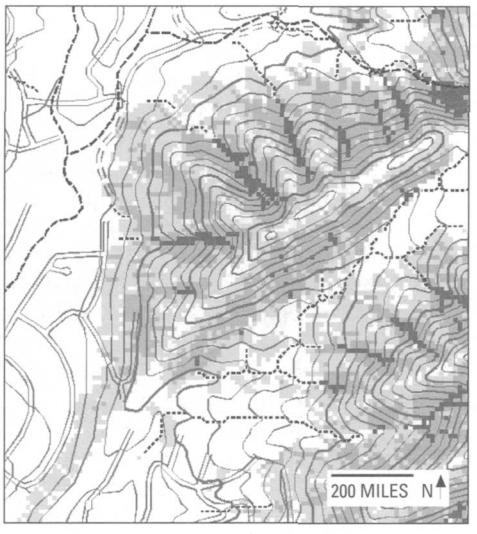
The USGS Landslide Hazards program seeks to reduce landslide losses that occur throughout the United States by:

- Developing technologies to map and assess landslide susceptibility and risk.
- Advancing our understanding of landslide processes and the geologic, topographic, hydrologic, and cultural factors that control slope failure.
- Developing and demonstrating landslide prediction capabilities to avoid, prevent, or mitigate landslide damage.
- Aiding the application of research results to improved planning, engineering design, and construction and to warning and emergency response plans.

Damage caused by a large, slow-moving landslide near Honolulu. This landslide, and others like it, disrupted streets, severed utilities, and damaged and destroyed many homes.



Path of a debris flow triggered by the New Year's Eve storm in Honolulu, 1987–88. The flow started near the top of the slope, moved rapidly down the steep face, and damaged two homes at the bottom of the slope.



EXPLANATION

Hazard from hillslopes

- High — Return period <500 years
- Moderate — Return period 500-2,000 years
- Low — Return period 2,000-10,000 years
- Maximum likely extent
- No hazard

Hazard along drainages

- Drainage from hillslopes; may carry debris flow and water-borne debris
- Drainage from headwaters; may carry large debris flows and abundant water-borne debris

Preliminary version of a map of debris-flow hazards in part of the Honolulu study area. Return periods are measured on 10-meter cells; larger cells would result in smaller return periods.

processes and applied research on delineating landslide hazard and risk with local cooperation and implementation to reduce actual losses from landslides.

Randall Jibson
coordinates the USGS research effort on landslide processes

For more information about the Landslide Hazards program, contact Randall Jibson at:

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Earthquake Studies: Increasing Awareness, Reducing Risk

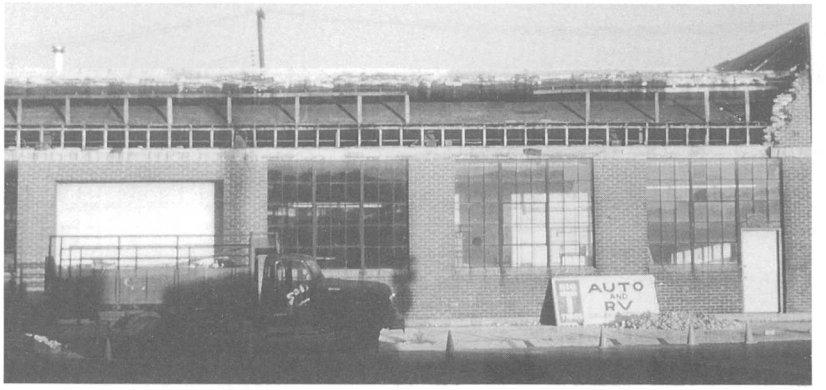
No technology is yet able to prevent earthquakes nor, for that matter, to predict precisely when or where future earthquakes will strike. In the past decade, earthquakes at Loma Prieta, Calif., in Armenia, and elsewhere have graphically demonstrated their tragic impacts on human lives and the deep, long-lasting economic losses to the affected region and to nations as a whole. More recently, the September 29, 1993, earthquake in India, in which many thousands of people died, is yet another sobering reminder of the destructive power of earthquakes. The USGS Earthquake Hazards Reduction program (EHRP) is designed to help provide the Nation with the scientific and technical tools needed to significantly improve its social, economic, and environmental preparation for damaging earthquakes. The USGS effort seeks to achieve a clearer understanding of the nature of the earthquake process, define the specific earthquake hazard for various geographic regions in terms of how big the earthquakes could be, how often they might recur, and the likelihood of future significant earthquakes in each region, and predict the actual effects by defining specific characteristics of the shaking and how the Earth's surface will respond to

the shaking (for example, landslides and soil liquefaction). Working cooperatively with other scientific agencies and many State and local officials to transfer the data, developed technologies, and risk assessments to those who need them is a critical program goal. Earthquakes are a unique class of hazards, unlike hurricanes, volcanoes, and floods, for which forecasts of timing and magnitude can be made hours to days in advance. Nonetheless, much can be done in advance to significantly reduce the risk from future earthquakes.

A Regional Approach to Earthquake Research

In the United States, earth scientists have long recognized that the earthquake threat is not uniform across the Nation, as residents of Alaska and California can attest, and yet earthquakes are not exclusively a problem of the Pacific Coast States. The sequence of four earthquakes that struck the New Madrid, Mo., area in 1811–12 was probably the largest and most potentially damaging in the United States; a recurrence of an earthquake of similar magnitude would be felt from Denver to New York City and would damage buildings over thousands of square miles in eight States. The USGS Earthquake Hazards Reduction program has reaffirmed a national commitment by continuing the deployment of new satellite-linked monitoring equipment throughout the United States and by supporting scientific investigations ranging from New England and South Carolina to Nevada and Hawaii.

A substantial proportion of the program's resources is focused on problems in the four regions having the highest earthquake hazard: southern California, northern California, the Pacific Northwest (Washington, Oregon, Alaska), and the Central United States (Arkansas, Illinois, Indiana, Kentucky, Mississippi, Missouri, Ohio, Tennessee). Each of these high-priority regions has a recently established regional USGS earthquake office



This unreinforced masonry building was damaged by the earthquakes that struck Klamath Falls, Oreg., on September 20, 1993.

This trench, northeast of New Madrid, Mo., shows clear evidence of multiple earthquakes in the region. The dark soil at the base is cut by a dike (next to the shovel), which has formed a thick sand blow on top. A younger, thick soil horizon has developed on top of the sand blow. All of these layers are cut by smaller sand dikes, probably from the 1811–12 New Madrid great earthquake series, which fed a sand blow at the top of the picture.

Regional Coordinators

Pacific Northwest and Alaska—Craig Weaver, Seattle, Wash.

Telephone (206) 553–0627
Internet weaver@usgs.gov

The USGS orchestrated the response to the September 20, 1993, Klamath Falls, Oreg., earthquake, coordinating its efforts with those of the Federal Emergency Management Agency, the U.S. Forest Service, Oregon's Department of Geology and Mineral Industries, and State universities in Oregon.

Northern California—William Bakun, Menlo Park, Calif.

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Internet bakun@usgs.gov

The USGS is a principal sponsor and participant in CONCERT (Coordinating Organizations for Northern California Earthquake Research and Technology), a technology transfer effort to get USGS research products into the hands of the user community in the San Francisco Bay area.

Southern California—James Mori, Pasadena, Calif.

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In cooperation with the Southern California Earthquake Center, a consortium of more than 100 researchers at 7 core academic institutions, USGS scientists conducted phase two of the Landers, Calif., assessment, which is an assessment of the hazard over the next 30 years.

Central United States—Buddy Schweig, Memphis, Tenn.

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The USGS provided support in the formation of a technical advisory team from State geological surveys of the region; the team will provide technical and scientific advice to the Central U.S. Earthquake Consortium of State emergency services.

and a regional coordinator (see box) who defines the USGS goals for that region and the short-term needs and objectives bearing on those goals. The regional coordinators are forging new linkages, collaborations, and agreements among academic researchers, USGS scientists, private industry, and Federal, State, and local government agencies.

Fully 30 percent of USGS program funding supports external research awards to private industry, State and local government entities, and universities. In FY 1993, the USGS received about 350 proposals in response to its annual Earthquake Program Request for Proposals and made about 100 awards on the basis of recommendations provided through a rigorous peer-review process. The regional coordinators have substantial input to setting the immediate and long-term needs to be addressed through this support. A few of the topics funded in FY 1993 include:

- Providing support for a collaborative earthquake project with the State geological surveys of Washington, Oregon, and Alaska.
- Deploying new state-of-the-art instrumentation on the Hayward fault in California to detect early signals of earthquake activity.
- Verifying the occurrence of a major earthquake in the Upper Midwest Wabash Valley in the last 4,000 years.
- Studying earthquake-wave attenuation in the Mississippi Embayment to improve predictions of future ground motion in urban areas including Memphis and St. Louis.
- Discovering features in the Columbia River valley of Oregon that suggest major earthquakes occurred in the past 300 years.

Getting the Information Out

Developing new technologies for transferring information is a vital part of the USGS earthquake program. For example, the fundamental earthquake data acquired at hundreds of monitoring stations are now routinely published in digital formats (such as CD-ROM), which scientists, engineers, planners, and local governments can acquire for a nominal fee. Each month, more Federal, State, local, and private agencies responsible for transportation, energy transmission, pipelines, and critical facilities access USGS telecommunication networks that provide information on recent or ongoing earthquakes. The USGS regional coordinators and individual USGS scientists work with broad-based regional earthquake mitigation groups such as the Central U.S. Earthquake Consortium (CUSEC), the Northeastern States Earthquake Consortium (NESEC), the Southern California Earthquake Center (SCEC), and Coordinating Organizations for Northern California Earthquake Research and Technology (CONCERT).

Geographic information systems (GIS) are now widely employed for communicating hazard and risk information on national, regional, State, and local scales. Use of GIS allows USGS products to be efficiently updated, enhanced, and disseminated either in hard copy, on computer disks, or by direct telecommunication links. For example, national maps showing the probabilities of expected levels of ground shaking for future earthquakes are the basis of seismic-design building codes across the country.

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Timely access to up-to-the-minute information on earthquakes anywhere in the Nation is critical to planning immediate and long-term responses. The USGS National Earthquake Information Center in Golden, Colo., disseminates much of this information. Analyses of the location, timing, and magnitude of an earthquake begin within seconds of the event, and distribution of the results by e-mail, fax, and telephone begins within minutes. In addition, the four regional earthquake offices, which have rapid access to regional seismograph networks, have a critical "onsite" role in the high-seismicity regions.

The USGS Earthquake Hazards Reduction program responds to user needs through public forums, technical results reported in scientific and engineering meetings and publications, policy group interactions, and vigorous collaboration with other Federal agencies such as the National Science Foundation, the Federal Emergency Management Agency, and the National Institute for Standards and Technology. Outreach activities in FY 1993 include:

- Collaboration with Humboldt State University in Arcata, Calif., to prepare and publish the full-color newspaper insert "On Shaky Ground—Living with Earthquakes on the North Coast."
- A workshop, in cooperation with the National Science Foundation, the National Academy of Sciences, and the Earthquake Engineering Research Institute, on the lessons learned from the Loma Prieta earthquake.
- Two workshops, organized in conjunction with the Federal Emergency Management Agency, on the probabilities of damaging earthquakes in the Northeast, held in Boston, Mass., and on earthquake hazards in rural America, held in Boise, Idaho.
- Collaboration with the Applied Technology Council on a major effort to develop new methods of transferring the latest results of USGS research to practicing engineers nationwide.
- Completion of new national earthquake risk maps, which will be the basis of new Building Seismic Safety Commission building codes to be adopted nationwide.
- Publication of USGS Professional Paper 1519 on the earthquake hazards and risk along the Wasatch Front, Utah.

Through these activities, the USGS Earthquake Hazards Reduction program continues to increase scientific understanding of how earthquakes happen and to disseminate that knowledge to decisionmakers, engineers, and the public. Understanding the earthquake process and carefully delineating the hazard posed by this process are major scientific challenges facing the Nation beyond the year 2000.

Randall G. Updike
coordinates the USGS Earthquake Hazards Reduction program and has written extensively on earthquake processes

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Understanding Volcano Hazards

Recent volcanic eruptions in the United States and abroad have shown the potential impact of volcanic activity in terms of casualties (25,000 in Colombia in 1985 and 500 at Mount Pinatubo in 1991) and socioeconomic losses ($1 billion from Mount St. Helens in 1980 and $200 million from Redoubt

Volcano in 1989–90). During this century, volcanoes in California, Washington, Alaska, and Hawaii have devastated hundreds of square miles and caused major economic hardships and loss of life. Significant impacts can occur hundreds of miles from a volcano. For example, in the past 25 years, more than 40 aircraft have been damaged by encounters with volcanic ash clouds. A Boeing 747 flying through an ash cloud from Alaska's Redoubt Volcano in 1989 temporarily lost power in all four engines and did not regain power until only a few thousand feet above the ground.

The goals of the USGS Volcano Hazards Program are to reduce loss of life caused by volcanic activity and to minimize the social and economic disruption that can occur when volcanoes threaten to erupt. These goals are pursued by studying volcanic processes to better understand how volcanoes act and to better interpret warning signs; by studying selected volcanoes near population centers to assess the hazard posed by future activity at the volcano; and by monitoring restless volcanoes to interpret the likelihood and probable style of an eruption.

Living with Volcanoes

Although volcanic activity worldwide is not on the rise, the impact on people and their activities is increasing as more homes are built in the shadow of volcanoes and as more long-distance aircraft fly over remote volcanoes. Because no violent eruptions threatened lives or property in the United States during the past year, USGS scientists were able to focus on expanding our basic knowledge of the causes and effects of the many types of volcanic activity. For example, in March 1993, the USGS organized a workshop of Japanese and USGS volcanologists who are studying volcano monitoring and processes of explosive eruptions. The workshop was held in Menlo Park, Calif., and was attended by more than 100 volcanologists, mainly from the United States and Japan but including scientists from several other countries. Workshop participants identified two topics as the most important for collaborative research to mitigate the hazards of explosive eruptions—processes of dome growth and seismic precursors to explosive eruptions.

To minimize the hazard that volcanic ash poses to aircraft, the USGS is working actively with the aviation industry, aircraft manufacturers, and other governmental agencies to gain a better understanding of how ash plumes behave over time, how to detect ash plumes quickly in remote airspace, and how to communicate information in real time to aircraft in the air or about to depart along affected routes. During FY 1993, the USGS cosponsored or participated in three international workshops on ash and aviation safety. The proceedings of the most recent workshop, which concerned the impact of volcanic ash on airports, are summarized in USGS Open-File Report 93–518, "Volcanic Ash and Airports: Discussions and Recommendations from the Workshop on Impacts of Volcanic Ash on Airport Facilities." In addition, USGS scientists are working with the International Civil Aviation Organization in revising procedures for detecting and issuing warnings of ash plumes in foreign airspace. The USGS also has formal collaborative agreements with the Federal Aviation Administration, the National Weather Service, and other regional agencies involved with disaster mitigation to address issues of aviation safety and volcanic eruptions.

Augustine Volcano, one of the most active in Cook Inlet, has been the focus of special study because of its frequent eruptions (1935, 1963–64, 1976, and 1986 in this century alone). USGS scientists have installed three tiltmeters and three Global Positioning System receivers

Global Positioning System receiver at a benchmark along Fortification Bluff, overlooking Cook Inlet in Alaska; a band of cloud wreaths Augustine Volcano in the distance.

on Augustine Island to monitor ground deformation continuously. If an eruption threatens, the Alaska Volcano Observatory—a consortium of the USGS, the University of Alaska, and the State of Alaska— should be able to warn people in the region, including the cities of Anchorage and Homer, and alert commercial aircraft to any possible danger. These warnings will help to minimize the socioeconomic disruption caused by volcanoes.

In May 1991, the Philippine Government invited USGS scientists to collaborate with Filipino volcanologists in assessing unrest at previously little-known Mount Pinatubo. The team provided warnings that led to the timely evacuation of thousands of Filipino residents and U.S. military personnel and dependents and hundreds of millions of dollars worth of military equipment just before the climactic eruption in June 1991. Clark Air Base was closed prematurely as a direct result of this volcanic activity, and ongoing mudflows and secondary eruptions continue to endanger the area. Scientists from the USGS, the Philippines, and the U.S. Army Corps of Engineers are investigating these hazards, funded in part by the U.S. Department of State.

James Riehle

is on the staff of the USGS Volcano Hazards program and the Geothermal Investigations program and has published extensively on volcano systems

USGS and Filipino scientists verify operation of a mudflow-detection station at Mount Pinatubo.

For more information about the Volcano Hazards Reduction program, contact James Riehle at:

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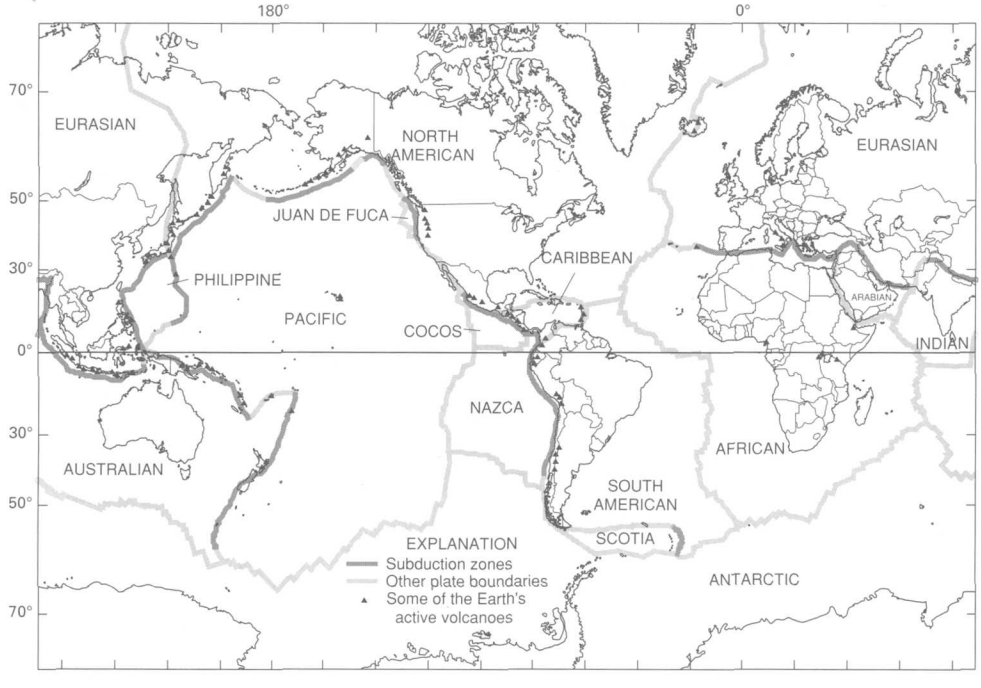
Deep Continental Studies

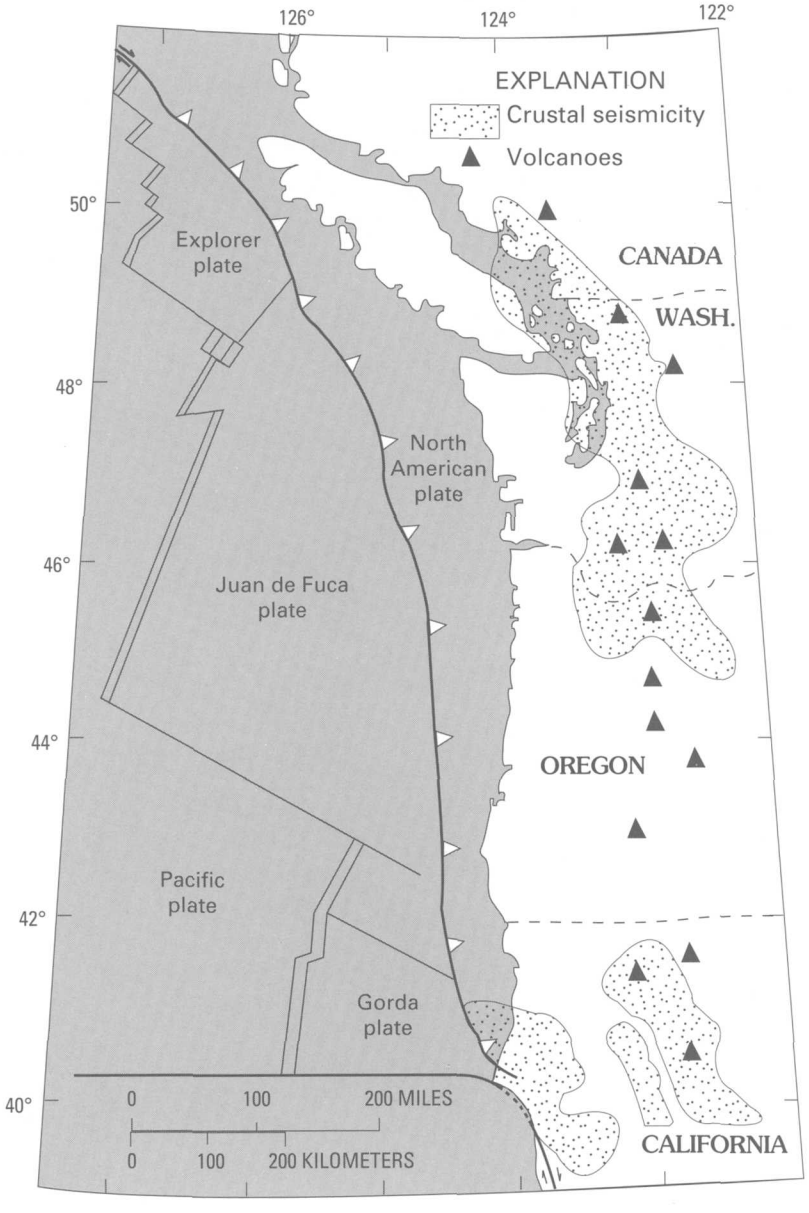
In our knowledge of the Earth and its processes, there is a large gap between the detail provided by shallow geologic exploration and the general knowledge of the deep roots of continents. Increasing our knowledge of these deeper zones is



Major tectonic plates of the Earth.

It is in the deeper zones that many critical mineral deposits form and that earthquakes and volcanoes originate.

essential, because it is there that many critical mineral deposits form and that earthquakes and volcanoes originate. The USGS Deep Continental Studies program promotes multidisciplinary research to expand our knowledge of deep crustal environments and processes that control or influence near-surface geology. The program provides basic information on hazards; management of land, mineral, and energy resources; and environmental concerns about the disposal of wastes. The challenges of deep drilling spur improvements in drilling instruments and technology.



The Explorer, Juan de Fuca, and Gorda plates are being subducted beneath the North American plate.

Evolution of Volcanic Arcs

Basic interdisciplinary research on the evolution of volcanic arcs (belts of volcanoes that parallel the deep ocean trenches) has led to a new understanding of their behavior, especially the relationships among volcanic eruptions (often explosive), earthquakes, and the descent of cold oceanic crust into the Earth's mantle. This new conceptual understanding is based on experimental and theoretical studies funded by the Deep Continental Studies program over the past 2 years.

The new model is based on the complex relationships among the dehydration of the descending ocean crust, the formation of a very dense rock called eclogite (which forms rapidly from crustal material under certain pressure and temperature conditions in the presence of water), and the melting of oceanic crust and overlying mantle rocks to form magmas. The formation of eclogite is controlled by the influx of water and the kinetics of mineral reactions that convert relatively voluminous minerals, commonly found in oceanic crust, into the much denser minerals that compose eclogite. The eclogite forms only along a narrow layer of the sinking slab, where the crustal minerals are present; the rest of the slab consists of mantle minerals that do not change volume as they sink. The reduction in volume that results from the formation of eclogite causes stresses in the oceanic crustal slab; these stresses, in turn, cause earthquakes. (An analogy is the cracking caused by thermal shock when an object is suddenly and unevenly heated or cooled, such as when a cold ice cube is dropped into lukewarm water.) Hence, water from the sinking oceanic crust not only aids in the melting of crust and mantle but also facilitates chemical

reactions that are ultimately the cause of powerful earthquakes.

Because most of the Earth's volcanoes are in volcanic arcs and most earthquakes occur within narrow zones beneath volcanic arcs, our new model provides a framework for understanding arc mechanics. We can now begin to quantify the buildup of stresses in downgoing slabs and improve our understanding of the episodic character of earthquakes and volcanic eruptions. As our understanding of the model's numerical aspects improves, we will be able to test it. The Pacific Northwest, between Seattle and Portland where the Juan de Fuca plate is forced beneath the North American plate, would be an excellent test area. The results of this fundamental work will have significant impact on earthquake and volcano hazards mitigation all over the world, wherever subduction zones are found.

Steven Bohlen

coordinates the USGS Deep Continental Studies program and has made numerous contributions to research on the mineralogy of the Earth's crust and mantle

Deep Continental Studies Program Components

Regional crustal experiments: Regional studies traversing major geologic features in order to define crustal compositions, structures, and geologic processes. These studies are focused on Alaska, southern California, and the Washington-Oregon-northern California area.

Continental scientific drilling: Multiagency activities determining the origin of continents, examining the ocean-continent boundary, and seeking to understand the occurrence of natural resources and natural hazards. Drilling has taken place in Colorado, California, New Mexico, and Iowa; collaborative studies are ongoing with Germany and Russia.

Physics and chemistry of deep continental materials: Crustal investigations into chemical and mechanical interactions, quantitative changes in processes, magmatism and fluid production and movement, and the high-temperature and high-pressure properties of geologic materials.

For more information about the Deep Continental Studies program, contact Steven Bohlen at:

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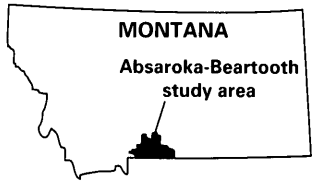
Mineral-Resource Surveys

Mineral-resource surveys provide the mineral-resource and mineral-environmental information required to make land-use and environmental policy decisions for effective management, preservation, and use of the Nation's lands and resources. The USGS is increasing its emphasis on environmental mineral investigations by developing and applying geochemical and geophysical techniques to regional and site-specific characterizations of the environment. For example, USGS geoscientists are helping to identify, characterize, and remediate environmental problems associated with active and abandoned mine sites. Selection and scheduling of study areas are conducted in close cooperation with Federal land-managing agencies, the U.S. Bureau of Mines (USBOM), State geological surveys, and the mining industry. The USBOM uses USGS estimates of undiscovered mineral resources to analyze potential mineral supplies, and the land-managing agencies use information from both agencies for planning land use and for estimating cumulative environmental impacts.

Evaluating Mineral Potential in National Forests

In response to a high-priority request from the U.S. Forest Service (USFS), the USGS assessed undiscovered mineral resources of 1.4 million acres of contiguous parts of the Gallatin and Custer National Forests in southwestern Montana. The USFS is using this information to develop comprehensive land- and resource-management plans for the Absaroka-Beartooth area, which lies within the Greater Yellowstone ecosystem.

The USGS provided quantitative estimates of undiscovered mineral resources to enable the USFS to evaluate the significance of the mineral potential. Most of the identified and estimated undiscovered resources of platinum, palladium, and chromium in the United States occur in the Absaroka-Beartooth study area. The USGS estimates that an additional 3,000 metric tons of platinum and palladium resources and 4 million metric tons of chromium resources are present in extensions of known deposits. Mean probabilistic estimates (in metric tons) for gross in-place undiscovered mineral resources include 200 tons of gold, 2,000 tons of silver, 130,000 tons of



molybdenum, 230,000 tons of nickel, 6.5 million tons of copper, and more than 6.5 million tons of chromium.

In this assessment, the USGS delineated a favorable tract for the occurrence of gold deposits on the basis of historical mining and exploration and a distinctive geologic environment in the southwestern part of the study area near Jardine, Mont. The USGS estimated a 50-percent probability that the tract contains at least 8.1 metric tons of gold in undiscovered deposits. Commercial exploration that started before the USGS study resulted in an announcement of a new discovery within the tract at Crevice Mountain that contains preliminary drill-indicated reserves of 12.4 metric tons of gold.

Among the results of the Absaroka-Beartooth study are new maps showing the geology, aeromagnetic and gravity data, and stream-sediment geochemical anomalies. Locations of mines, prospects, mineral occurrences, and tracts favorable for various types of mineral deposits also are included. Because these data are shown at the map scale used by the USFS (1:126,720), they can be easily incorporated into the USFS planning process as base maps for ecosystem management. The results of the USGS study are published in "Mineral-Resource Assessment of the Absaroka-Beartooth Study Area, Custer and Gallatin National Forests, Montana" (USGS Open-File Report 93–207).

Identified resources are defined as resources whose location, quality, and quantity are known or estimated from specific geologic evidence. Identified resources may be economic, marginally economic, or subeconomic. Identified resources include demonstrated (measured and indicated) and inferred resources.

Estimated undiscovered resources are defined as resources whose existence is only postulated; these postulated resources may be in deposits that are economic, marginally economic, or subeconomic.

Mineral Studies Help Protect Habitat

The USGS published a mineral-resource assessment requested by the Bureau of Land Management (BLM) for use in land-planning efforts to protect the habitats of the desert tortoise and the Mohave ground squirrel in the western Mojave Desert of southern California. The Western Mojave Management Area has been the site of mineral exploration and mining activity since the early 1800's. The USGS report (Open-File Report 92–595, "Evaluation of Selected Metallic and Nonmetallic Mineral Resources, West Mojave Management Area, Southern California") provides quantitative estimates of undiscovered gold, silver, copper, borate, lead, zinc, tungsten, iron, and molybdenum and qualitative descriptions of undiscovered saline, zeolite, and clay resources. The estimated value of undiscovered borate salts, which are used primarily in manufacturing glass fibers for insulation and textiles, is larger than that of all other quantified resources combined. USGS estimates of undiscovered mineral resources assist the BLM in developing reserve management plans that provide for multiple resource use while maintaining the viability of critical habitat areas for the desert tortoise and the Mohave ground squirrel.

Mineral-Environmental Investigations

Mineral-environmental studies apply geological, geochemical, and geophysical expertise to environmental challenges such as establishing geochemistry baselines, characterizing natural and human-induced hazardous sites, and predicting potential environmental impacts caused by mining. Studies underway for several ongoing mineral-resource assessments include:

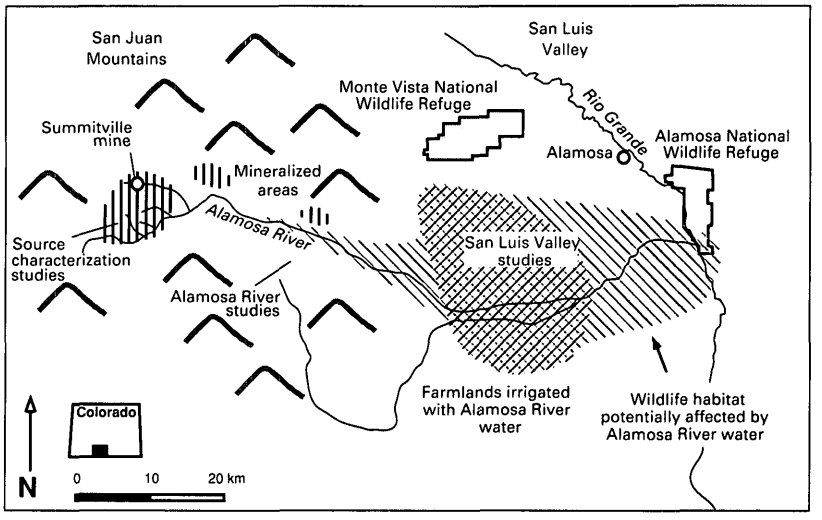
- In the Routt National Forest in northern Colorado, the USGS is conducting acid-mine drainage studies and analyzing stressed vegetation downwind from a powerplant.
- The USGS is comparing the soil and water chemistry of samples collected during FY 1993 with the chemistry of baseline samples collected before the recent opening of a smelter near the BLM's Mimbres Resource Area in southwestern New Mexico.
- In the Wenatchee National Forest in northeastern Washington, USGS scientists are comparing the geochemistry of natural drainage and mine drainage.
- A comprehensive mineral-environmental assessment is being prepared to complete the mineral-resource assessment of the San Juan National Forest in southwestern Colorado.

Minerals-Related Contamination

Water of the Alamosa River, which runs through the San Luis Valley in southwestern Colorado, is used extensively for irrigation, domestic purposes, and water supply to the Alamosa National Wildlife Refuge and nearby wetlands. Increasing concentrations of heavy metals and acid in the river water, attributed to recent mining at Summitville, Colo., have drawn national attention. These environmental problems are compounded by the erosion of natural sources of highly mineralized rocks in the San Juan Mountains and by contamination from historical mining. To address these problems, the USGS has begun site-specific studies at the now-abandoned Summitville mine and detailed geologic and geophysical work in the San Luis Valley.

At Summitville, USGS scientists are evaluating the contamination problems at and downstream from the mine. Geologists and geophysicists are working on a detailed map of the fracture systems and chemically toxic zones at the mine site to establish the hydrologic paths of contaminated water. These studies will provide information for onsite remediation by the Environmental Protection Agency (EPA). The USGS also is providing information to the EPA on the concentrations of chemical elements that have not been monitored previously in the Summitville drainages, on the geologic and geochemical processes that control the drainage chemistries, and on baseline geochemical conditions now present on the site before any reclamation or remediation.

The San Luis Valley downstream from the Summitville mine is being examined to determine the extent and effects of metal contamination in wetlands of the Alamosa National Wildlife Refuge and adjacent farms and forests. The studies are providing information on the changes in soil geochemistry that have resulted from the recent mining. Scientists are analyzing the metal content of tree rings from nearby forests to evaluate changes that have occurred through time. Other studies include monitoring the concentration and mobility of metals in irrigation-ditch sediments and ponds and comparing the metal concentrations in crops irrigated by Alamosa River water with those of crops irrigated by other sources.



The Summitville mine and its downstream environmental effects in the San Luis Valley, Colo.

Cooperators in the San Luis Valley studies include the Geologic and Water Resources Divisions of the USGS, the U.S. Fish and Wildlife Service, the Office of Surface Mining, the U.S. Forest Service, the EPA, the State of Colorado, local extension services, irrigation districts, and farmers.

Information and Technology Transfer

USGS geologists organized and taught an environmental geochemistry course in late April 1993 to more than 100 geologists, environmental consultants, regulators, and governmental officials concerned about minimizing the environmental impacts of mineral development. The course focused on the geochemical and biogeochemical processes that control how mineral deposits and mining byproducts interact with the environment. This course was one of several held in conjunction with the Society of Economic Geologists international meeting "Integrated Methods in Exploration and Discovery" in Denver, Colo.

The USGS continues to increase the effectiveness and accessibility of its nonfuel mineral-resource information. In FY 1993, the Minerals Information Offices (see p. 107 for locations) completed minerals-related research for 3,398 clients affiliated with industry and other business interests, government agencies, academia, trade associations, and the general public. Custom searches of the Mineral

Resources Data System, a data base of more than 90,000 mineral sites worldwide, helped resolve environmental, land-use, and exploration questions for more than 800 clients. The *Mineral Resources Newsletter*, an information digest of USGS and related mineral-resource activities, is distributed quarterly to more than 10,000 individuals and groups. In addition, mineral-related technology training was given to staff of the U.S. Forest Service, Department of State, and government agencies in Venezuela and Argentina.

Dede Bohn

has studied the geologic structure and mineral resources of the Western United States and Alaska for the past decade

For more information about mineral-resource surveys, contact Willis White at:

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Monitoring and Charting the Earth's Magnetic Field

The Earth's magnetic field, believed to be produced by movement in its fluid iron core, changes continuously and irregularly as magnetic north swings around true or geographic north. Precise determinations of magnetic declination (the difference between true north and magnetic north) are required for all maps and charts. Numerous Federal agencies require detailed geomagnetic data for statutory missions, including the operation of satellites.

The USGS operates 11 magnetic observatories, conducts magnetic field surveys to determine rates of changes in the magnetic field components, and works with other Federal agencies to obtain satellite data as part of a worldwide data collection effort. The USGS National Geomagnetic Information Center, located in Denver, Colo., collaborates with 30 international observatories to collect and exchange satellite data and makes these international data readily available to users in the United States.

In addition to the data collection projects, the USGS Magnetic Field Monitoring and Charting program funds research on a wide variety of topics. Variations in the geomagnetic field enable scientists to study many types of geologic processes, whose time spans range from mere seconds to millions of years, from deep within the Earth's core to the far reaches of space. Such studies include research on electromagnetic dynamo models of the Earth's molten core in an attempt to explain the origin of planetary magnetic fields; field polarity reversals, which are vitally important to paleomagnetic, archeomagnetic, and paleoclimatic research; conductivity of the Earth's crust and mantle; mathematical modeling to predict changes in the field; development of magnetic monitoring and measuring equipment, including data acquisition systems and methods; and relationships between solar-induced geomagnetic disturbances and long-term global weather patterns.

The program provides advice and information to people in other governmental agencies, the academic community, and the private sector. Services provided include the calibration of magnetic instruments, recommendations on the installation and operation of magnetic equipment and data acquisition systems, and advice on methods for identifying and eliminating magnetic influences on satellite spacecraft.

Precise determinations of the difference between true north and magnetic north are useful in a number of different applications, including charts and maps produced by various Federal agencies:

- USGS topographic maps and military, Federal Aviation Administration, and National Oceanic and Atmospheric Administration navigational charts.
- Aeromagnetic anomaly maps used in exploration for fossil fuels, geothermal energy, and minerals.
- Studies of geologic structures associated with earthquake and volcano hazards.
- Prediction of atmospheric conditions that affect missile flight and disrupt satellite data transmissions.
- Information concerning potential communications disruptions caused by solar flares.
- Monitoring of real-time magnetic indices that contribute to the U.S. Global Change program by providing basic information on changes in the Earth's magnetic field, especially those caused by solar activity (sunspots).
- Determinations of the attitude of many spacecraft.
- Retracing old boundaries and settling court disputes.

World Magnetic Charts Available

A series of world magnetic charts published in 1993 shows the magnetic declination, horizontal and vertical intensities, inclination, and total field intensity components of the Earth's magnetic field. These charts display contours of the absolute values of each component for the current magnetic epoch. Additionally, each chart displays contours of the average rate of change in that component, so that a user can compute a localized field value for a short period of years before and after the epoch date of the chart.

To improve the data available to its users, the National Geomagnetic Information Center, with the support and cooperation of other agencies, established new magnetic observatories in Hungary, Brazil, and India to fill large gaps in global data availability. These observatories are owned and operated by the countries in which they are located. The data are available in near real time for use by USGS researchers and other users in the United States.

John Wood

coordinates the USGS Magnetic Field Monitoring and Charting program and has written extensively on the Earth's magnetic properties

To access the base computer models developed in publishing these magnetic charts, call 1 (800) 358–2663.

For more information on monitoring and charting the Earth's magnetic field, contact Donald Herzog at:

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Internet herzog@gldfs.cr.usgs.gov

Ice-Core Laboratory Dedication

Climate changes can result from both human actions (emissions of carbon dioxide, methane, and other greenhouse gases) and natural events (volcanic eruptions or meteorite impacts). By studying the record of climate changes preserved in ice, scientists may be able to evaluate current changes in the atmosphere and predict future changes. To that end, the most advanced ice-core laboratory in the world was dedicated in Denver, Colo., in August 1993. A joint effort of the National Science Foundation, the University of Colorado, and the USGS, the laboratory is the only storage and curatorial facility for ice cores in North America. The lab allows scientists to examine and measure ice cores, and it preserves these ice samples in a long-term repository for present and future investigations. The cores are stored in a continuously monitored cold room at a controlled temperature of −31 °F. In an adjacent laboratory kept at a more temperate climate of −10 °F, scientists can examine the 1-meter lengths of cores in "relative comfort." The laboratory's data base can be accessed remotely by telephone, so that researchers throughout the world can review repository holdings.

The laboratory, housed at the USGS Denver facility, curently holds more than 10,000 meters of ice cores from the polar caps of Antarctica and Greenland, including the world's deepest ice core, the GISP2, from central Greenland. Climate records now being reconstructed from the GISP2 core have fundamentally changed the way scientists view climate change and indicate that major shifts in temperature and precipitation can occur in as few as 5 years rather than centuries, as previously thought. These ice cores also provide the only known direct record of atmospheric changes over the last 250,000 years.

For more information on the ice-core laboratory, contact:

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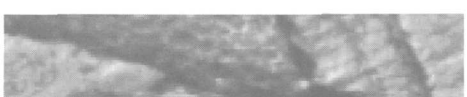
Internet jfitz@bpgsvr.cr.usgs.gov

Elizabeth Ann Rieke, Assistant Secretary for Water and Science (center), and Robert M. Hirsch, Acting Director of the USGS, join ice-core lab technical director Joan Fitzpatrick for the August 1993 dedication of the new facility.

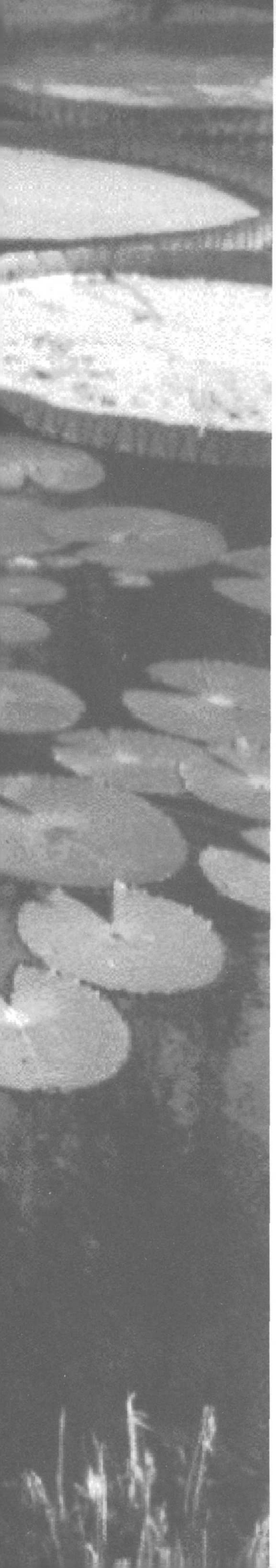


At Work Across the Nation in Water Resource Investigations

Mission

The USGS has the principal responsibility within the Federal Government to provide the hydrologic information and understanding needed by others to achieve the best use and management of the Nation's water resources. To accomplish this mission, the Water Resources Division, in cooperation with State, local, and other Federal agencies:

- Systematically collects and analyzes data to evaluate the quantity, quality, and use of the Nation's water resources and provides results of these investigations to the public.
- Conducts water resources appraisals describing the occurrence, availability, and physical, chemical, and biological characteristics of surface and ground water.
- Conducts basic and problem-oriented hydrologic and related research that aids in alleviating water resources problems and provides an understanding of hydrologic systems sufficient to predict their response to natural or human-caused stress.
- Coordinates the activities of Federal agencies in the acquisition of water resources data for streams, lakes, reservoirs, estuaries, and ground water.
- Provides scientific and technical assistance in hydrologic fields to other Federal, State, and local agencies, to licensees of the Federal Energy Regulatory Commission, and to international agencies on behalf of the Department of State.
- Administers the State Water Resources Research Institutes Program and the National Water Resources Research Grants Program.



Of Floods and Forecasts: Critical Water Information for the Nation

Water-data stations at selected locations throughout the Nation are used by the USGS Hydrologic Data Collection program to obtain records on stream discharge (flow) and stage (height), including floodflow monitoring; reservoir and lake stage and storage; well and spring discharge and ground-water levels; and the quality of surface and ground water. These data provide a continuing record of the quantity and quality of the Nation's surface- and ground-water resources and thus provide the hydrologic information needed by Federal, State, and local agencies and the private sector for the development and management of land and water resources.

In cooperation with State and local agencies, the USGS collects, stores, analyzes, and disseminates data on water use for the Nation. Every 5 years since 1950, the National Water-Use Information program has prepared estimates of (1) water withdrawn from surface- and ground-water sources, (2) consumptive use, and (3) instream use and wastewater releases. These reports, the latest of which was published in 1990, are used to develop and evaluate trends in water use and to plan for more effective uses of the Nation's water resources in the future.

The Flood of 1993

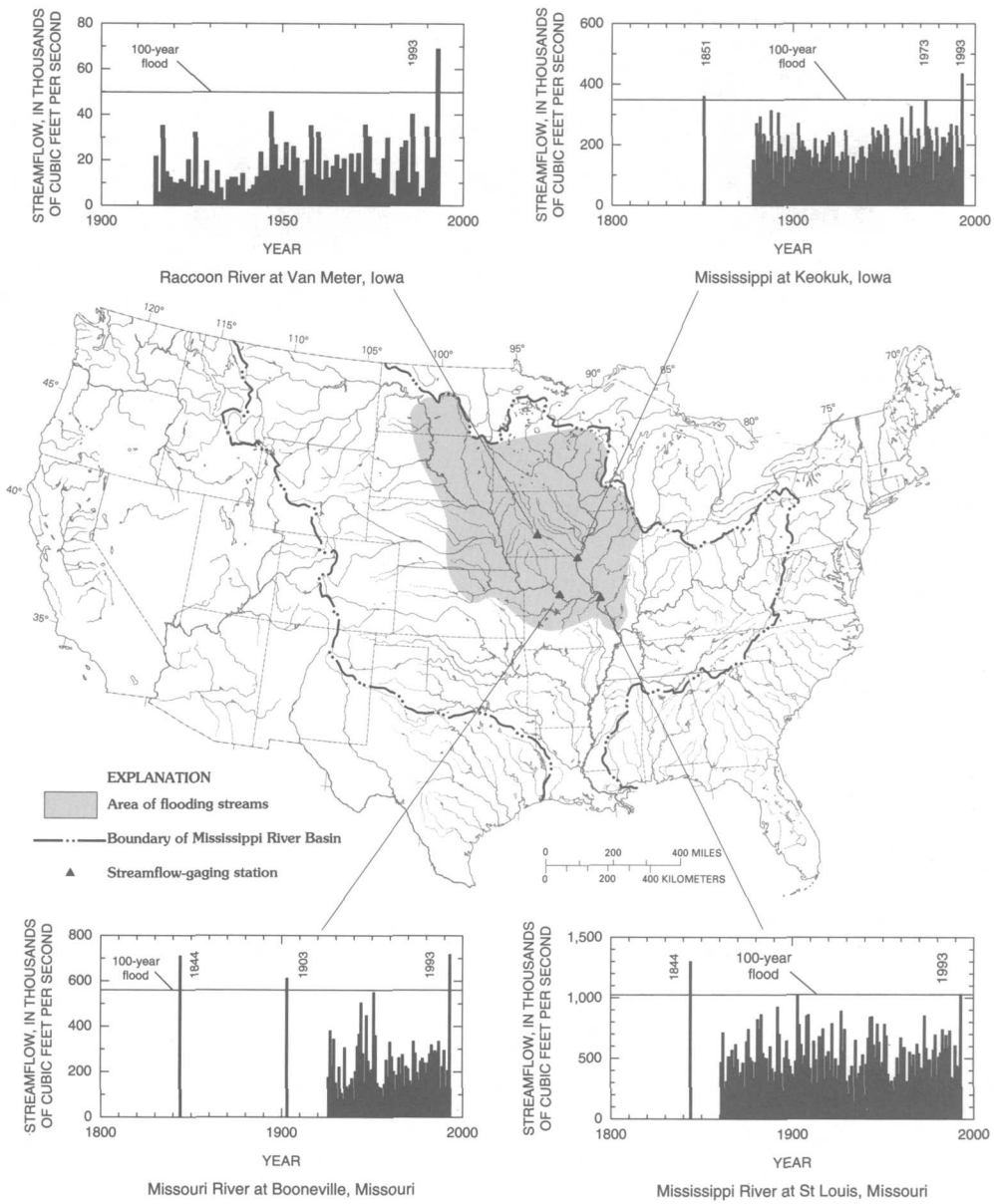
The months of June to August 1993 will long be remembered by the people of the Midwest as the "Summer of the Flood." The floods, which were the result of a succession of severe storms in the upper Mississippi River Basin, were the most severe, in terms of damage, in the history of the United States. Unofficial estimates of damage to property and agricultural losses have been as high as $10 billion, and many tens of thousands of people were forced from their homes.

The flooding presented the USGS with the scientific challenge of monitoring floodwaters in extremely hazardous conditions and conducting followup studies that will help planners and managers in the affected States recover from this year's natural disaster and plan appropriately for future floods. During the floods, the USGS furnished continuous information on streamflow and other related topics to the National Weather Service (NWS), the U.S. Army Corps of Engineers, the Federal Emergency Management Agency (FEMA), and many State and local agencies as part of its mission to provide basic data on the Nation's surface- and ground-water resources at more than 50,000 sites across the United States. The NWS uses the data in forecasting floods and issuing flood warnings. The Corps uses the data to manage water projects, such as diversions, dams, locks, and levees. FEMA and many State and local emergency management agencies use USGS hydrologic data and NWS forecasts as part of the basis of their local flood-response plans.

The flood of 1993 was the result of a series of unusual climatic factors. A wet spring followed by record-breaking rains in June and July produced more than a year's worth of precipitation in 7 months, which in turn produced the record-breaking floods on the Mississippi River. Precipitation was as much as 200 percent of normal for the 6 months preceding the June and July storms. As a result, streamflows were also well above normal, reservoirs were filled to the point where little reserve storage capacity remained, and wet soil conditions were conducive to runoff of most of the later rainfall.

Extreme streamflows—ones that exceeded the 100-year recurrence interval—were recorded at 45 stream-gaging stations in 9 States.

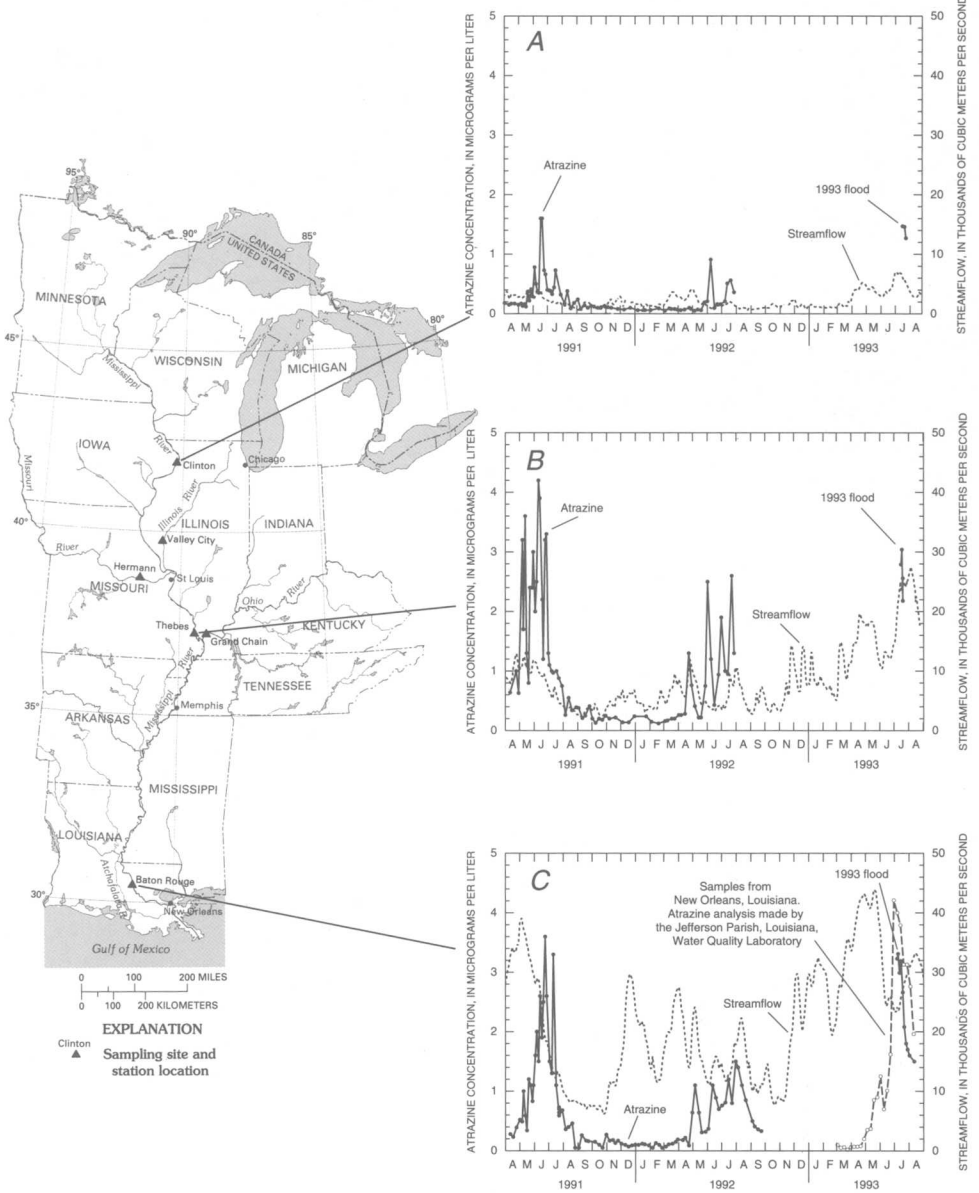
In June and July, the jet stream consistently dipped abnormally south over the Plains area east of the Rocky Mountains. That stalled weather system, coupled with a high-pressure zone in the



Historical peak discharges and peak discharges for the 1993 flood at selected streamflow-gaging stations in the upper Mississippi River Basin.

H. WILLIAM HADFIELD

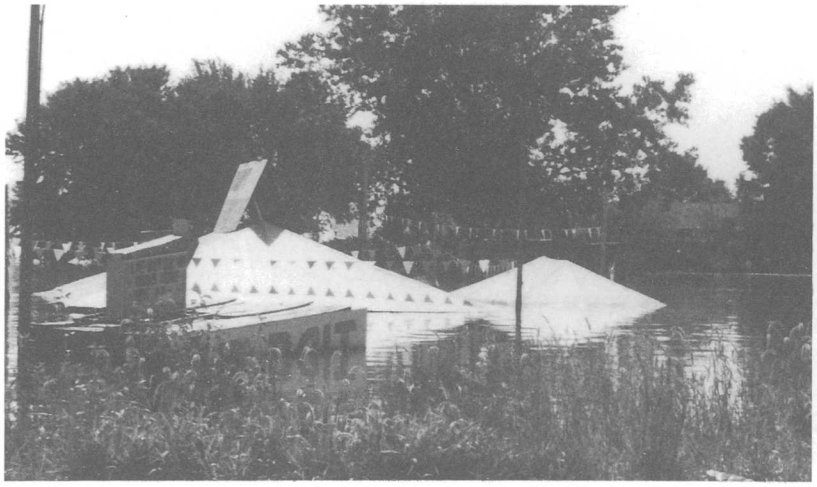
Flooded filling stations on Highway 67 at West Alton, Mo. (July 26, 1993).



Streamflow and temporal distribution in the concentrations of atrazine at three sites on the Mississippi River from April 1991 through August 1993. *A*, Clinton, Iowa; *B*, Thebes, Ill.; *C*, Baton Rouge, La.

H. WILLIAM HADFIELD

This flooded farmhouse near West Alton, Mo., was on high ground surrounded for many weeks by floodwaters of the Missouri and Mississippi Rivers (July 26, 1993).



H. WILLIAM HADFIELD

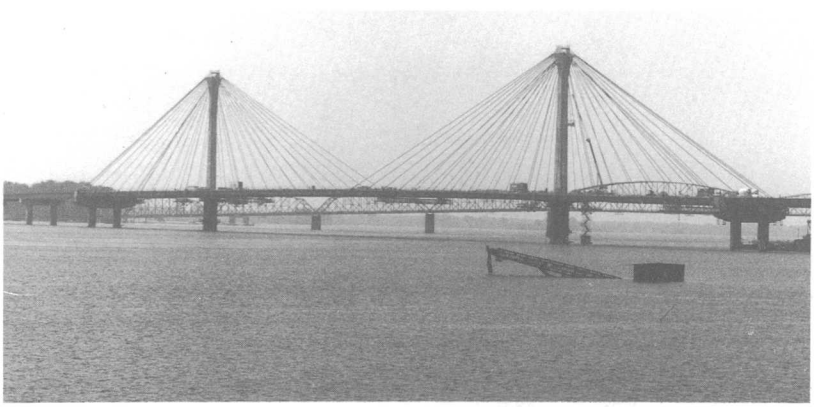
Submerged "Fresh Bait" shops along Highway 67 near West Alton, Mo. (July 26, 1993).

H. WILLIAM HADFIELD

The ConAgra flour mill and entrance to the Great River Road in Alton, Ill., at the confluence of the Mississippi and Missouri Rivers. The front doors to the mill are nearly under water 1 week before the flood crest (August 1, 1993). The old high-water marks painted on the sides of the building are already covered by the floodwaters (July 26, 1993).

NICK B. MELCHER

Interstate Highway 80 spans the Des Moines River in flood upstream from Des Moines, Iowa (July 12, 1993).



H. WILLIAM HADFIELD

The new Alton Bridge still under construction and submerged crane in foreground. The riverbank, which is hidden by the flood, is at the first pier of the new bridge (on the right) below the cables and white cement trucks. Usually, 20 to 30 more feet of the main bridge support towers are visible above the water line (August 9, 1993).

Southeastern United States, brought large amounts of warm, moist air into the upper Midwest where it collided with the cool, dry air and caused repeated severe rainfalls. All or parts of nine States in the Midwest received large amounts of precipitation that resulted in floods on many streams in June, July, and August. Extreme streamflows—ones that exceeded the 100-year recurrence interval—were recorded at 45 stream-gaging stations in 9 States. All-time record-high flows—some that were more than twice the previous record—were measured on streams in Minnesota, Iowa, South Dakota, Nebraska, Kansas, Missouri, and Wisconsin.

The timing of the June and July storms was another critical climatic factor in the resulting flooding. Floodwaters from storm runoff in northern parts of the upper Mississippi River Basin reached downstream points at about the same time as later storm runoff from tributaries lower in the basin, which contributed to the magnitude of peak discharges at some sites on the Mississippi and lower Missouri Rivers.

The recurring storms throughout most of the upper Mississippi River Basin resulted in long periods when rivers were

above flood or bankfull stage. The Mississippi River at St. Louis, Mo., for example, was above flood stage for more than 10 weeks. Total volume of runoff at this location during July and August 1993 was more than 400 percent above normal for these months. The peak stage at this site on August 1, 1993, exceeded the previous maximum recorded stage by more than 6 feet. New maximum peak stages for the period of record were set at more than 60 gaging stations. Some of these new record stages may have been influenced by construction of levees or other channel alterations and were not necessarily coincident with new record peak discharge.

The hydrologic and social effects of runoff throughout the flood area were severe and widespread. Although most Federal levees withstood the floods, many others that protected populated areas or agricultural land either were overtopped or failed. One failed levee on the Raccoon River in Des Moines, Iowa, caused this city of 250,000 people to be without drinking water for 19 days. Other cities experienced similar disruptions in their water supply delivery systems. Thousands of acres of land were inundated along the Mississippi and Missouri Rivers and their major tributaries. Damaged highways and submerged roads disrupted overland transportation throughout the flooded region. Many bridges in the flood-affected area were inundated, and some failed owing to scour of the channel bed by the fast-moving floodwaters and subsequent failure of bridge piers or abutments. At the State Route 51 bridge at Chester, Ill., downstream from Ste. Genevieve, Mo., more than 20 feet of scour occurred around one bridge pier. The Mississippi and Missouri Rivers were closed to navigation before and after the flooding. Millions of acres of productive farmland remained under water for weeks during the growing season, and severe erosion caused rills and gullies in many tilled fields throughout the Midwestern U.S. farmbelt. Banks and channels of many rivers were severely eroded, and sediment was deposited over large areas of the basin's flood plain. The record flows submerged many areas that had not been affected by previous floods. Because industrial and agricultural areas were inundated, there was concern about the transport and fate of industrial chemicals, sewage effluent, and agricultural chemicals in the floodwaters.

H. WILLIAM HADFIELD

Looking toward Missouri from Alton, Ill. The old Clark Bridge (Highway 67) spanning the Mississippi River was kept open during most of the flood, closing for only 1 week during the crest. Dust visible at the end of the bridge (right) is from traffic on gravel that was used to build up the upper (new) roadway about 6 feet above the floodwaters. The lower (old) section of the roadway had been flooded for quite some time before this photograph was taken on August 9, 1993.

H. WILLIAM HADFIELD

Farm buildings under water just west of the canal that bypasses, on the Illinois side, the Chain of Rocks segment of the Mississippi River north of St. Louis, Mo. (July 26, 1993).

Herbicide concentrations in Midwestern farmbelt streams typically are highest in late spring and early summer, shortly after application of the herbicides to cropland. The wet spring in 1993 delayed planting of crops in parts of the upper Midwest, so most of the planting and subsequent application of herbicides

STEVEN J. KALKHOFF

South Skunk River near Colfax, Iowa, floods roads and farmsteads (July 12, 1993).

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occurred in late spring or summer during short dry periods. Whereas it was anticipated that abnormally high streamflows in 1993 would dilute the herbicides to lower-than-normal concentrations in the Mississippi River, the intense and sustained rainfall that began soon after the herbicides were applied, together with the widespread extent of the rainfall on the farmbelt, caused larger-than-normal amounts of herbicides to be flushed into the streams. As a result, concentrations of herbicides such as atrazine were similar to the maximum levels (about 3 parts per billion for atrazine) measured in previous years when streamflows were much lower. Once herbicides reach streams, they persist for longer periods of time than they do in the soil because streamwater contains less organic matter and fewer microorganisms to degrade the chemicals. Consequently, most of the large amounts of herbicides that were flushed into the Mississippi River and its tributaries ultimately were transported to the Gulf of Mexico.

Concentrations of nitrate in streams were similar to levels measured in previous years. The concentrations at all sites were well below the drinking-water standard of 10 parts per million of nitrate. The large total loads of nitrate flushed into the Gulf of Mexico during midsummer present a longer term concern because the higher nitrate load could stimulate algal growth and affect the Gulf ecosystem along the Louisiana coast. Monitoring by the National Oceanic and Atmospheric Administration showed that the salinity of surface water in the Gulf shelf was lower than average for this time of year and that the phytoplankton biomass was higher than average, all of which could be attributed to larger-than-average seasonal inflows of freshwater and nutrients, such as nitrate.

The hydrologic legacy of the flood of 1993 is far from over. USGS hydrologists are conducting a series of investigations to document the effects of the flooding and to improve understanding of the related processes. A special publication series (USGS Circular 1120) documents various aspects of the flood. The series includes data and findings on the magnitude and frequency of peak discharges; precipitation; water-quality characteristics, including nutrients and man-made contaminants; transport of sediment; assessment of sediment deposited on flood plains; effects of inundation on ground-water quality; flood-discharge volume; effects of reservoir storage on flood peaks; stream-channel scour at selected bridges; extent of flood-plain inundation; and documentation of significant geomorphic changes.

Charles W. Boning
has acquired extensive experience in surface-water data collection and hydraulic analysis of stream systems in his 33 years with the USGS

Forecasting Water Demand

With the implementation of the National Water-Use Information (NWUI) program in 1978, the USGS began to establish the framework for studying the water-demand side of the water-supply-and-demand equation. As the era of building large dams and conveyance systems draws to a close, the transition is well underway to an era of integrated water management that balances water-supply management options with water-demand management options. The NWUI program is in a position to support the transition to integrated water management and to analyze and evaluate the growing emphasis on water-use accounting, water-use efficiency, conservation, water-demand modeling, and other demand-management options that are occurring in the 1990's. The USGS has established water-demand forecasting studies with a number of cooperators.

Florida.—In cooperation with the Florida Department of Environmental Regulation (FDER), the USGS has forecasted drinking-water needs for each county in Florida for the years 2000, 2010, and 2020 by determining, for each county, (1) the projected population, (2) the percentage of projected population that will be served by a public-supply water system, and (3) the projected per capita use. The FDER will use these projections as a basis for making informed decisions regarding the protection and management of drinking-water resources in Florida.

Tennessee.—The USGS, in cooperation with the Upper Duck River Development Agency (UDRDA) and the Tennessee State Planning Office, conducted a study of water use and availability in the Duck River basin above Columbia, Tenn.

The Duck River is the main source of water for public supply, industry, commerce, and agriculture in the basin. The members of the UDRDA are concerned that existing water supplies will not meet future water demands without an additional surface-water impoundment of the Duck River at Columbia. This study forecasts annual water demand for 5, 10, and 25 years on the basis of anticipated growth in the area. These projections, in conjunction with other flow-duration characteristics, demonstrated that the Duck River cannot meet future water-use requirements without additional storage.

California.—As part of an ongoing effort to better manage the water resources in the Salinas River basin, the USGS is assisting representatives from the Monterey County Water Resources Agency (MCWRA) in quantifying existing water use and in estimating future water demands in the municipal, commercial, and industrial sectors of the Salinas River basin. The results are being linked to information acquired from studies and analyses of agricultural and other basin users that were conducted jointly by the Bureau of Reclamation and the MCWRA.

Colorado.—In cooperation with the Denver Water Department (DWD), the USGS has analyzed weekly (1980–87) and hourly (1986–87) water-use data for 16 study sites in the city and county of Denver. Linear relations developed for estimating seasonal water use were based on lot size and billing type (flat rate versus block rate). Outdoor water use, the largest use of water, was significantly related to lot size. The data were used by the DWD to support a change from a flat rate to a metered billing system.

Wayne B. Solley
has been in charge of the National Water-Use Program for the past 10 years

Coordinating Water Information for the Nation

Water resources information is acquired by and shared among thousands of Federal, State, and local government agencies, Native American tribes, private groups, and individuals. Federal agencies, including the Departments of Agriculture, Commerce, Defense, Energy, Interior, and Transportation, as well as the Environmental Protection Agency, the Tennessee Valley Authority, and other independent Federal agencies, use water resources information in the construction and operation of water projects, forecasts and emergency response, management of natural resources, environmental regulations and enforcement, interstate and international treaties and compacts, and research. Federal and non-Federal organizations use water information to manage natural resources, protect the environment, and develop and operate the Nation's infrastructure. The USGS leads the effort to encourage cooperation and to provide water-resources information that is responsive to the public need.

Water Information Coordination

The Water Information Coordination Program (WICP), for which the USGS has lead responsibility, was established by guidance from the Office of Management and Budget (Memorandum No. M–92–01). WICP is designed to ensure that water information is available for effective decisionmaking at all levels of government and the private sector in order to manage natural resources and protect the environment.

WICP promotes active partnerships among all water resources information collectors and users to achieve more effective and economical natural-resource management and environmental protection. These partnerships also are needed to avoid duplications of effort and to make better use of available resources to meet water-information requirements.

Major accomplishments under the program in FY 1993 include:

- Publication of a report titled "Ambient Water-Quality Monitoring in the United States" prepared by WICP's Intergovernmental Task Force on Monitoring Water Quality (see following article).
- The Secretary of the Interior established a subcabinet-level steering committee, chaired by the Assistant Secretary for Water and Science, to oversee the implementation of WICP.

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WICP's goals are being accomplished by focusing on four major aspects of coordination: (1) review by Federal and non-Federal organizations of water-information collection and dissemination programs to evaluate their effectiveness and to identify needed changes; (2) development of plans and priorities that can adjust existing information-collection activities to meet current and future needs more effectively and efficiently; (3) development and dissemination of consensus water-information standards and identification of comparable sampling and analytical methods, which will assist in integrating data and ensure consistency of those data; and (4) development and implementation of plans and procedures to improve the availability and usefulness of data and interpretive products.

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- Participation of the private sector in WICP through the Advisory Committee on Water Data for Public Use (ACWDPU), chaired by the Director of the USGS. At the ACWDPU meeting July 14 and 15, 1993, a new subcommittee—the National Water-Quality Assessment Advisory Council—was established, which includes representatives of ACWDPU member organizations and Federal agencies.

Nancy C. Lopez
is Chief of the Office of Water Data Coordination and has had more than 25 years of experience as a hydrologist in both the Federal and the private sectors

Needed: Better Water-Quality Information

More than $500 billion has been spent on water-pollution abatement since the 1970's, but the effectiveness of these investments in achieving the objectives of the Clean Water Act and other Federal and State legislation related to water quality is inadequately documented. Better water-quality information is needed to evaluate the effects of past or present water-pollution control efforts on the Nation's fresh surface-water, coastal-water, and ground-water resources and to effectively manage those efforts. Because of this need for better information, numerous groups have requested greater coordination, consistency, and collaboration among Federal, State, and local agencies engaged in water-quality monitoring activities.

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The Intergovernmental Task Force on Monitoring Water Quality (ITFM) is a partnership between Federal, State, interstate, and tribal agencies to improve water-quality monitoring nationwide. The Environmental Protection Agency (EPA) and the USGS began discussions in April 1991 to develop a strategy for solving a number of pervasive problems associated with water-quality monitoring activities. Subsequent discussions with representatives of other Federal and State organizations led to general agreement that a joint task force was needed to improve water-quality monitoring. The ITFM began work in January 1992.

The ITFM is part of the implementation of a 1991 Office of Management and Budget (OMB) directive to strengthen nationwide coordination of water information. The USGS has the lead responsibility for the Water Information Coordination Program, and other Federal agencies are active participants. The ITFM is chaired by an EPA representative; a USGS representative serves as vice chair, and the USGS provides administrative and management support. Members of the ITFM currently include 10 Federal and 10 State and interstate agency representatives. To date, over 90 additional Federal, State, and other governmental agency representatives have been involved in the deliberations of the ITFM and its task groups on institutional framework, environmental indicators, data-collection methods, data management and information sharing, and assessment and reporting.

The ITFM's first report, "Ambient Water-Quality Monitoring in the United States: First Year Review, Evaluation, and Recommendations," was released in 1993 in response to an OMB requirement to evaluate water-quality monitoring and recommend improvements. The report proposes implementing an overall strategic plan to improve water-quality monitoring by assessing status and trends in the United States. Many of the basic approaches recommended in the initial report, however, also would improve monitoring to meet four other recognized purposes: characterizing existing and emerging problems, designing and implementing water management and regulatory programs, evaluating program effectiveness, and responding to emergencies. The ITFM views water-quality monitoring as encompassing the full range of activities required to obtain, manage, store, interpret, present, share, and report water-quality information useful to decisionmakers and the public. Such monitoring is an integrated activity for evaluating the physical, chemical, and biological character of water in relation to human health, ecological conditions, and designated water uses.

The ITFM report recommends that:

- An integrated, voluntary, nationwide strategy for water-quality monitoring is needed to enhance the implementation of defensible water-quality programs and management decisions. A national intergovernmental committee will oversee implementation of the strategy.

- Changing water programs require changes in monitoring. Water management programs are changing to focus on multimedia, geographically based activities; biological and ecological information; and nonpoint source, wetlands, and sediment concerns. Water-monitoring programs must be responsive to these changing information needs.

An integrated, voluntary, nationwide strategy for water-quality monitoring is needed. . .

- Better integration of water-quality monitoring activities is now achievable because public and private organizations are more open to cooperation. Also, recent technological advances have created new opportunities to improve water-quality monitoring.
- Monitoring investments will be more effective through integration of existing programs to sharpen monitoring objectives, improve data consistency, and facilitate more effective interpretation and reporting.
- Everyone interested in monitoring should be invited to participate in developing and implementing the process, to help refine the recommendations, and to initiate the proposed changes needed to improve monitoring activities.
- Training programs for personnel from participating agencies should be established to support implementation of the strategic plan.

Bernard A. Malo
is the executive secretary of the ITFM and the recipient of several awards from the American Society for Testing and Materials for his standards development work with the Committee on Water

Improved Access to Water Information

The USGS, the Nation's largest earth-science agency, makes extensive use of computer technology to accomplish its mission. Data-base management is a large part of the computational workload of USGS water resources programs because hydrologic data are collected in all 50 States, Puerto Rico, and the Pacific Islands Trust Territory. Streamflow is measured at about 10,000 locations, water levels are measured in about 31,000 wells, water quality is sampled at over 11,000 locations, and water-use data are collected throughout the Nation. All of these data are stored in computerized data bases and in a new system called the National Water Information System-II.

National Water Information System-II

The National Water Information System-II (NWIS-II) provides a single data system for storing and processing basic data in support of environmental assessments. NWIS-II also functions as an archive for all data used in completed studies and in published products of the USGS and as a depository for hydrologic and related environmental data. NWIS-II was developed in cooperation with other agencies, including the Environmental Protection Agency (EPA) and the National Oceanic and Atmospheric Administration.

NWIS-II has been developed as a distributed data-base management system on a network of workstations and file servers using a UNIX operating system and the INGRES relational data-base management system. The software and data are being distributed on file servers located in about 100 USGS offices

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throughout the country. Data and functional capabilities of the NWIS-II include:

- An integrated data base of water-chemistry analyses, biological surveys, streamflow data, well and aquifer characteristics, water use, sediment surveys, and related location and land-use descriptions. Data structure also provides the capability to store information on the history of activities, participants, methods, and equipment used to collect, process, and analyze environmental data.

Data. . .include 3.4 million water-quality analyses, 780,000 station-years of streamflow data, and well and aquifer characteristics for more than 1 million sites.

- Data transferred from existing data-base systems of the USGS, which include 3.4 million water-quality analyses, 780,000 station-years of streamflow data, and well and aquifer characteristics for more than 1 million sites.
- A graphics interface using multiple windows, which insures that the system is efficient and flexible for the user.
- Flexible input and update capability, which includes support for keyboard entry, abbreviations, and mouse-driven selections from pick lists.
- Extensive reference lists, which include location descriptions from the USGS Geographic Names Information System, 13,000 parameters that correspond to EPA's STORET parameter codes, and the National Ocean Data Center's (NODC) taxonomic file. The NODC file has more than 200,000 taxa, including many vertebrates, invertebrates, and algae.
- Links to water-quality and taxonomy laboratories, by which the user can request analytical and identification services, container labels with bar codes can be created, and laboratories can transmit results to the user for storage on a file server in the office originating the request.
- A flexible data retrieval and report system, which supports both X-Window and character-based hardware for producing export files, ASCII reports, and publication-quality reports.

NWIS-II was developed and is being released as two components. The first component, released in 1993, consists of subsystems for inputting, updating, processing, and storing locational, water-quality, ground-water, and biological data. The second release, scheduled for early in 1994, includes subsystems for processing streamflow, sediment-transport, and water-use data, including the capability to process data by using a geographic information system (GIS) interface. Access to NWIS-II by other governmental agencies and the general public will continue to be granted through the USGS National Water Data Exchange office located in Reston, Va.

Thomas H. Yorke

has managed water-resources monitoring and research activities for more than 10 years and for the past 3 years has been responsible for the operation and maintenance of USGS hydrologic data systems, including the development of NWIS-II

Distributed Information System-II

A Distributed Spatial Data Library is also being developed and implemented. This online library is a collection of spatial data, programs, and techniques, a portion of which is located at each Water Resources Division office. Data, documentation, computer programs, and other electronic documents are accessible to the public through any software that is compatible with the Wide-Area Information System (WAIS) communication protocol.

The Distributed Information System-II (DIS-II), an advanced minicomputer-based distributed information system that was implemented beginning in February 1991, provides a new generation of computer hardware and software and a migration to open-systems technology. The system can be procured and used with and can be connected to other DIS-system computers throughout the USGS and other bureaus of the Department of the Interior.

DIS-II workstations/servers are powerful desktop computers equipped with

high-resolution graphics monitors and software and peripheral devices that permit the most advanced tasks to be conducted at each individual workstation. Every USGS Water Resources Division office has its own system of workstations and supporting devices. Because these workstations are interconnected by Ethernet, a local-area network, information, equipment, and programs can be shared among all workstations in an office.

The workstation/server approach has dramatically improved the computing response times for scientists and researchers from within and outside the USGS.

Data-processing activities for the water resources program are coordinated with other USGS programs, other Department of the Interior bureaus, and other Federal agencies, such as the Environmental Protection Agency, that have an interest in developing collections of spatial data for environmental analyses. Coordination is effected through participation in the Federal Geographic Data Committee, the Department of the Interior Geographic Data Committee, the USGS Geographic Data Committee, and the GIS Laboratory Steering Committee.

Gloria J. Stiltner
has been involved with or directed the implementation of DIS-II since 1983

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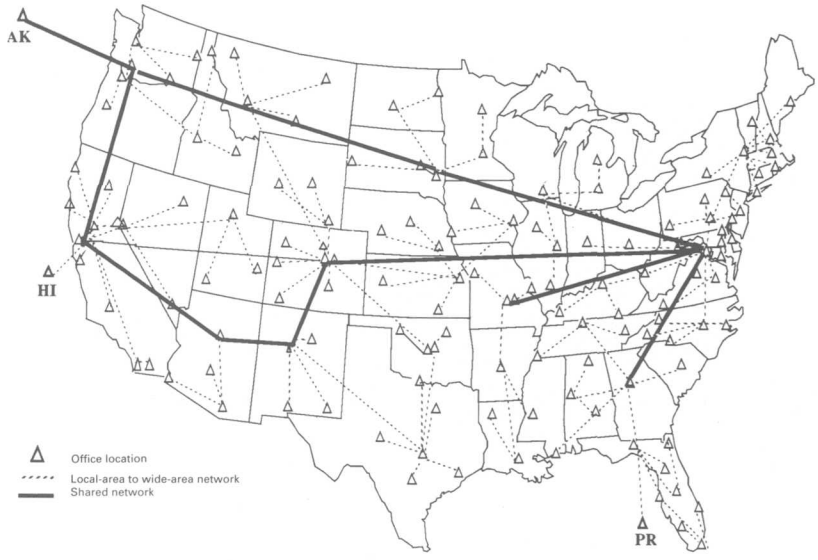


Workstation computers are connected to a wide-area telecommunications network known as the Distributed Information System-II. A wide-area Transmission Control Protocol/Internet Protocol (TCP/IP) communications routing-based network connects all USGS Water Resources offices using the DIS-II. Thus, a user of any DIS-II system can connect to any other DIS-II system, move files, or gain access to remote data bases. The DIS-II communications network is based on high-performance TCP/IP routers running at speeds of from 56 kilobytes per second to 1.5 megabytes per second. Shared-data communication networks are cost effective and enable users at all sites to share data with universities, research centers, and private organizations.

A USGS hydrologist demonstrates one of the functions available to users on the DIS-II network at the National Computer Technology meeting held May 17–22, 1992, in Norfolk, Va.

Assessing the Quality of the Nation's Water

During recent decades, the Nation has made major investments in water-quality management and protection, and the potential exists for much larger investments in the future. Considerable sums of money also have been spent on acquiring water-quality data for many purposes. Until the recent implementation of the National Water-Quality Assessment (NAWQA) program, however, the capability to provide consistent information on the status, trends, and causes of the condition of surface- and ground-water quality nationwide did not exist. This information is needed to determine whether past investments in improving water quality have been cost effective and to provide a sound basis for future decisions.

Under the NAWQA program, assessments of surface- and ground-water quality conditions are being conducted in 60 major river basins and aquifer systems throughout the Nation. Assessments began in 20 study units in 1991 (20 study units are being added in 1994 and a final 20 in 1997).

Point versus Nonpoint Sources of Phosphorus in Rivers

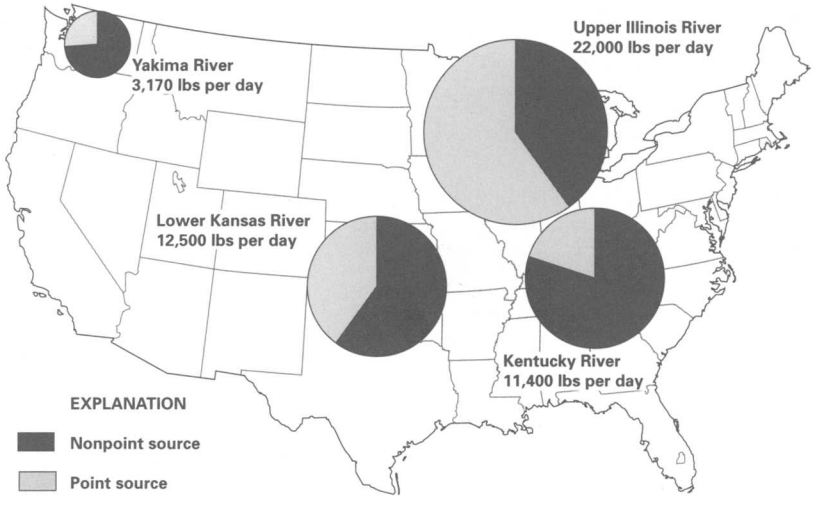
A major component of the NAWQA program, referred to as "national synthesis," combines study-unit findings with existing data as well as data from large regional water-quality surveys to characterize and explain, to the extent possible, similarities and differences in the occurrence and distribution of pesticides and nutrients nationwide. This study of the relative magnitudes of point and nonpoint sources of phosphorus in streams draining four river basins is an example of these synthesis efforts.

A major topic of discussion in congressional hearings on reauthorizing the Clean Water Act of 1972 is the magnitude and extent of nonpoint-source pollution and its effect on the Nation's streams and aquifers. The reason for this concern is the recognition that the Nation has made a considerable investment to control pollution from point sources and, although these investments are believed to have been successful, additional upgrading of wastewater-treatment levels may not be cost effective for achieving further improvements in water quality. Thus, water resources management agencies are increasing their focus on controlling nonpoint sources of contaminants to improve water quality. Phosphorus is of particular concern. At elevated levels in streams and rivers draining into lakes and estuaries, phosphorus causes nuisance growths of algae and aquatic plants.

The four river basins studied—the Kentucky River basin in Kentucky; the upper Illinois River basin in Illinois, Indiana, and Wisconsin; the lower Kansas River basin in Kansas and Nebraska; and the Yakima River basin in Washington State—were part of the NAWQA pilot effort. In general, phosphorus loads (in pounds) and yields (in pounds per square mile) in the upper Illinois and Kentucky River basins were significantly larger than in the lower Kansas and Yakima River basins because of differences in average annual streamflow between the basins. The average annual streamflow from the Kentucky and upper Illinois River basins is more than 2.5 times larger than that from the lower Kansas and Yakima River basins.

Phosphorus yields were largest for the upper Illinois River basin. The upper Illinois River basin has the largest percentage (75 percent) of land devoted to cultivated row crops, the largest phosphorus fertilizer application rates, and, because of the large population in the basin (about 7.6 million people), the

Average daily phosphorus loads (in pounds) in four rivers during average annual streamflow conditions.



largest loadings of phosphorus from wastewater effluent. In contrast, the yield of phosphorus was smallest for the Yakima River basin, where the population is small and much of the land is covered by forests, grazing lands, orchards, and crops that tend to be more permanent and thus undergo less erosion.

One of the conclusions that can be drawn from this effort is that the relative importance of point and nonpoint sources is highly variable. In this example, nonpoint sources account for 40 to 80 percent of the total amount of phosphorus in the stream. In some areas of the country, especially major population centers like Chicago, point sources of contaminants are still very important. The 20 study-unit investigations that began in 1991 are providing similar types of information on point and nonpoint sources of contamination. As part of the national synthesis efforts, the NAWQA program will be bringing together the results from these studies related to nutrients and pesticides to compare and contrast the findings and to explain the similarities and differences. This information will be available to water managers, policymakers, and the public for the planning and evaluation of point- and nonpoint-source management programs and other water-quality protection programs.

William G. Wilber
is the coordinator of the National Synthesis component of the NAWQA program and has worked on the design and implementation of the program since 1985

Jerri V. Davis
is a hydrologist working on the Ozark Plateaus NAWQA study-unit investigation.

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Hazardous Substances in the Water Environment

Hazardous chemicals and radioactive wastes pose significant concerns for the Nation's water resources. The USGS conducts research and investigations into the disposal of hazardous chemicals and radioactive wastes. The information from these studies is useful in alleviating the effects of waste on surface- and ground-water resources.

Through the Toxic Substances Hydrology program, USGS hydrologists, chemists, and biologists provide the information necessary to improve waste-disposal practices and to help mitigate surface- and ground-water contamination problems. By studying major types of contaminants in ground water and surface water and by developing new methods to assess the extent of contamination, scientists can determine the occurrence, movement, and fate of toxic substances in the hydrologic system. The site characterization, modeling, prediction, and remediation methods and techniques developed and tested through this program are useful in designing effective strategies for the tens of thousands of hazardous-waste sites across the country that have been identified for potential cleanup.

The Department of Defense (DOD) Environmental Contamination Hydrology program provides scientific and technical data and interpretations needed to characterize hazardous-waste sites and to support the evaluation of plausible remedial alternatives. These activities support the DOD Installation Restoration program, which addresses issues of contamination resulting from past operations at military installations, and the DOD Environmental Compliance program, which deals with contamination resulting from current operations.

USGS research and field studies in the Nuclear Waste Hydrology program are directed toward a better understanding of the mechanisms of radionuclide transport in ground water and toward developing methods and techniques for site characterization. The program provides consultation on the hydrologic aspects of nuclear waste disposal to the Department of Energy (DOE), the Nuclear Regulatory Commission, the Environmental Protection Agency (EPA), and other Federal agencies. The role of the USGS in the national high-level radioactive-waste repository program, led by the DOE, is supported through this program. Earth-science information and technical assistance are also provided to States in their management of low-level radioactive waste.

Natural Remediation of Oil Contamination in Ground Water

Petroleum hydrocarbons are significant ground-water contaminants in the United States. The combination of accidental spills during production, refining, and transportation of petroleum products and leaking underground storage tanks has created thousands of sites where petroleum hydrocarbons have contaminated ground water. Although the number of contaminated sites is large, the impact of these discharges is mitigated by natural biological degradation. Interdisciplinary research conducted under the USGS Toxic Substances Hydrology program at a field site contaminated by crude oil has demonstrated that petroleum hydrocarbons can be degraded by microorganisms that occur naturally in the environment.

In 1979, a buried high-pressure pipeline near Bemidji, Minn., burst, spilling 10,500 barrels of crude oil . After cleanup of oil from the land surface, 2,500 barrels (105,000 gallons) of crude oil remained in the unsaturated zone and near the water table in the sand-and-gravel aquifer. Because the spill was located in a remote area where ground water is not used extensively, the remaining oil was left in place. All changes observed over time in the distribution of crude-oil components can be attributed to natural processes. At present, the oil is moving very slowly near the top of the water table as a separate fluid phase, and vapors from the oil are moving in the unsaturated zone. Although ground-water chemistry and biogeochemical processes have changed over time, the area of contaminated ground water has not expanded significantly from 1983 to 1992.

In 1979, a buried high-pressure oil pipeline burst, spilling approximately 10,500 barrels of crude oil at a remote site near Bemidji, Minn.

USGS investigations at the Bemidji field site have provided strong evidence that petroleum hydrocarbons are degraded by natural processes and that these processes can limit the spread of contaminant plumes in ground water. The Bemidji study is significant because it is one of the very few field sites where natural degradation has been documented. A full understanding of the natural degradation processes at this site and at other contaminated sites will provide a stronger scientific basis for decisions about whether and when to employ costly physical and chemical cleanup procedures.

Gail Mallard

coordinates a USGS program that supports investigations of contaminants in water resources

Mary Jo Baedecker

is a chemist with the USGS and has conducted research on organic contaminants in ground water

Isabelle Cozzarelli

is a USGS hydrologist who conducts research on the fate and effects of petroleum products in ground water

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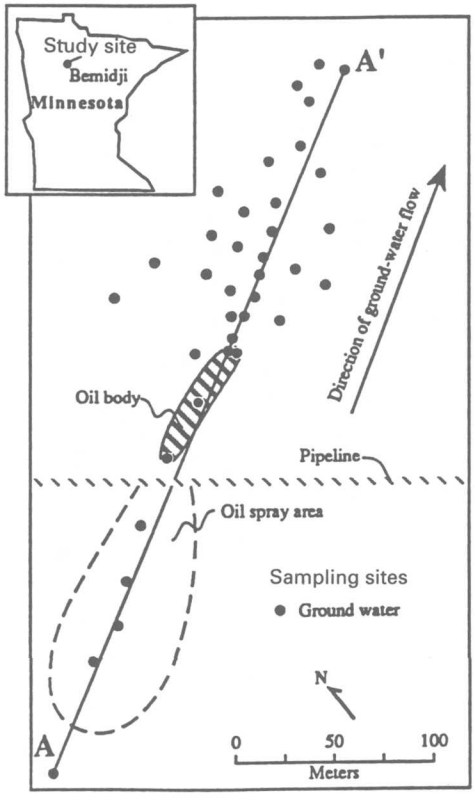


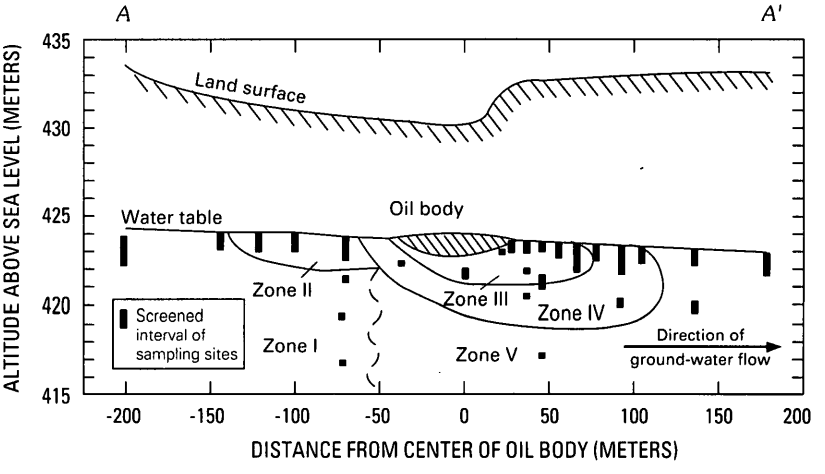
Location of study site near Bemidji, Minn., showing the approximate location of the oil body, sampling sites, and cross section *A–A'* (see box) (from Baedecker and others, *Applied Geochemistry*, v. 8, p. 569–586, 1993).

A generalized section through the contaminant plume shows five zones having different water chemistries. The screened intervals of wells in the aquifer are shown (modified from Baedecker and others, *Applied Geochemistry*, v. 8, p. 569–586, 1993).

Zone II underlies the area where the land surface was sprayed with oil. In this zone, hydrocarbons are gradually being degraded and transported vertically through the unsaturated zone with recharge water. Ground water in this zone contains no volatile hydrocarbons but has high concentrations of carbon dioxide, which indicate microbial degradation of hydrocarbons.

A plume of contaminated ground water containing dissolved constituents from the crude oil, such as benzene and alkylbenzenes, and products from biochemical reactions, such as organic acids, has developed downgradient from the spill site. The part of the plume nearest the oil body (zone III) is lacking in oxygen (anaerobic) and is characterized by high concentrations of hydrocarbons, bicarbonate,reduced iron, manganese, and methane. Bacteria that do not require oxygen are able to degrade some crude oil components in this area. Further downgradient (zone IV), the ground water contains low concentrations of oxygen, and a different group of bacteria is primarily responsible for hydrocarbon degradation. Here, hydrocarbon concentrations are lower than they are in the anaerobic zone of the plume because aerobic degradation proceeds more rapidly and more completely.

In the area farthest from the oil spill (zone V), concentrations of some organic and inorganic constituents are above background levels (the levels in zone I), but the concentrations of hydrocarbons are below the EPA maximum levels of contaminants allowable for drinking water. Ground water is moving rapidly enough for crude-oil components to have reached this area. The rate of solubilization of hydrocarbons from the oil body, however, is about the same as the rate at which hydrocarbons are degraded by microbial processes.



Environmental Contamination at Department of Defense Sites

Activities at more than 100 military installations in 38 States and 2 foreign countries highlighted FY 1993 efforts of the Department of Defense Environmental Contamination (DODEC) hydrology program. Facilities involved include those of the Air Force, Army, Navy, Marine Corps, Air National Guard, Army National Guard, and Defense Logistics Agency. Major concerns are the presence and transport of chlorinated hydrocarbons (trichloroethene, dichloroethene, vinyl chloride), constituents of fuels (benzene, toluene, xylenes), and trace metals (lead) in soil and water. Current research studies address natural bioremediation and augmented bioremediation of fuel hydrocarbon compounds in the shallow water-table aquifer.

Ongoing projects provide opportunities to increase knowledge in the definition of the hydrogeologic framework within many terranes; movement of ground water and contaminants in different terranes; ground-water-flow modeling in different terranes; occurrence of heavy metals in ground water; isotope geochemistry; surface and borehole geophysics; soil gas and its relation to ground-water contamination; and slug tests and other tests in aquifers to determine aquifer properties in different terranes. The development of relational data bases and use of geographic information system (GIS) technology, as well as the analyses of water quality and the quality control of analytical data and field data, are also benefits derived from the DODEC hydrology program.

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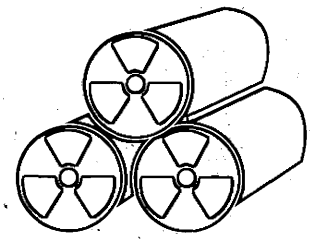

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Examples of projects active during FY 1993 include:

- Research on the effectiveness of both natural and augmented bioremediation on the degradation of organic compounds in the subsurface. Results of this research being conducted for the Air Force are expected to be important to the development of cost-effective methods of mitigating organic compounds in the subsurface, a principal problem at U.S. military bases throughout the world.
- Study of contamination of soil and ground water by trichloroethylene at an Environmental Protection Agency (EPA) National Priority List facility at F.E. Warren Air Force Base in Wyoming.
- Hydrologic assessment of surface- and ground-water systems, ground-water-flow modeling, and research in paleohydrology at an EPA National Priority List facility at the Rocky Mountain Arsenal in Colorado.
- Migration of petroleum hydrocarbons in the shallow freshwater aquifer of the atoll Diego Garcia in the Indian Ocean.
- Assessment of ground-water contamination migrating from landfills and technical support of the Department of Defense (DOD) Installation Restoration Program at Hill Air Force Base in Utah.
- Soil and ground-water contamination studies in support of EPA Resource Conservation and Recovery Act (RCRA) facility assessments and investigations and stormwater-runoff monitoring at Fort Bragg in North Carolina.
- Soil and ground-water contamination studies in support of EPA RCRA facility investigations at MacDill Air Force Base in Florida.
- Regional ground-water hydrogeology and ground-water-flow modeling at Wright-Patterson Air Force Base in Ohio.
- Hydrogeologic framework of the shallow water-table aquifer and soil-gas surveys to identify sources of ground-water contamination at the Naval Surface Warfare Center in Dahlgren, Va.

John D. Powell
has been involved in USGS environmental contamination studies for the past 13 years

Nuclear Waste and Water Resources

Nuclear waste arises from the generation of nuclear power, from the production of nuclear weapons, and from medical, industrial, and other miscellaneous sources. Broad agreement exists that these wastes must be sequestered from the environment, by deep geologic disposal in the case of high-level waste and by shallow disposal or near-surface engineered structures in the case of low-level waste. For all options, the hydrology of the site is a key factor in assessing the performance of the total waste-disposal system. Key elements of the Nuclear Waste Hydrology program include:

- Refining methods and techniques for the hydrologic characterization of environments.
- Finding new instrumentation and techniques for the characterization and monitoring of disposal sites.
- Defining hydrogeologic and geochemical processes that occur when nuclear waste, rocks, and ground water interact.
- Improving understanding of ground-water flow and contaminant transport in fractured rocks.

Recent accomplishments of the Nuclear Waste Hydrology program are as follows:

- Using innovative well-logging techniques, the USGS conducted a comprehensive evaluation of the hydrology in the vicinity of waste-disposal sites at the Idaho National Engineering Laboratory.
- Studies of soil-water movement at a newly excavated experimental trench in the very dry Amargosa Valley in Nevada indicate that there is little if any downward movement below 9 meters (about 27 feet) in depth.
- A study at a low-level radioactive disposal site in New York State confirmed the role of plants in the uptake of carbon-14 released at such disposal sites.

Newell J. Trask
is the Chief of the Branch of Nuclear Waste Hydrology

Characterizing a Safe Repository for Nuclear Waste

The USGS historically has been active in acquiring and analyzing hydrologic, hydrogeologic, and geologic information in southern Nevada as a part of ongoing local, State, and national programs. Following enactment of the Nuclear Waste Policy Act of 1982, the USGS expanded the investigations at and around Yucca Mountain, Nev., in cooperation with the Department of Energy (DOE). Yucca Mountain is currently the sole site being characterized as a potential site for a mined geologic repository for the long-term storage of high-level radioactive waste. Characterization of the mountain is necessary to determine its suitability as a location for a safe, permanent, underground repository. Site suitability will be determined by matching documented characteristics against Federal standards and regulations promulgated by the Nuclear Regulatory Commission, which ultimately will administer the licensing process.

Studies at Yucca Mountain are taking place in two physical settings. Surface-based testing consists of detailed surface mapping, digging trenches to expose surficial geology, and drilling both deep and shallow boreholes for geophysical and (or) stratigraphic analyses and hydrologic testing of the unsaturated and saturated zones. Exploratory Studies Facility (ESF) testing will be done in a U-shaped tunnel about 5 miles long that enters the northern part of Yucca Mountain in a westerly direction, then will turn in a southerly direction in line with the crest of the mountain about 800 feet beneath the crest, and ultimately will turn in an easterly direction to exit the mountain. The ESF, construction of which began in April 1993, will provide underground access to geologic and hydrogeologic features for refining results of surface-based testing. In addition to extensive hydrologic and seismic monitoring, representative accomplishments in FY 1993 include:

- Completed maps that establish the abundance, distribution, and geographic orientation of known and suspected Quaternary faults within about 62 miles of Yucca Mountain.
- Completed draft reports for the resolution of issues centering around erosion and the origin (atmospheric water or upwelling ground water) of calcite-silica deposits near faults. These reports should allow DOE to complete work on erosion and the calcite-silica issues.
- Dry drilling and coring of the first deep, unsaturated-zone hydrologic test hole, which reached a depth of about 1,670 feet. Core and stratigraphic analyses have begun.
- Successful installation of sensitive seismographs in two boreholes in excess of 1,640 feet deep to provide documentation of microearthquakes that could not otherwise have been accurately recorded.
- Continued mapping of the lateral extent of the Ghost Dance fault at a scale of 1:240 (1 inch=20 feet) in order to resolve any potential effects on the design of the repository, such as fast pathways for water within the unsaturated zone.

G. Louis Ducret
serves as senior manager for the Yucca Mountain Project Branch

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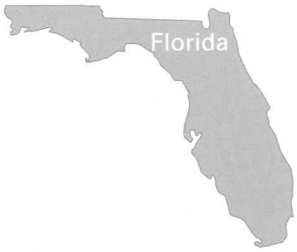
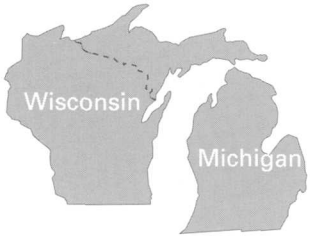
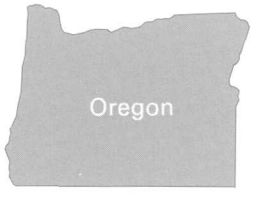
Cooperative Federal-State Water Resources Activities

The Federal-State Cooperative Water Resources program is a unique partnership between the USGS and State and local agencies. Although State and local cooperators provide at least half the funds, the USGS conducts most of the work. For almost 100 years, studies under this program have contributed to the advancement of earth science and the compilation of a major part of the Nation's hydrologic information. From its earliest days, the responsibility for developing stream-gaging procedures, concepts of surface- and ground-water flow, and analytical techniques for investigations of water quality has been vested in the program. In 1993, hydrologic-data collection, interpretive investigations, and research were conducted as part of the cooperative program by USGS scientists located in offices in every State, Puerto Rico, and several territories, through agreements with more than 1,000 cooperating agencies.

The number of investigations that emphasize water-quality issues, such as aquifer contamination, river-water quality, stormwater-runoff quality, and the







For more information on the Federal-State Cooperative program, contact:

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effects of acid rain, coal mining, and agricultural chemicals and practices on the hydrologic system, has increased since the early 1970's. The following are examples of investigations into water quality and other related topics conducted as part of the cooperative program.

Florida: Ground water and wetland interaction.—The Everglades ecosystem thrives in water having very low phosphorus concentrations. Recent urban and agricultural development in the surrounding areas have raised phosphorus concentrations enough to cause concern. As a result, the South Florida Water Management District has asked the USGS to investigate the ground water/surface water interactions in the Everglades. Once an improved understanding of the flow system has been developed, the sources, movement, and distribution of phosphorus will be analyzed with the objective of comparing different management techniques.

Kansas: Movement of pesticides in surface and ground water.—A cooperative project between the USGS, the Kansas State Board of Agriculture, and Kansas State University is determining the potential for decreasing the amount of atrazine and other triazine herbicides transported to surface and ground water. Concentrations of atrazine, alachlor, and their selected metabolites are being measured in suspended sediment in surface runoff under different land-management practices, such as terraced, clean-tilled, and ridge-tilled cornfields with and without grassed filter strips. The effects of these different land-management practices on the quality of ground water as well as on the volume of herbicides infiltrating to ground water are being evaluated.

Michigan and Wisconsin: Quality of water in streams tributary to Lake Superior.—The USGS, in cooperation with the Michigan and Wisconsin Departments of Natural Resources, is using state-of-the-art technology to estimate the amount of contaminants reaching Lake Superior in inflow from its major tributaries. Data are being collected uniformly from throughout the Lake Superior region. A computerized long-term data base, now accessible to every agency studying the Great Lakes, provides information that is being used to evaluate efforts by State and Federal agencies to lessen the harmful effects of selected contaminants in Lake Superior.

Oregon: Water quality in the Tualatin River.—Excessive phosphorus in the Tualatin River has resulted in nuisance growths of planktonic algae and periodically low concentrations of dissolved oxygen in the lower part of the river. Although it has long been believed that water-quality problems could be solved by eliminating phosphorus from wastewater treatment plants and surface runoff from urban and agricultural lands, this USGS investigation in cooperation with the Unified Sewerage Agency of Washington County has shown that ground water discharging to the river and its tributaries contains phosphorus concentrations from 5 to 100 times larger than expected; these excessive concentrations are hampering clean-up efforts. Phosphorus in ground water comes from both human activities and natural sources, but some of the highest concentrations seem to occur naturally in an aquifer that contains large amounts of organic matter buried by catastrophic floods during the Pleistocene Epoch. Remediation strategies for the Tualatin River are being reviewed on the basis of results of the investigations to date, so that millions of dollars will not be spent on possibly ineffective "best management practices" in urban and agricultural areas.

South Carolina: Degradation rates of petroleum hydrocarbons.—The USGS, in cooperation with the South Carolina Water Resources Commission, is investigating an extensively contaminated, shallow water-table aquifer that underlies a fuel tank farm in Hanahan, S.C. Data collected to date reveal that petroleum hydrocarbons in the aquifer are being degraded anaerobically in a complex pattern of zones dominated by iron-reducing, sulfate-reducing, and methanogenic (gas-producing) conditions that change dynamically over time and space. Further investigation is designed to determine relative rates of hydrocarbon degradation under these same aquifer conditions and how degradation rates are affected by continually changing conditions. The results will help responsible agencies design bioremediation strategies at this site and similar sites nationwide.

Bruce K. Gilbert
has prepared annual reports describing the Federal-State Cooperative program and its accomplishments since 1983

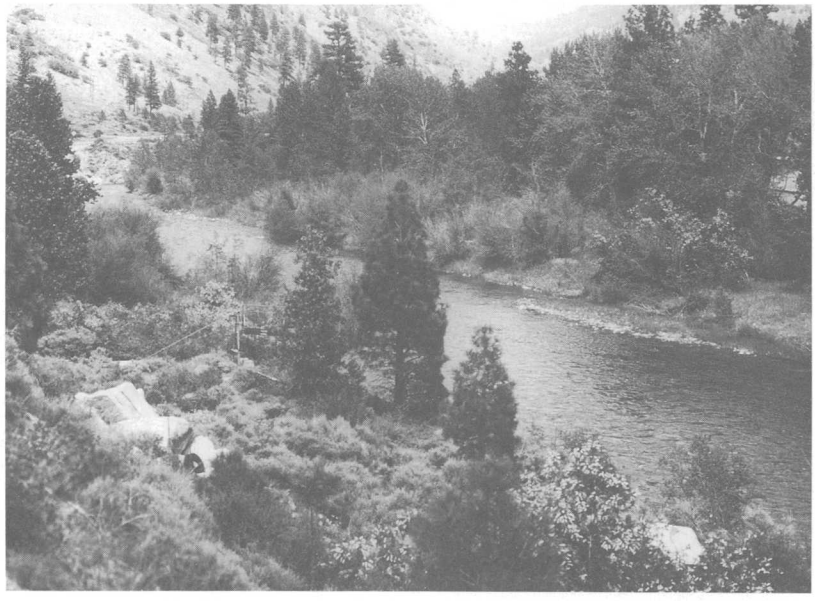
The Truckee-Carson Program

After decades of litigation and negotiation, the Truckee-Carson-Pyramid Lake Water Rights Settlement Act, Public Law (P.L.) 101–618, was passed in 1990. The law provides a framework for constructing a complex combination of operating criteria to balance interstate allocation of water and water demands for municipal, irrigation, fish and wildlife, water-quality, and recreational uses in the Truckee and Carson River basins of Nevada and California.

The USGS Truckee-Carson program was established to support the Department of the Interior in the implementation of P.L. 101–618 as follows:

- Consolidate and (or) develop as necessary a streamflow and water-quality gaging-station network in order to document water resources and support river operations.
- Calibrate, test, and use interbasin hydrologic and hydraulic computer models to support the management and allocation of water and the assessment of environmental effects.
- Provide technical guidance to other Federal agencies during negotiations for the Truckee River Operating Agreement.

Computer models of the watersheds and geographic information system coverages are being linked with operation/allocations models (developed as a joint effort with the Bureau of Reclamation) so that alternative management scenarios can be analyzed at hourly, daily, weekly, seasonal, or annual time scales. Easy-to-evaluate numerical, statistical, and graphical results allow managers to test and improve long-term operating policies responsive to the many competing demands for water. Although development and calibration of the models are basin specific, the underlying decision-support modeling system has national transfer value.



STEVEN N. BERRIS

The Truckee River near the Farad gaging station, a key measuring point in the allocation of the river's water supply between Nevada and California.

The data network and the models adapted or developed by the USGS under the Truckee-Carson program will be used extensively by the Bureau of Reclamation, the Bureau of Indian Affairs, and the Fish and Wildlife Service. Principal State agencies benefiting from the program include the California Department of Water Resources, the California Department of Fish and Game, the Nevada Department of Conservation and Natural Resources' Divisions of Water Resources, Water Planning, and Environmental Protection, and the Nevada Department of Wildlife. Potential users include two Native American tribes, about a dozen counties in California and Nevada, and several utility and irrigation districts.

Larry R. Bohman
has studied surface-water modeling for the USGS for the past 15 years

For more information on the Truckee-Carson program, contact:

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National Research Program

The National Research Program (NRP), established in the late 1950's, encompasses a broad spectrum of scientific investigations. The program is designed to encourage research that provides new knowledge and insights into varied and complex hydrologic phenomena, processes, and systems that are neither well understood nor defined. The sciences of hydrology, mathematics, chemistry, physics, ecology, biology, geology, and engineering are used to gain a fundamental understanding of the processes that affect the availability, movement, and quality of the Nation's water resources. Results of the investigations conducted under the NRP are applicable not only to the solution of current water problems but also to future issues, anticipated or unanticipated, that may affect the Nation's water resources.

The emphasis of research activities has changed through time to reflect the emergence of promising new areas of inquiry and the demand for new tools and techniques with which to address water resources issues and problems. Many issues addressed by NRP scientists involve potential threats to human health, ecosystems, and (or) the potential high social costs of control or mitigation. Knowledge gained and methods developed in this program apply to all of the hydrologic investigations of the USGS, to water-oriented investigations and operations of other agencies, and to the general scientific community.

In recent years, NRP scientists have:

- Completed the Nation's first systematic water-quality study of the Mississippi River system.
- Conducted a multidisciplinary study to develop the techniques and understanding needed to characterize fluid movement and chemical transport in fractured bedrock.
- Discovered microorganisms that can naturally remove a variety of contaminants from ground water, including aromatic hydrocarbons and uranium.
- Developed a method to identify recently recharged ground water, thereby helping to determine the vulnerability of ground water to contamination.
- Developed a method for assessing the sensitivity of surface waters to acid deposition.

Linda C. Friedman
is the assistant to the Chief of the Office of Hydrologic Research

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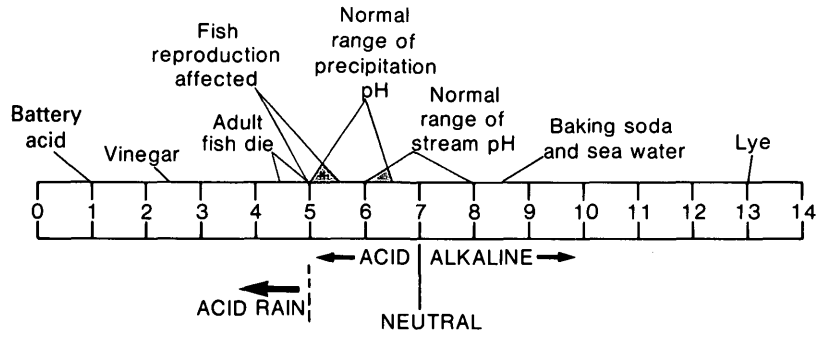
Acid Rain

Strong acids (sulfuric and nitric acids), formed when atmospheric pollutants emitted from powerplants, factories, and motor vehicles combine with water in the atmosphere, have fallen as acid rain and snow on the Northeastern United States and southeastern Canada during the last several decades. This acidic precipitation is believed to be responsible for the acidification of sensitive lakes and streams, damage to high-elevation forests and historical structures, and impaired visibility in affected areas. The USGS, in cooperation with other Federal agencies and many State agencies, is participating in a coordinated nationwide program to define the causes and effects of acid rain and to assess the benefit of reduced emissions of the precursors of acid rain, as required by the Clean Air Act Amendments of 1990. The USGS is the lead agency for monitoring deposition under the Federal Interagency National Acid Precipitation Assessment program (NAPAP).

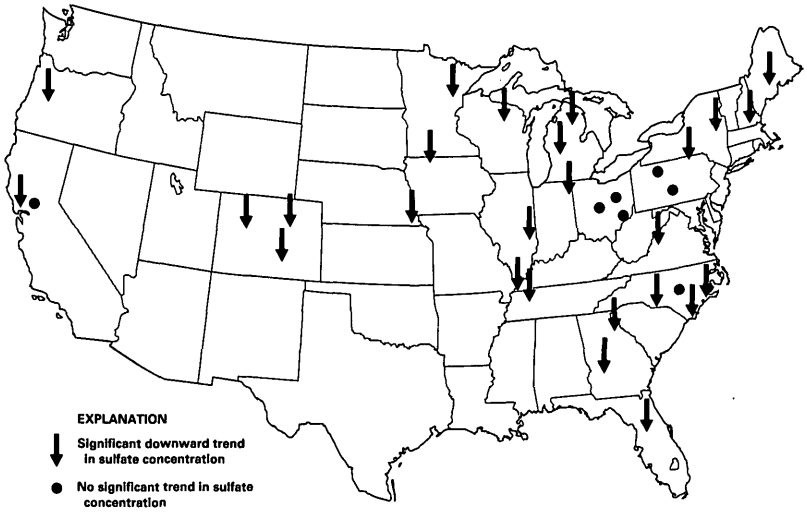
Significant Downward Trend in Sulfate

Operation of the National Trends Network (NTN), a 150-station, nationwide, multiagency network for monitoring precipitation chemistry in the United States, is coordinated by the USGS. Selected sensitive lakes and streams throughout the Nation are monitored through the NTN to document changes in water chemistry that may result from the effects of acid rain, and research is conducted in several sensitive watersheds to define how the geochemical processes caused by acid rain affect water quality.

An analysis of trends was conducted in FY 1993 on data from the 33 stations in the NTN that had the longest records. The analysis covered 1980 through 1991 and showed substantial and statistically significant downward trends in sulfate deposition at 26 of the 33 stations. Downward trends in nitrate deposition were also preponderant but were statistically significant at only three stations. Trends



Strong acids can decrease the pH of precipitation to less than 5.6, the pH of pure water in equilibrium with atmospheric carbon dioxide.



Locations of atmospheric-deposition collection stations where sulfate levels were down, indicating a decrease in the acidity of precipitation between 1980 and 1991.

Collectively, the trends indicate that the acidity of precipitation decreased between 1980 and 1991.

in pH were mostly upward, showing decreasing acidity, and were highly significant at nine stations. Collectively, the trends indicate that the acidity of precipitation decreased between 1980 and 1991. These results as well as continuing trends analyses are helping public officials evaluate the effectiveness of the newest provisions of the Clean Air Act as well as remain alert to other threats to water quality from atmospheric pollution.

R.J. Pickering

has been in charge of the USGS Acid Rain program since its inception in 1982 and is an expert on water quality

For more information on the NTN, contact:

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The National Water Summary: Stream Water Quality

To acquire information about the availability, quantity, quality, and use of water resources and to organize it in ways that portray the condition of the Nation's water resources to national, State, and local officials and the general public is the goal of the National Water Summary (NWS) program. Each NWS report covers one specific water-resources topic through extensive documentation in articles on the technical or institutional aspects of the topic and in State-by-State summaries as well as through descriptions of hydrologic conditions and water-related events.

Stream water quality is the topic of the latest published report, "1990–91 National Water Summary—Hydrologic Events and Stream Water Quality." This 600-page, four-color report presents information on hydrologic conditions and water-related events for water years 1990 and 1991 and information on the status and trends of water quality in streams in the United States, Puerto Rico, and the western Pacific islands. As represented by the statistical analyses of as many as eight water-quality constituents and water properties, State water-quality summaries present information on conditions for water years 1987–89 and trends for one or more of the water-year periods 1970–89, 1975–89, 1980–89, and 1982–89. Articles on statistical analysis and quality assurance of water-quality data, trends in national water quality for the 1980's, and trends in water quality in four basins for the period extending from about 1905 to the present also are included.

For more information on the National Water Summary, contact Kenneth Lanfear at:

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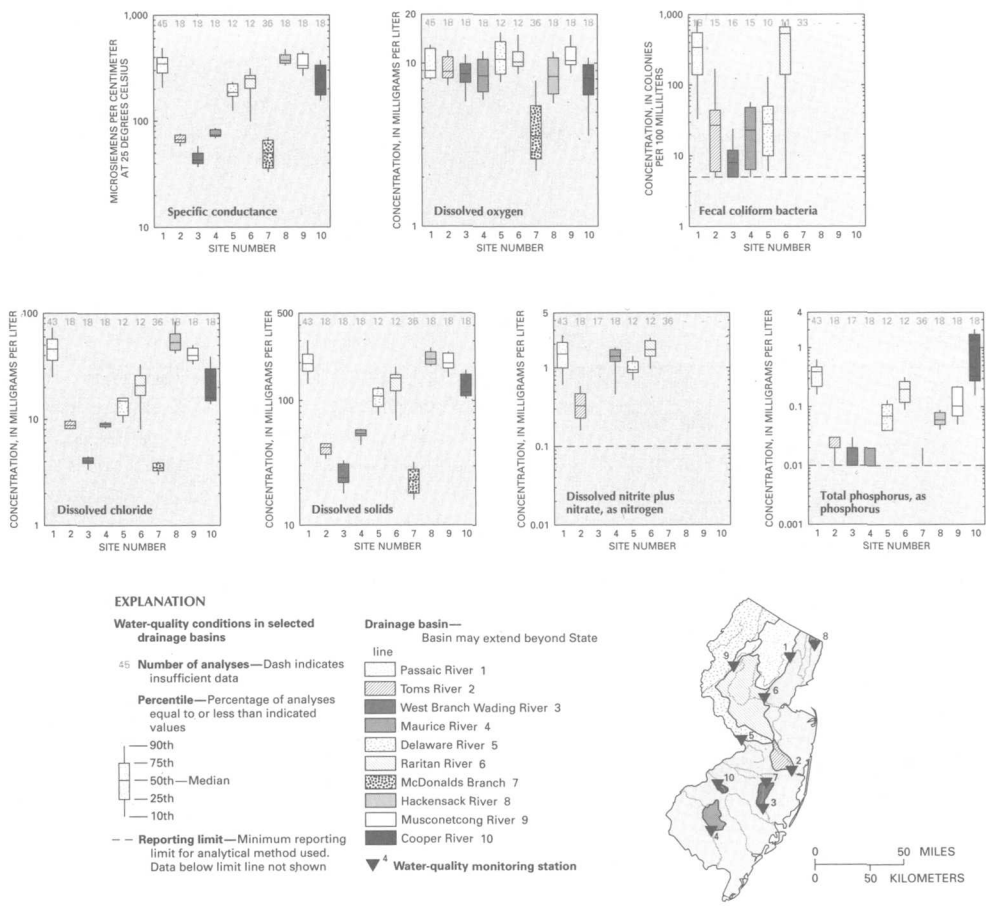
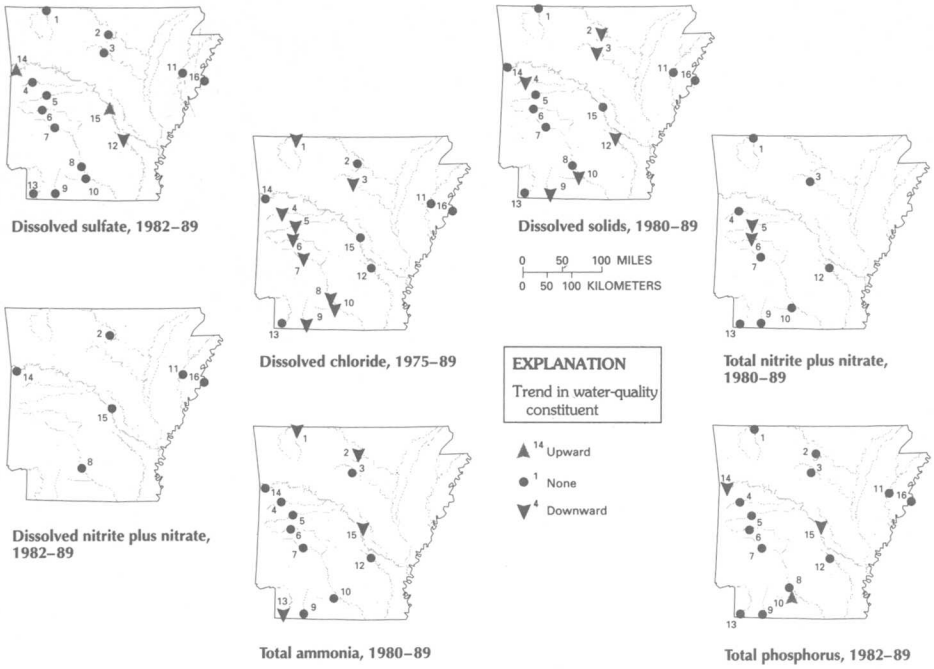
Richard W. Paulson

produced the National Water Summary report series for 7 years and has been a water resources consultant since his retirement from the USGS in October 1993



Water quality of selected streams in New Jersey, water years 1987–89 (data from USGS files).



Trends in water quality of selected streams in Arkansas, by water years (data from USGS and Arkansas Department of Pollution Control and Ecology files).

State Water Resources Research Institutes Program

Each year, the State Water Resources Research Institutes support nearly 800 research projects at over 100 college and university campuses nationwide. More than 1,200 students have received training by participating in these research projects and the Institutes' information-transfer projects. In recent years, the Institutes have published nearly 1,000 reports a year, nearly one-fourth of them articles in refereed scientific journals. The Institutes have also sponsored more than 130 conferences and published nearly 200 newsletters each year.

The program is implemented through grants to 54 Institutes, one in each State, the District of Columbia, Puerto Rico, the Virgin Islands, and Guam, which also serves the Federated States of Micronesia. Grants are used by the Institutes to support a program of research, education, and information transfer on State and regional water-resources problems.

Recent accomplishments under the Institutes program, which is administered by the USGS, are as follows:

- A project sponsored by the North Carolina Water Resources Research Institute has identified a new and previously unknown algae that has been responsible for massive fish kills. The results of the project were reported widely by national and international media.
- The Virginia Water Resources Research Center sponsored a project on safe drinking water, which provided the groundwork for State legislation passed in 1992 providing technical assistance for small water-treatment plants.
- The Wisconsin Water Resources Center sponsored research leading to the development of a copper toxicity test that is now being used to identify potential copper toxicity in Wisconsin's drinking-water supplies. The research leading to the development of the test was cited by the American Chemical Society as one of the most innovative findings of the year.
- The results of a project sponsored by the Texas Water Resources Institute are being used as a basis for changing Texas State regulations regarding the capture, storage, and onsite disposal of dairy wastes.
- The New Mexico Water Resources Research Institute sponsored a large interdisciplinary project to develop a reservoir-management model being used by the New Mexico Department of Game and Fish.

John E. Schefter

has administered the Water Resources Institutes State agency program since 1989

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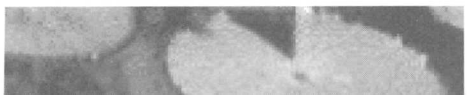
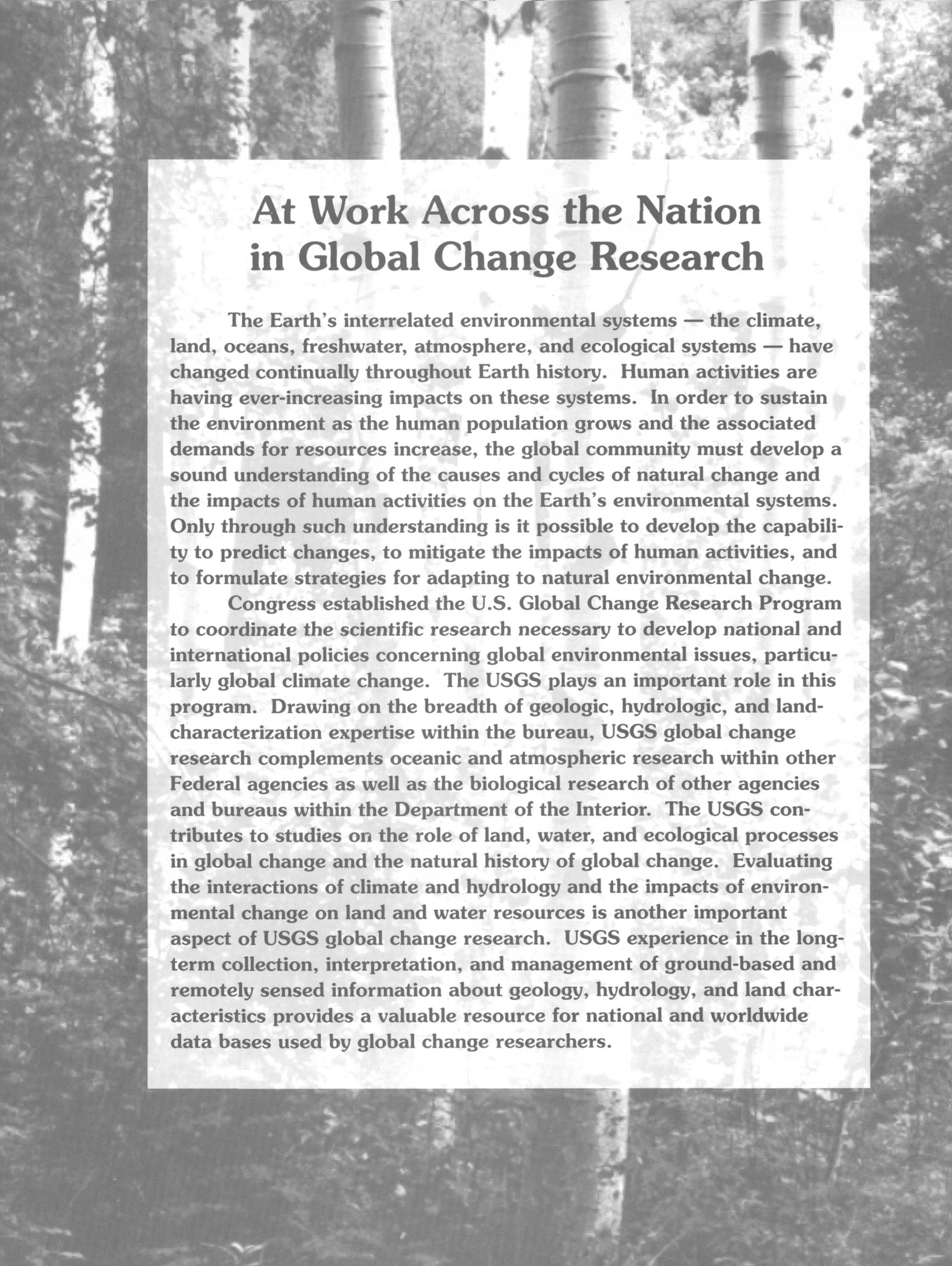




At Work Across the Nation in Global Change Research

The Earth's interrelated environmental systems — the climate, land, oceans, freshwater, atmosphere, and ecological systems — have changed continually throughout Earth history. Human activities are having ever-increasing impacts on these systems. In order to sustain the environment as the human population grows and the associated demands for resources increase, the global community must develop a sound understanding of the causes and cycles of natural change and the impacts of human activities on the Earth's environmental systems. Only through such understanding is it possible to develop the capability to predict changes, to mitigate the impacts of human activities, and to formulate strategies for adapting to natural environmental change.

Congress established the U.S. Global Change Research Program to coordinate the scientific research necessary to develop national and international policies concerning global environmental issues, particularly global climate change. The USGS plays an important role in this program. Drawing on the breadth of geologic, hydrologic, and land-characterization expertise within the bureau, USGS global change research complements oceanic and atmospheric research within other Federal agencies as well as the biological research of other agencies and bureaus within the Department of the Interior. The USGS contributes to studies on the role of land, water, and ecological processes in global change and the natural history of global change. Evaluating the interactions of climate and hydrology and the impacts of environmental change on land and water resources is another important aspect of USGS global change research. USGS experience in the long-term collection, interpretation, and management of ground-based and remotely sensed information about geology, hydrology, and land characteristics provides a valuable resource for national and worldwide data bases used by global change researchers.

"Global change" means changes in the global environment (including alterations in climate, land productivity, oceans or other water resources, atmospheric chemistry, and ecological systems) that may alter the capacity of the Earth to sustain life.
—Global Change Research Act of 1990

Good data will be vital in solving the problems associated with global climate changes. The U.S. must be a leader in developing these information resources.
—From Red Tape to Results: Creating a Government that Works Better & Costs Less

Snapshots of the Past, Models of the Future

Global Snapshots Reveal Past Climate Change

Through the looking glass of past climate changes, researchers can view possible future climate changes. Understanding past climates provides the basis for clearly distinguishing those changes caused by human activities from those caused by natural climate variation. USGS scientists study the geologic record to assemble histories of past climate variation and worldwide "snapshots" of climates at specific times in the past by using fossil and geochemical data. These geologic histories and global snapshots will help in assessing the causes, consequences, and extremes that might result from any future climate changes.

Recent work by USGS scientists on a 600,000-year climate record from Devils Hole in Death Valley National Monument, for example, questions the prevailing theory about the cause of the ice ages. The Milankovitch theory holds that systematic variations in the tilt and wobble of the Earth on its axis and in its orbit around the Sun cause predictable variations in the distribution of solar energy that reaches the surface of the Earth. The theory predicts cycles of low and high levels of incoming solar energy at the Earth's surface that should match the waxing and waning of ice ages. The ages of climate changes in the Devil's Hole record have been determined in detail by using uranium and thorium isotopic dating methods. The pattern of climate change in the Devil's Hole record matches well the pattern of other climate records (such as those obtained from ice cores in Antarctica and from deep-sea sediment cores), but the pattern does not match as well the cycles of change in incoming solar energy predicted by the Milankovitch theory. Researchers on the Devil's Hole project support a competing hypothesis for the causes of climate change—the nonlinear dynamic hypothesis, which holds that ice-age climates are the result of complex interplay between the oceans, the polar ice caps, and the atmosphere. This research demonstrates the need for reducing uncertainties about the causes of climate change and fosters a healthy skepticism about our current ability to forecast the future.

Recent work by USGS scientists on a 600,000-year climate record from Devils Hole in Death Valley National Monument, for example, questions the prevailing theory about the cause of the ice ages.

By reconstructing worldwide snapshots of past climates, scientists can test how effective climate models are in simulating known past conditions and thereby improve the ability to model and predict the impacts of future changes in global climate. International concern about possible global warming is focusing the attention of scientists on understanding climate conditions during periods in the geologic past when the average global temperature was higher than it is today. USGS scientists currently are working with scientists around the world reconstructing climate snapshots for a warm period during the Pliocene Epoch, about 3 million years ago, and for a geologically brief interglacial interval when the Earth was only slightly warmer than it is today,

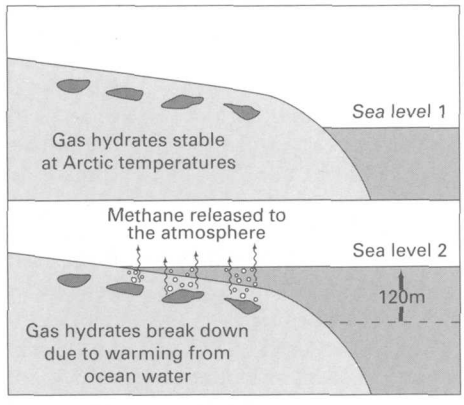
about 130,000 years ago, preceding the last great ice-sheet advance.

Where is the Missing Carbon?

The more scientists understand the processes that govern the atmosphere today, the more reliably they will be able to predict future changes. Much of the solar energy reaching Earth heats its surface. Some of this heat, along with heat energy generated within the Earth itself, is radiated back toward space. Certain gases in the atmosphere, called greenhouse gases (water vapor, carbon dioxide, and methane, for example) absorb heat radiated from the Earth and, in turn, radiate energy back to the land and lower atmosphere, trapping heat in a manner similar to warming in a greenhouse. Many scientists believe that increases in atmospheric concentrations of greenhouse gases caused by human activities will increase the "greenhouse effect" in the atmosphere and lead to global warming.

The amount of carbon dioxide produced each year by human activities—mainly the use of fossil fuels and the destruction of forests—exceeds our best estimate of the combined amount of carbon dioxide absorbed each year into the atmosphere and oceans by about 2 billion tons. Much of this carbon dioxide is thought to be absorbed by the land, but exactly how much and in what form are unknown. Locating this missing carbon dioxide and understanding the role of natural additions and subtractions in the global carbon budget are important steps in developing realistic national and international policies to regulate human emissions of greenhouse gases to the atmosphere.

Scientists have only recently learned about the missing carbon. Current theory suggests that this carbon is being stored on land. To test this hypothesis, USGS scientists are studying the movement of carbon between land and the atmosphere and between the land and the oceans, as well as in sediments, water, and soil, to help determine what happens to the greenhouse gas produced by human activities. Much of this research involves monitoring and experiments at several geographically distributed Water, Energy, and Biogeochemical Budget (WEBB) study sites established by the USGS, including alpine, forested upland, temperate lake, and tropical rain forest environments. At the Panola Mountain WEBB site near Atlanta, Ga., for example, the USGS is studying the past and present rates of carbon accumulation, erosion, transport, and burial in an area that was almost entirely deforested during the last century and is now recovering. Preliminary results suggest that recovering temperate forests in middle latitude regions, such as in the Panola Mountain watershed, are important carbon storage areas that help in balancing the present-day carbon budget.



Seal-level rise causes relatively warm ocean water to cover cold Arctic strata. The resulting breakdown of stable gas hydrates within the sediment releases gas into the atmosphere.

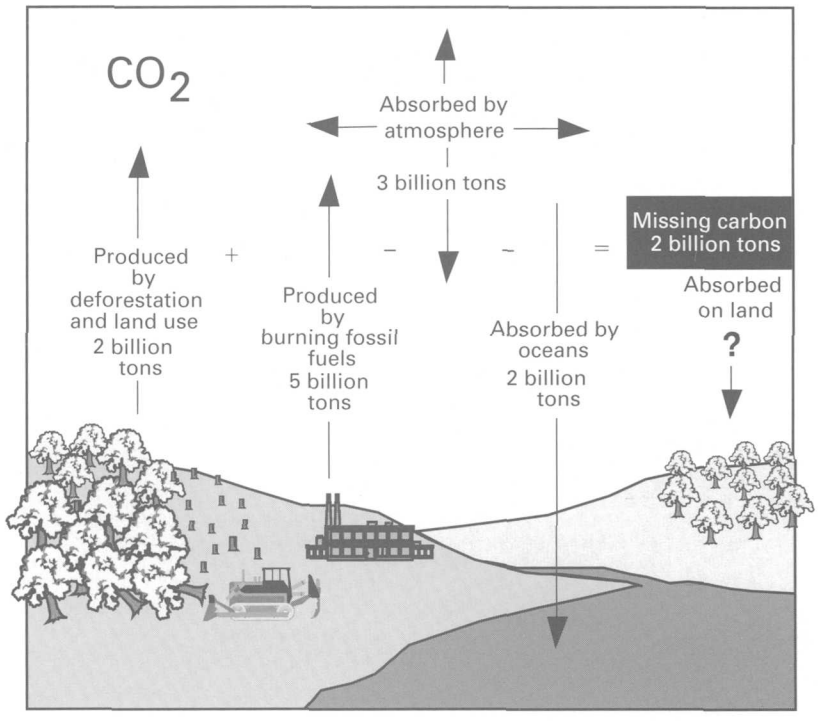
A Partner in Global Change

As the Nation's principal conservation agency, the Department of the Interior is responsible for managing public lands and other resources throughout the United States and its Trust Territories. Today, a major concern of resource managers is how natural and cultural resources are affected by environmental change, whether caused by human activities or by natural variability. The USGS contributes to departmental global change research on sensitive environments and resources. This research provides information necessary for managers to make decisions on a variety of environmental issues, including the ability to sustain water supplies, ecological systems, and biological diversity.

USGS Global Change Research Goals

- Describe past and contemporary states and changes in the Earth's environment.
- Improve understanding of land-atmosphere and land-ocean exchanges of water, energy, carbon, and nutrients.
- Facilitate access to and use of global change data and information for research, resource management, education, and policy decisions.

A potential source of large volumes of greenhouse gas is the methane naturally produced and stored in Arctic environments. Naturally formed methane occurs in Arctic wetlands, frozen in permafrost, and is trapped in Arctic sediments as methane hydrate, a solid compound consisting of a methane molecule surrounded by ice. Should Arctic temperatures or sea level rise, as the global warming theory suggests will happen, methane stored in the Arctic could be released and further increase the concentration of greenhouse gases in the atmosphere. The USGS is studying the formation, amount, and distribution of methane in Arctic permafrost, wetlands, and sediments to assist in estimating the potential for methane release to the atmosphere in response to regional or global environmental change.

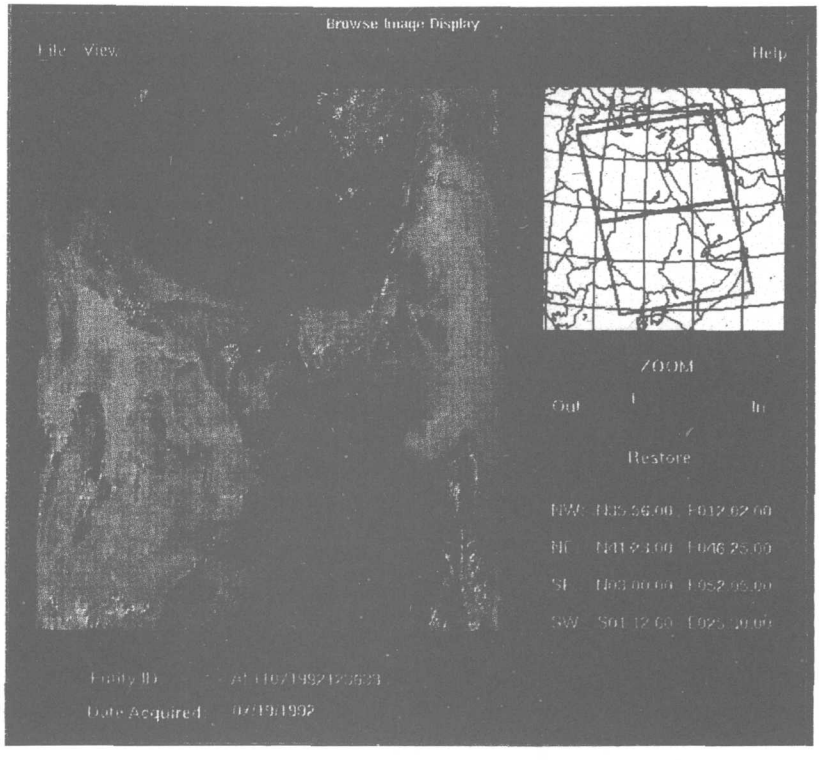


The amount of carbon dioxide produced each year by human activities—mainly the use of fossil fuels and the destruction of forests—exceeds our best estimate of the combined amount of carbon dioxide absorbed each year into the atmosphere and oceans by about 2 billion tons. Current theory suggests that this carbon is being stored on land.

Providing Data and Information

The complexity of global change requires that many types of data and information from a variety of scientific disciplines be available to conduct research, manage natural resources, educate the public, and make informed policy decisions. Large quantities of data and information must be assembled, documented, archived, and disseminated to meet the demand of the scientific community. It is equally important to provide data bases and communicate research results outside the scientific community as a basis for decisionmaking and public education.

The USGS is working with other Federal agencies to develop the Global Change Data and Information System to improve access to data and information. As part of this effort, the USGS is preserving the 21-year archive of data from



Interactive GLIS browse screen showing an advanced very high resolution radiometer (AVHRR) satellite image of the eastern Mediterranean and Red Sea areas. For direct-dial access, modem settings should be at 8 bits with no parity and 1 stop bit, then dial (605) 594–6888. For network access, telnet to the Internet address glis.cr.usgs.gov on any standard computer terminal.

the Landsat series of Earth-observing satellites and making these data available to the public in useful formats. The Global Land Information System (GLIS), showcased at the United Nations Conference on Environment and Development in Rio de Janeiro in 1992, can be used to learn about these data and their availability. GLIS is a "user friendly" interactive computer-based system that provides information about global land data sets and how to obtain them. It can be accessed via computer modem from remote locations throughout the world. The system is based at the USGS EROS Data Center in Sioux Falls, S. Dak.

CD-ROM technology is offering another significant improvement in archiving and disseminating global change data by providing an inexpensive means of offering large regional, continental, and global data sets. New CD-ROM products available from the USGS include the Hydro-Climatic Data Network, which provides historical streamflow data for sites throughout the United States and its Territories, 10-day preprocessed global AVHRR data, and the land-cover characteristics data base, which includes information reflecting selected seasonal vegetation changes, along with elevation, soils, and climate data for the conterminous United States. These data bases provide the "real-world" basis for predictive modeling, which is needed for solving the problems associated with global climate change.

Understanding Global Change

An improved understanding of Earth systems increases the capability to predict future global climate change by enhancing the ability of the scientific community to build and run reliable Earth system models. Researchers use sophisticated computer models, called general circulation models (GCM), to evaluate changes in global climate conditions as a result of the complex interplay between Earth's changing environmental systems. The usefulness of GCM's are limited by the accuracy of the assumptions and mathematical formulas used in creating the models and the quality of the data used for running the models. Improving the reliability of model simulations of future global change depends on reducing uncertainties about the processes operating within each of the Earth's critical environmental systems and how these systems interact to regulate the global climate.

GCM's must incorporate mathematical representations of the movement of energy, water, and carbon between the land, atmosphere, and oceans. USGS participation in global modeling activities includes simulations of past climates, detailed descriptions of the land surface, and improvements in the mathematical representation of hydrologic processes and terrestrial environments. Land characterization and surface hydrology are critical to predicting climate, water resources availability, agricultural productivity, ecosystem change, and

Gunnison River Basin Study

In the Gunnison River basin of Colorado, a modeling framework for coupling atmospheric, hydrologic, and water management variables has been developed in cooperation with the Bureau of Reclamation. In the spring of 1993, this model enabled the bureau to regulate flow from dams on the Gunnison more effectively and thereby avoid downstream flood hazard during the spring snowmelt season. Other techniques and models are being developed for estimating impacts such as desertification and changes in permafrost. Understanding the potential impacts of global change in arid and cold regions is especially important, because these fragile environments would in many instances be the first to show the impacts of climate change. Because of this sensitivity, the study of arid and cold regions is important to the early detection of global change. As the case of methane in the Arctic indicates, climate change in cold regions could even trigger processes causing further environmental change.

desertification. The USGS is providing modelers with high-quality data sets that allow for more accurate representations of current environmental conditions in GCM's and other models of terrestrial processes. USGS scientists are developing techniques and data sets that integrate information about contemporary environmental systems, using Landsat and National Oceanic and Atmospheric Administration satellite data, along with a variety of ground-based information.

Improved understanding of the impacts of climate change on people and on ecological systems also depends on having better models at landscape, watershed, and regional scales that are relevant to resource managers. USGS global change research has developed improved analytical methods and modeling procedures for evaluating the sensitivity of land and water resources to global change. These techniques help quantify the potential impacts of change and have already helped to solve water-management problems in the Delaware River Basin, the Gunnison River basin of Colorado, and the American and Carson River basins of California and Nevada.

The USGS is participating in the development of a multiagency laboratory for Terrestrial Ecosystems Regional Research and Analysis (TERRA) located in Ft. Collins, Colo. The TERRA laboratory is developing analytical techniques that realistically incorporate land and natural resource management considerations into the components of global computer models that represent terrestrial ecosystems.

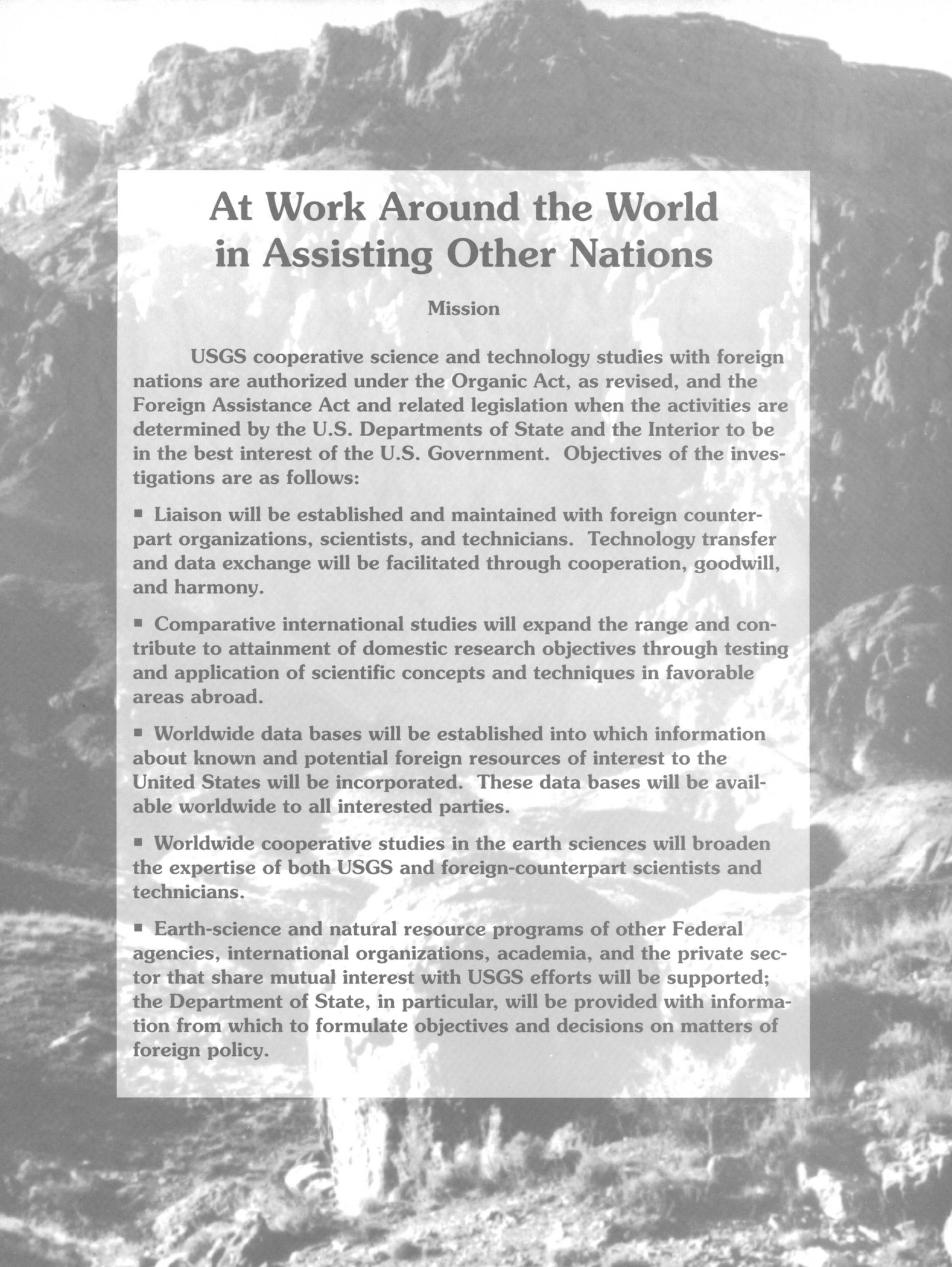
USGS global change research has developed improved analytical methods and modeling procedures for evaluating the sensitivity of land and water resources to global change.

Through this balanced program of ground-based observations and remote sensing, process studies, data management, and modeling, all based on long-term experience in earth-science research, the USGS is contributing information needed by the Nation to assess the causes and consequences of global change.

USGS global change research is coordinated by a multidisciplinary team whose combined experience spans the technical expertise of the entire bureau.

For more information on USGS global change research, contact:

Telephone (703) 648–4450
Internet mdcarr@usgs.gov



At Work Around the World in Assisting Other Nations

Mission

USGS cooperative science and technology studies with foreign nations are authorized under the Organic Act, as revised, and the Foreign Assistance Act and related legislation when the activities are determined by the U.S. Departments of State and the Interior to be in the best interest of the U.S. Government. Objectives of the investigations are as follows:

- Liaison will be established and maintained with foreign counterpart organizations, scientists, and technicians. Technology transfer and data exchange will be facilitated through cooperation, goodwill, and harmony.
- Comparative international studies will expand the range and contribute to attainment of domestic research objectives through testing and application of scientific concepts and techniques in favorable areas abroad.
- Worldwide data bases will be established into which information about known and potential foreign resources of interest to the United States will be incorporated. These data bases will be available worldwide to all interested parties.
- Worldwide cooperative studies in the earth sciences will broaden the expertise of both USGS and foreign-counterpart scientists and technicians.
- Earth-science and natural resource programs of other Federal agencies, international organizations, academia, and the private sector that share mutual interest with USGS efforts will be supported; the Department of State, in particular, will be provided with information from which to formulate objectives and decisions on matters of foreign policy.

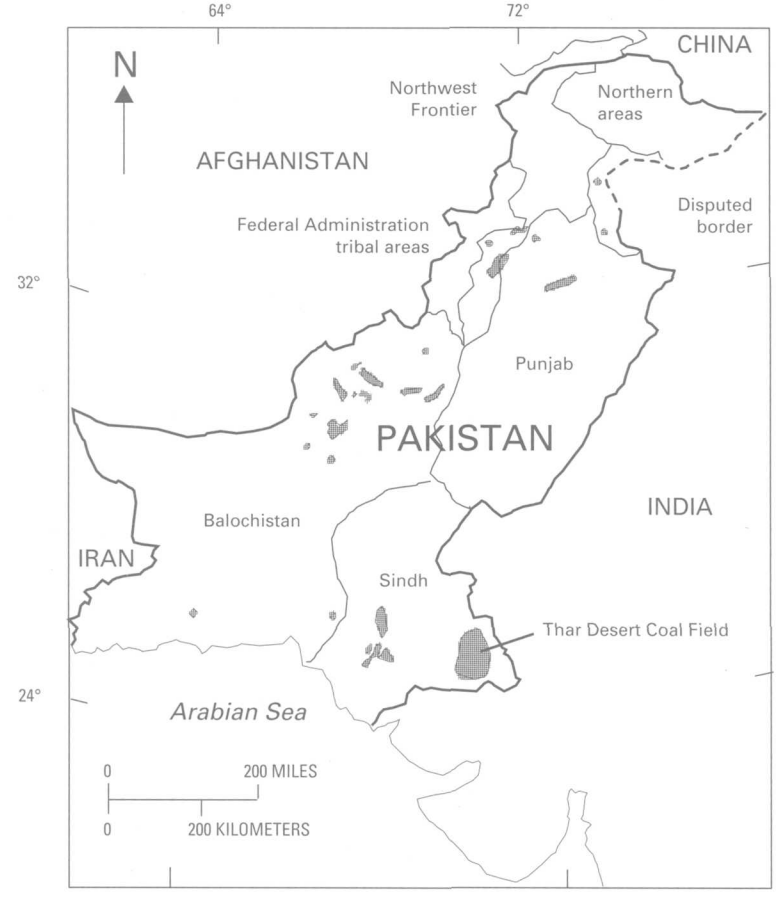
Significant Coal Discovery in Pakistan

A joint coal-resource evaluation and assessment program was completed in 1993 by the USGS, the U.S. Agency for International Development (USAID), and the Geological Survey of Pakistan (GSP). This multidisciplinary program, which began in 1985, focused on exploring and assessing Pakistan's coal resources.

Over the first 6 years of the project, the program increased estimates of Pakistan's coal resources from a few tens of millions of tons of coal to more than 9 billion tons. During the last 2 years, a world-class coal deposit was discovered in the Thar Desert area in southeastern Pakistan. The Thar coal field is estimated to contain around 80 billion tons of coal. The discovery of the Thar Desert coal field is the most significant energy discovery in Pakistan's history. This field has the potential to make Pakistan self-sufficient in energy well into the 21st century and perhaps even beyond.

The discovery of the Thar Desert coal field is the most significant energy discovery in Pakistan's history.

The first evidence of the presence of coal in the Thar Desert area came in the late 1980's from water-well drillers in Sindh Province, who reported the presence of coal beneath the desert in the



Location of Pakistan coal fields and occurrences (compiled by P.D. Warwick).

cuttings from water wells at several locations in the desert. USGS and GSP scientists ran a geophysical log in one of these water wells that indicated the presence of as much as 60 feet (18 meters) of coal at a depth of about 450 feet (140 meters). Four coal test holes were drilled in the Thar Desert in the spring of 1992. The first of these drill holes confirmed the presence of 60 feet of coal in several beds near the water well that had been geophysically logged. Another of the test holes indicated a 96-foot-thick (30-meter-thick) coal bed at a depth of around 450 feet (140 meters).

In late 1992 and early 1993, a drillhole program in the Thar Desert roughly defined the extent of the field. The field is about 70 miles (110 kilometers) long and about 35 miles (55 kilometers) wide and covers about 2,000 square miles (5,000 square kilometers). The thick-coal axis trends north, and total coal thicknesses decrease to the east, west, and north. The average total-coal thickness throughout the field is 37 feet (11 meters); depths to the coal range from 443 to 804 feet (135 to 245 meters). Throughout most of the field area, the coal occurs in several beds over an interval of around 150 feet (45 meters). The Thar Desert coal has the rank of lignite B and is relatively low in sulfur (about 1 percent) and in ash (less than 8 percent). These analyses indicate that the Thar Desert coal is similar to the coals of the Fort Union region in North Dakota and Montana.

Although the USGS program in Pakistan is completed, USGS scientists continue to work on the final Thar Desert coal report, which is scheduled to be completed in early 1994. A Pittsburgh, Pa., coal company plans to drill 10 closely spaced holes in the Thar field to determine the feasibility of mining the Thar coal deposit.

Jack Medlin
coordinates USGS research programs in Asia and the Pacific

For more information on coal-resource investigations in Pakistan, contact:

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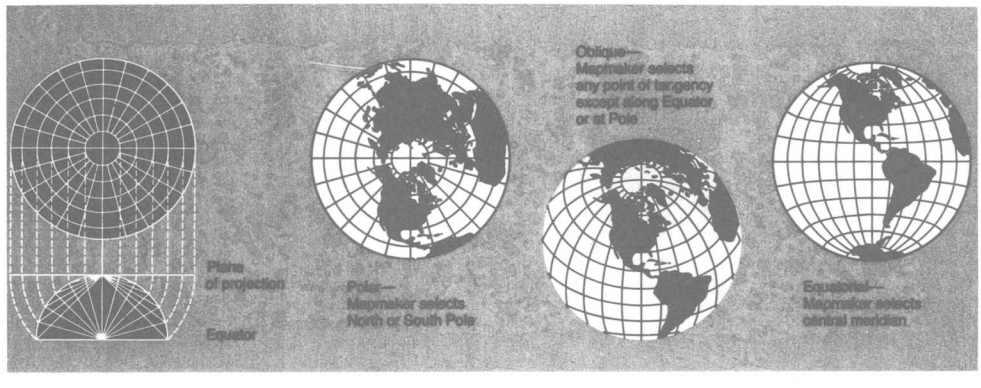
Internet jmedlin@usgs.gov

International Volunteers Collaborate with USGS on Pacific Region Study

The Pacific basin and surrounding land areas cover more than one-half of the globe and encompass a vast range of environments and earth-science concerns, from volcano and earthquake hazards to mineral and energy resources. For the past 20 years, volunteer (nonreimbursed) earth scientists have been working with the USGS and the Circum-Pacific Council for Energy and Mineral Resources (a private nonprofit foundation) to study, compile, interpret, and publish earth-science data on this immense area.

The Pacific region has been divided into four quadrants and two polar regions, each represented by a panel of volunteer earth scientists who are experts on their regions. Panel members change as the subject matter changes to bring the latest and best information to the studies. Panel chairmen, two of whom have been with the project since it began in 1973, focus and manage the work.

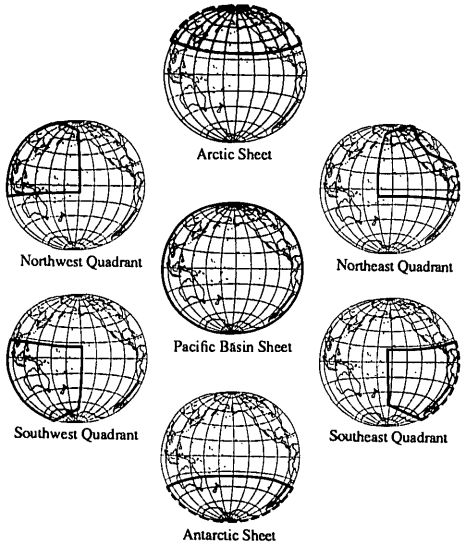
The products of this international volunteer network are a series of overlapping maps accompanied by explanatory notes and supplementary data. All maps produced since 1990 are published, sold, and distributed by the USGS.



Lambert azimuthal equal-area projection used by the USGS in the circum-Pacific map series.

Current Panel Chairmen

Northeast Quadrant	Kenneth J. Drummond, National Energy Board of Canada, Alberta, Canada
Southeast Quadrant	Jose Corvalan, Servicio Nacional de Geologia y Mineria, Santiago, Chile
Southwest Quadrant	R. Wally Johnson, Australia Geological Survey Organisation, Canberra, Australia
Northwest Quadrant	Tomoyuki Moritani, Sumitomo Construction Co., Ltd., Tokyo, Japan
Arctic Region	George Moore, Oregon State University, Corvallis, Oregon
Antarctic Region	Ian W.D. Dalziel, University of Texas, Austin, Texas



Boundaries for the six 1:10,000,000-scale circum-Pacific maps and the 1:17,000,000-scale Pacific basin sheet. Large parts of both the Arctic and Antarctic sheets are not shown on these index maps.

Table 1. List of circum-Pacific maps by dates published

[Until 1990, the circum-Pacific maps were published by the American Association of Petroleum Geologists (AAPG); these maps are available from the AAPG Bookstore in Tulsa, Okla. All maps produced since 1990 are published, sold, and distributed by the USGS]

Year	Map
1977.....	Northeast Geographic Map
	Northwest Geographic Map
	Northeast Base Map
	Northwest Base Map
1978.....	Southwest Geographic Map
	Southeast Geographic Map
	Antarctica Geographic Map
	Southwest Base Map
	Southeast Base Map
	Antarctica Base Map
	Pacific Basin Geographic Map
	Pacific Basin Base Map
1981.....	Northeast Plate-Tectonic Map (revised and reprinted 1982, 1986)
	Northwest Plate-Tectonic Map (revised and reprinted 1982, 1987)
	Southeast Plate-Tectonic Map (out of print)
	Southwest Plate-Tectonic Map (revised and reprinted 1982, 1986)
	Antarctica Plate-Tectonic Map (out of print)
1982.....	Pacific Basin Plate-Tectonic Map (revised and reprinted 1983, 1985)
1983.....	Northeast Geologic Map
1984.....	Northeast Geodynamic Map
	Northeast Mineral-Resources Map
1985.....	Southeast Geodynamic Map
	Southwest Geodynamic Map
	Tectonicostratigraphic Terranes Map
	Pacific Basin Manganese Nodule/Sediment Map
	Northwest Geodynamic Map
	Antarctica Geodynamic Map
	Pacific Basin Geodynamic Map
	Southeast Geologic Map
1986.....	Northeast Energy-Resources Map
1988	Northwest Geologic Map
	Southwest Geologic Map
	Antarctica Geologic Map
1989.....	Arctic Base Map
1990	Arctic Geographic Map
	Arctic Geodynamic Map
	Pacific Basin Natural Hazard (revised and reprinted 1992)
1991.....	Southeast Energy Resources
	Southwest Tectonic Map
1992.....	Northwest Energy Resources
	Arctic Plate-Tectonic Map

Publications are printed in English; those on the Southeast Quadrant are in Spanish as well. Base maps, constructed by the USGS, are at a scale of 1:10,000,000 for the quadrants and polar regions and 1:17,000,000 for the one-sheet ocean-centered Pacific basin. All base maps are on Lambert azimuthal equal-area projections and are individually centered to minimize distortion. Topography and bathymetry have been added to the base and printed in color as a geographic

series. In addition, 41 thematic maps (including geology, geodynamics, plate and regional tectonics, energy resources, mineral resources, and natural hazards) were published through 1992; production continued on 17 more, and 3 on energy resources for the Southwest, Northwest, and Southeast quadrants are in proof stage.

The Circum-Pacific Council for Energy and Mineral Resources was established in 1972 to promote earth-science data collection and research; sponsor conferences, symposia, and workshops; and publish books and maps of the region. Exemplifying the best in international scientific cooperation, the Circum-Pacific Map Project provides valuable earth-science information to help solve the many problems of resource development, including environmental problems, and to promote the general welfare of all peoples living within the circum-Pacific region.

For more information on circum-Pacific mapping, contact:

Telephone (415) 329–4002
Internet ggryc@frans.wr.usgs.gov

George Gryc
is the general chairman of the Circum-Pacific Map Project, a cooperative effort with the Circum-Pacific Council for Energy and Mineral Resources, and a senior researcher at the USGS

A Data Telecommunications System for the AGRHYMET Program in West Africa

The prolonged and frequent drought conditions in West Africa have prompted concerted international efforts to deal with this devastating natural hazard. The USGS's EROS Data Center (EDC) in Sioux Falls, S. Dak., has designed a communications network to link the Agriculture-Hydrology-Meteorology (AGRHYMET) Regional Center (ARC) in Niamey, Niger, to centers in nine other countries of the Sahel—Burkina Faso, Cape Verde, Chad, Gambia, Guinea-Bissau, Mali, Mauritania, Niger, and Senegal. This network provides agricultural, weather, and climate data to assess environmental conditions and predict drought.

A field test conducted in April 1992 proved that data could be transmitted in minutes between the ARC in Niger and a center in Burkina Faso. In turn, researchers in Africa can log onto a remote computer at the EDC and tap into extensive global data bases and archives of remotely sensed imagery.

Since 1989, the ARC has used images from the National Oceanic and Atmospheric Administrations's polar orbiting satellites to map vegetative cover throughout the Sahel at 10 daily intervals at a ground resolution of 1 kilometer. EDC employees, under the sponsorship of the U.S. Agency for International Development (USAID), assisted in the project.

The year 1993 saw the end of the USAID's Participating Agency Service Agreement. During FY 1993, the EDC concentrated on completing the installation of PC-based geographic information systems (GIS) in the National AGRHYMET Centers (NAC) of member nations. Gambia, Guinea-Bissau, Mali, and Senegal were completed in FY 1993 (Burkina Faso, Cape Verde, and Niger had been brought online in FY 1992). Personnel from the EDC and the ARC installed hardware, software, and a local-area network and presented a one-week GIS training workshop to NAC staff and representatives from other natural resource ministries within each country.

To support these GIS installations, the EDC is providing digital data sets to each NAC. These sets include administrative boundaries, roads, cities, historical data sets derived from daily advanced very high resolution radiometer (AVHRR) acquisitions, interpretations of land use from Landsat data, and other natural resource data derived from existing maps of soils, vegetation, and so on.

EDC staff stationed at the Niamey field office in Niger support the AGRHYMET Program by developing procedures to derive specific information from satellites and other data sources. Their most recent development is a means of comparing current greenness with historical averages on a district-by-district basis. This procedure can be used to identify areas and populations that may suffer from lack of rain and resulting crop failures.

EDC staff in Sioux Falls are investigating ways of using AVHRR data to monitor the seasonal development and status of ephemeral bodies of water in the

For more information on the AGRHYMET project, contact:

Telephone (605) 549–6027
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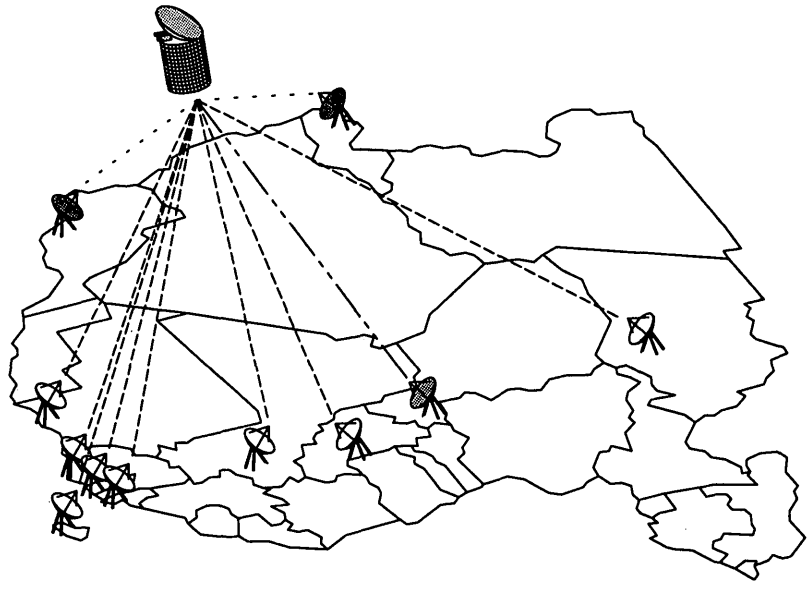
Tillabury region of Niger. These water bodies are important to populations that raise cattle.

The EDC continues to provide logistical support by procuring equipment, supplies, and repair services.

Stephen Howard
is a senior scientist at the EDC who has worked on the AGRHYMET program since its inception 5 years ago

Gray Tappan
is a senior scientist and geographer at the EDC currently assigned to the Senegal Land-Use Change Project



AGRYMET data communications network.

GIS Applications in the Lake Baikal Region of the Russian Federation

As the Russian Federation moves to a more market-based economy, the application of geographic information system (GIS) technologies will play a critical role in coordinating the development of programs to effectively manage Russian national resources. To assist in this transition, the USGS is helping the Russian Federal Service for Geodesy and Cartography (RUSKARTOGRAFIA) set up GIS applications centers.

These centers have potential benefits to the RUSKARTOGRAFIA in that GIS capabilities can be applied to the privatization of land and cadastral development; infrastucture inventory, prioritization, and reconstruction; nuclear materials storage and hazard mitigation; facilities siting; and many other applications. In addition, the centers can function as training centers to instruct other Russian scientists, as well as those from other republics, in the capabilities and applications of GIS.

The USGS will benefit through access to elevation and land-characterization data and other base cartographic and geographic information for global change analyses.

In cooperation with the U.S. Department of State, Bureau of Oceans and International Environmental and Scientific Affairs, Office of Science and Technology, and the RUSKARTOGRAFIA, the USGS is assisting in the following tasks:

- Providing hardware, software, and training to institute two GIS applications centers in RUSKARTOGRAFIA facilities in Moscow and Irkutsk.
- Creating a GIS to assess the ecological conditions of the Lake Baikal drainage basin.
- Using the resultant GIS approach to develop a land-management plan for the Baikal basin to better manage the resources and protect the environment.

The Lake Baikal region of Russia was selected by the RUSKARTOGRAFIA, the Department of State, and the USGS because of its unique environmental and natural characteristics. Lake Baikal is the world's deepest and largest body of freshwater and is experiencing problems with pollution from logging and mining operations. The project is viewed by the RUSKARTOGRAFIA as an important part of a larger effort to protect Lake Baikal and improve the economy of the region by developing its natural resources on the principles of sustainable use. As a pilot project, the Lake Baikal GIS supports major scientific and technological agreements between the United States and Russia and affords the opportunity for cooperative programs in natural resource management and environmental protection throughout Russia.

The USGS will provide the technical expertise in collecting digital data and organizing it into a demonstration GIS for the Lake Baikal region. Most of the data will be collected by the RUSKARTOGRAFIA and will meet USGS digital

cartographic standards. The GIS will provide the mechanism for assessing the ecological conditions of the Lake Baikal drainage basin.

The USGS will also provide technical expertise and has offered to train RUSKARTOGRAFIA scientists on GIS workstations that will be shipped to Russia. A senior Russian management team has been invited to visit the GIS Research Laboratory in Reston, Va., as well as several USGS mapping centers.

For more information on the Lake Baikal project, contact:

Telephone (703) 648–5110
Internet asteve1@usgs.gov

Alan R. Stevens
is the primary architect of the bilateral agreement between the USGS and the RUSKARTOGRAFIA

International Workshop on Arctic Contamination

In an unprecedented show of scientific dialog and international cooperation, scientists from Russia, the United States, Norway, Ireland, Finland, Great Britain, Monaco, and Canada joined together in a workshop on arctic contamination, held in Anchorage, Alaska, May 2 to 7, 1993.

The U.S. Interagency Arctic Research Policy Committee Workshop, organized and conducted by the USGS, brought together more than 200 scientists and officials concerned about the short- and long-term consequences of potential contamination of large areas of the Arctic by radionuclides and other toxic materials. The workshop also dealt with the potential effects of arctic contaminants on areas well beyond the physical boundaries of the Arctic.

A March 1993 Russian Federation report, which was a major impetus for convening the workshop, identified more than 2 million curies of radionuclide wastes that have been disposed of in the Kara and Barents Seas. The report documents that radionuclide wastes were also introduced into the northwestern-most Pacific Ocean, the Sea of Japan, and the Sea of Okhotsk. The long-term effects of these hazardous materials is

exacerbated by the fact that the contaminants may be transported from their points of disposal by movement of sea ice, ocean water, and sediment.

Materials that have been introduced into the Arctic Ocean and atmosphere by the former Soviet Union include liquid radioactive waste, fueled and unfueled nuclear reactors from submarines and icebreakers, sealed barrels of solid and mixed radioactive waste, and other nonradioactive hazardous and toxic waste. Other nations have also contributed significant concentrations of contaminants to the Arctic. High trace-metal accumulations, some of which may be natural, are found at many sites in the non-U.S. Arctic. No information has been collected to indicate that critically high levels of trace-metal contamination exist in Alaskan samples.

Of particular scientific concern is the fact that study of the movement of sea ice, ocean water, and sediment has been insufficient to make the kind of reliable predictions of the trajectories of pollutants that have been made in other oceans. Another concern is the freezing into sea ice of contaminants disposed of in the shallow seas. Once frozen in sea ice, these contaminants can travel long distances without being diluted. If the contaminated sea ice were to reach the warmer waters of the Chukchi or Bering Sea, the melting and release of the contaminants into the ecosystem could affect marine mammals and fish.

Participants in the workshop identified and summarized existing data about arctic contamination and determined that too little credible scientific information exists to perform a detailed risk assessment of the effects of contamination on human health and on the health of the arctic ecosystem. Workshop presentations about the extent, magnitude, and timing of marine, terrestrial, and atmospheric contamination in the Arctic were compiled in a special issue of the journal *Arctic Research of the United States*, edited by the USGS, and published in March 1994.

If the contaminated sea ice were to reach the warmer waters of the Chukchi or Bering Sea, the melting and release of the contaminants into the ecosystem could affect marine mammals and fish.

A primary result of the workshop has been a USGS-led international effort to identify scientific institutions in Europe, Asia, and North America holding existing arctic environmental data and information sets that can be used to develop baseline information about arctic contaminants. Working with the United Nations Environmental Programme's Global Resources Information Database, the Russian Ministry of Environmental Protection, and representatives from the arctic rim nations, the USGS has taken the lead role in coordinating the development of an international directory of arctic environmental data.

Bruce Molnia
coordinates international polar and environmental programs for the USGS and was instrumental in organizing the U.S. Interagency Arctic Research Policy Committee Workshop

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Internet bmolnia@usgs.gov

International Agreements and Activities


Cooperation in surveys, mapping, and remote-sensing activities in international border mapping, and the accessing of global change data with the Canadian Surveys, Mapping, & Remote Sensing Sector of the Department of Energy, Mines, and Resources
Scientific and technical cooperation in earth sciences with the Icelandic Council of Science
Arctic Ocean
Beaufort Sea
GREENLAND (DENMARK)
ICELAND
UNITED STATES
Baffin Bay
Yukon Territory
Pacific Ocean
CANADA
Northwest Territories
Labrador Sea
British Columbia
Alberta
Hudson Bay
Newfoundland
Manitoba
Quebec
Saskatchewan
Ontario
P.E.I.
New Brunswick
Nova Scotia
Statement of intent regarding cooperation in geological sciences with the Geological Survey of Canada
Atlantic Ocean
EXPLANATION
Countries having international agreements with the USGS
Agreements that began during FY 1993
UNITED STATES
0
500 MILES
0
500 KILOMETERS


Scientific and technical cooperation in earth and mapping sciences with the Ministry of Energy and Mines
Scientific and technical cooperation in earth and mapping sciences with the Guyana Geology and Mines Commission
VENEZUELA
GUYANA
SURINAME
FRENCH GUIANA (FRANCE)
COLOMBIA
ECUADOR
PERU
BRAZIL
Establishment of global telemetered seismic network station with the University of Brasilia
BOLIVIA
Scientific and technical cooperation in earth and mapping sciences with the Ministry of Energy and Mines
PARAGUAY
Scientific and technical cooperation in earth sciences with the Ministry of Mines and Metallurgy
Establishment of global telemetered seismic network station with the Comision Nacional de Desarrollo Regional Integrado del Chaco and the National University of Asuncion
Establishment of global telemetered seismic network station with the Academia Nacional de Ciencias de Bolivia/Observatorio San Calixto
URUGUAY
ARGENTINA
CHILE
Establishment of global telemetered seismic network station with the Instituto Nacional de Prevencion Sismica
Scientific cooperation in earth sciences with the Servicio Nacional de Geologia y Mineria
Statement of intent regarding cooperation in earth sciences with the Secretaria de Mineria
EXPLANATION
Countries having international agreements with the USGS
Agreements that began during FY 1993
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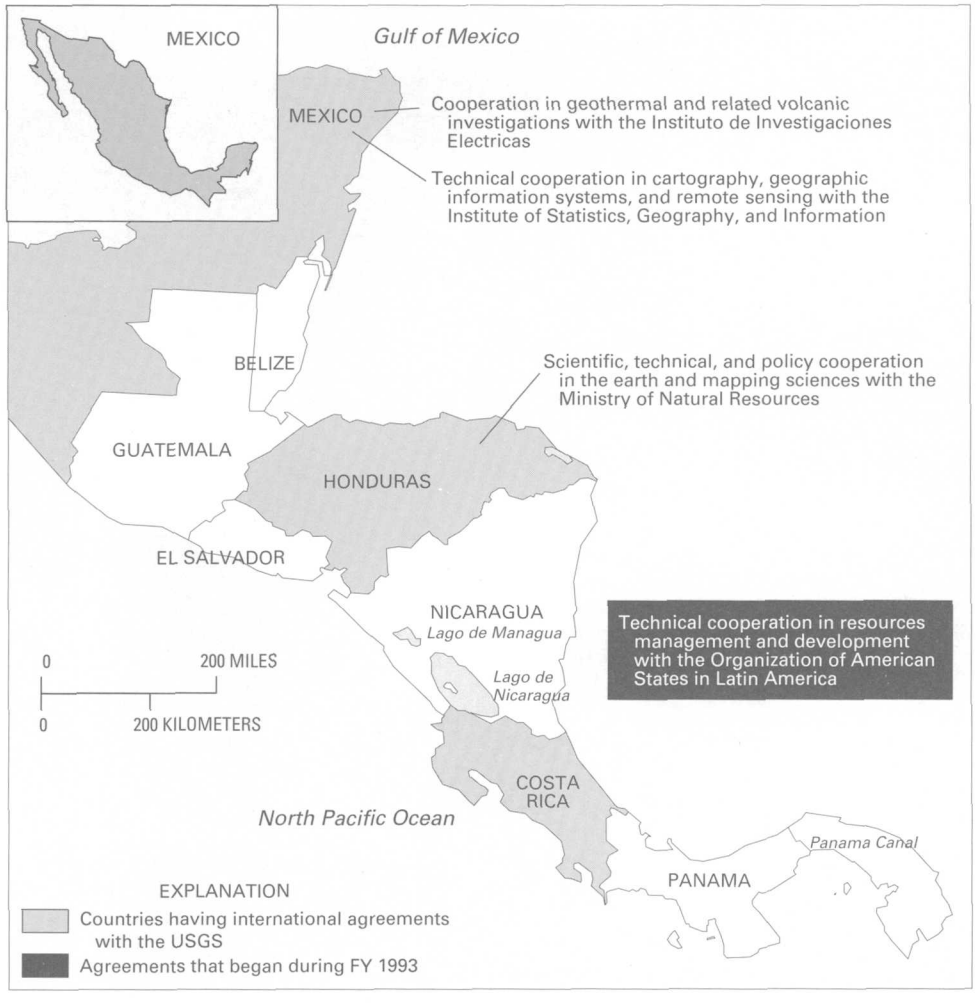
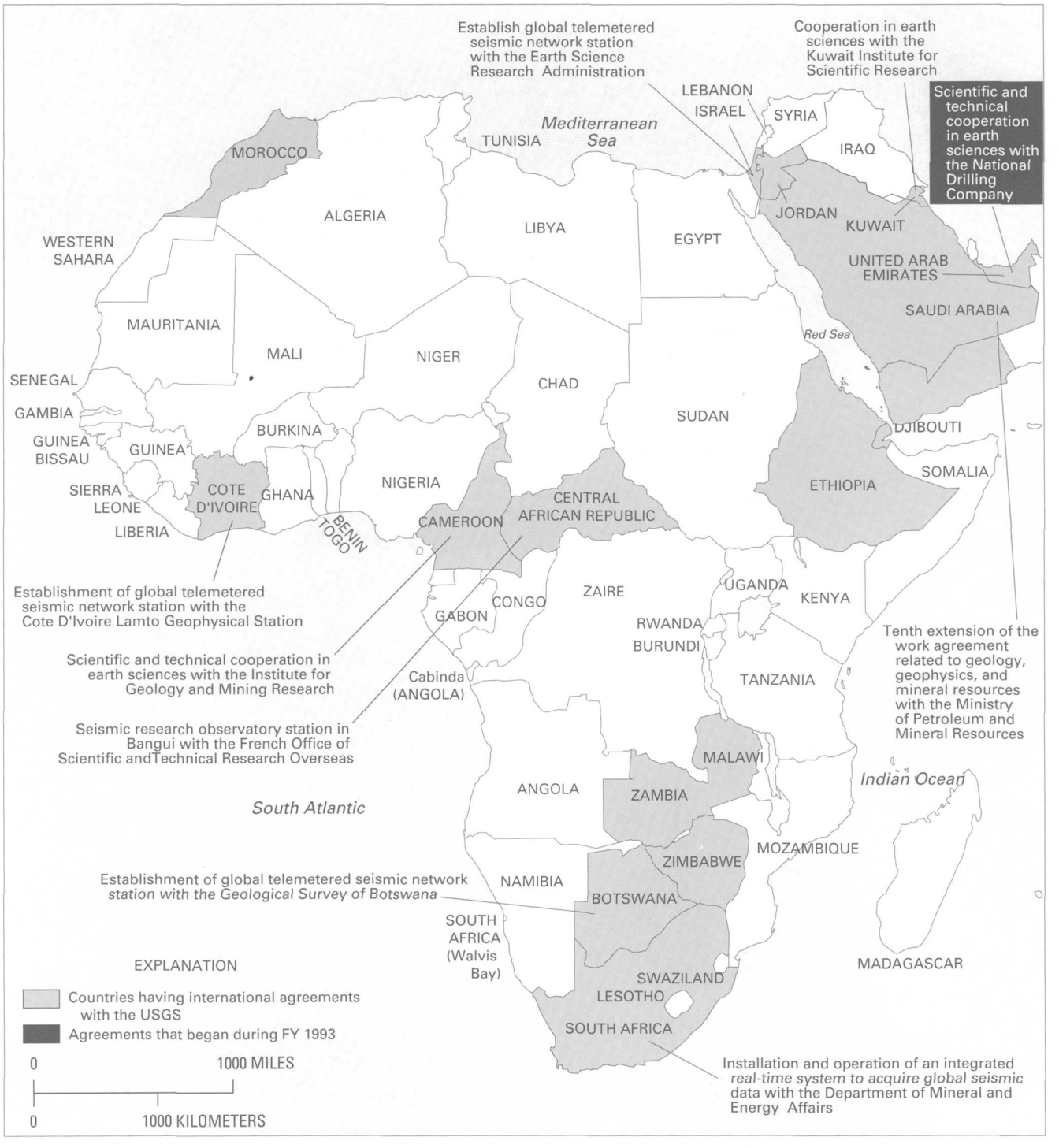


Scientific and technical cooperation in topographic mapping of portions of Antarctica with the Department of Lands and Surveys

Worldwide:

Cooperation in the International Decade for Natural Disaster Reduction with UNESCO (United Nations Educational, Scientific, and Cultural Organization)

Establishment and operation of a global resource data base facility with the U.N. Environmental Program and U.S. National Aeronautics and Space Administration


Establish global telemetered seismic network station with the Earth Science Research Administration
Cooperation in earth sciences with the Kuwait Institute for Scientific Research
Scientific and technical cooperation in earth sciences with the National Drilling Company
LEBANON
ISRAEL
SYRIA
Mediterranean Sea
TUNISIA
IRAQ
MOROCCO
ALGERIA
LIBYA
EGYPT
JORDAN
KUWAIT
WESTERN SAHARA
UNITED ARAB EMIRATES
SAUDI ARABIA
Red Sea
MAURITANIA
MALI
NIGER
CHAD
SUDAN
SENEGAL
GAMBIA
BURKINA
DJIBOUTI
GUINEA BISSAU
GUINEA
SOMALIA
ETHIOPIA
SIERRA LEONE
COTE D'IVOIRE
GHANA
NIGERIA
CENTRAL AFRICAN REPUBLIC
LIBERIA
BENIN
TOGO
CAMEROON
Establishment of global telemetered seismic network station with the Cote D'Ivoire Lamto Geophysical Station
UGANDA
KENYA
ZAIRE
CONGO
GABON
RWANDA
BURUNDI
Tenth extension of the work agreement related to geology, geophysics, and mineral resources with the Ministry of Petroleum and Mineral Resources
Scientific and technical cooperation in earth sciences with the Institute for Geology and Mining Research
Cabinda (ANGOLA)
TANZANIA
Seismic research observatory station in Bangui with the French Office of Scientific andTechnical Research Overseas
MALAWI
Indian Ocean
South Atlantic
ANGOLA
ZAMBIA
MOZAMBIQUE
ZIMBABWE
Establishment of global telemetered seismic network station with the Geological Survey of Botswana
NAMIBIA
BOTSWANA
SOUTH AFRICA (Walvis Bay)
MADAGASCAR
SWAZILAND
LESOTHO
SOUTH AFRICA
Installation and operation of an integrated real-time system to acquire global seismic data with the Department of Mineral and Energy Affairs
EXPLANATION
Countries having international agreements with the USGS
Agreements that began during FY 1993
0
1000 MILES
0
1000 KILOMETERS


Scientific and technical cooperation in earthquake studies with the State Seismological Bureau
Scientific and technical cooperation in earth sciences with the Chinese Academy of Geological Sciences
Scientific and technical cooperation in surface-water hydrology with the Bureau of Hydrology of the Ministry of Water Resources
Scientific and technical cooperation in surveying and mapping studies in the development of geographic information systems, the application of remote-sensing information, and the development of map-production management systems with the Bureau of Surveying and Mapping
Statement of intent regarding cooperation in the earth sciences with the Korea Institute of Geology, Mining and Materials
Sea of Okhotsk
KAZAKHSTAN
Scientific and technical cooperation in the earth sciences with the State Geological Center
MONGOLIA
NORTH KOREA
KYRGYZSTAN
Sea of Japan
JAPAN
CHINA
AFGHANISTAN
SOUTH KOREA
East China Sea
Cooperation in hydrology, water resources, and global climate change with the Public Works Research Institute, Ministry of Construction
PAKISTAN
BHUTAN
NEPAL
INDIA
VIETNAM
TAIWAN
HONG KONG
MYANMAR
LAOS
Cooperation in earth sciences with the Geological Survey of Japan
BANGLADESH
Bay of Bengal
THAILAND
PHILIPPINES
South China Sea
Technical cooperation in seismology and earth-quake-monitoring systems development with the Central Weather Bureau
KAMPUCHEA
SRI LANKA
MALAYSIA
0 1000 MILES
0 1000 KILOMETERS
EXPLANATION
Countries having international agreements with the USGS
Agreements that began during FY 1993
INDONESIA

At Work Across the Nation in Information Systems and Administrative Support

Mission

The Information Systems Division provides support and services to the Director of the USGS, to major programs in each division of the USGS, the Department of the Interior, and to other government agencies on information technology and automated data processing (ADP). The Division operates the USGS mainframe computer located in Reston, Va., and Technology Information Centers and minicomputers in ADP service centers nationwide.

The Division assists users in acquiring ADP and telecommunications hardware, software, and services; coordinates and improves information systems through systems analysis and design; provides user education and assistance; and conducts research into better ways to use computer technology to solve mission-related problems. The Division manages and operates voice, data, and video communications for the USGS, including DOINET, the data communications network of the Department of the Interior, from which gateways provide access to other national networks and supercomputer systems.

The Administrative Division provides administrative direction and coordination in support of the scientific and technical programs of the USGS. This support includes policy guidance and program direction and provides leadership and authority for various administrative management and technical support functions, including personnel, manpower utilization, finance, administrative management systems, management analysis, records management, procurement and contract negotiation, property and facilities management, security, safety, and motor vehicle management.

The Division also manages the development, maintenance, and operation of the financial management system for the entire U.S. Department of the Interior. These functions are carried out at the National Center in Reston, Va., and through Regional Management Offices in Denver, Colo., and Menlo Park, Calif.

Information Systems Activities

Data Processing and Telecommunications

The USGS is responsible for the management and operation of a large mainframe-based multiple computer data center in Reston, Va., that provides computational resources to a large interagency customer base located across the United States. This customer base consists of over 8,800 registered users nationwide, who use the data center's computing facilities for purposes such as financial and administrative accounting, tracking of surface-mining activities, and the Automated Minerals Information System, a worldwide data base of mineral deposit information. Customers outside the USGS include the National Park Service, the Bureau of Indian Affairs, the Bureau of Reclamation, the Bureau of Mines, and the Office of Surface Mining Reclamation and Enforcement at the Department of the Interior and other Federal agencies such as the General Services Administration and the Department of Commerce's Patent and Trademark Office. The USGS also manages, evaluates, and operates networks and provides technical advice and assistance in communications hardware and software capabilities.

Expanding Data Storage for Future Needs

The USGS has embarked on a 5-year plan to significantly expand data-storage resources available within the data center. This expansion will address the rapid increases in data-storage requirements associated with computer modeling and scientific visualization activities, digital cartographic data-base functions, and long-term archival needs of the bureau's many earth-science data collections.

A diverse mixture of online, near-line, and archival storage technology is planned. The two traditional methods of data storage—online direct-access magnetic media and offline tape data storage in a library—will be supplemented by an intermediate "near-line" storage technology. This newer technology will offer lower cost storage of large volumes of data, at retrieval speeds somewhere

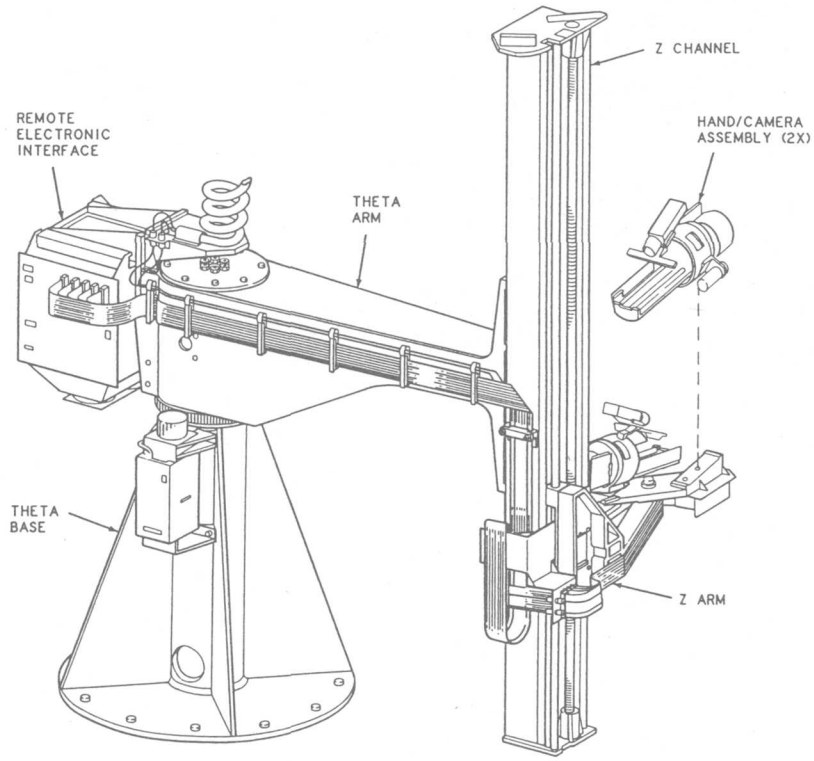
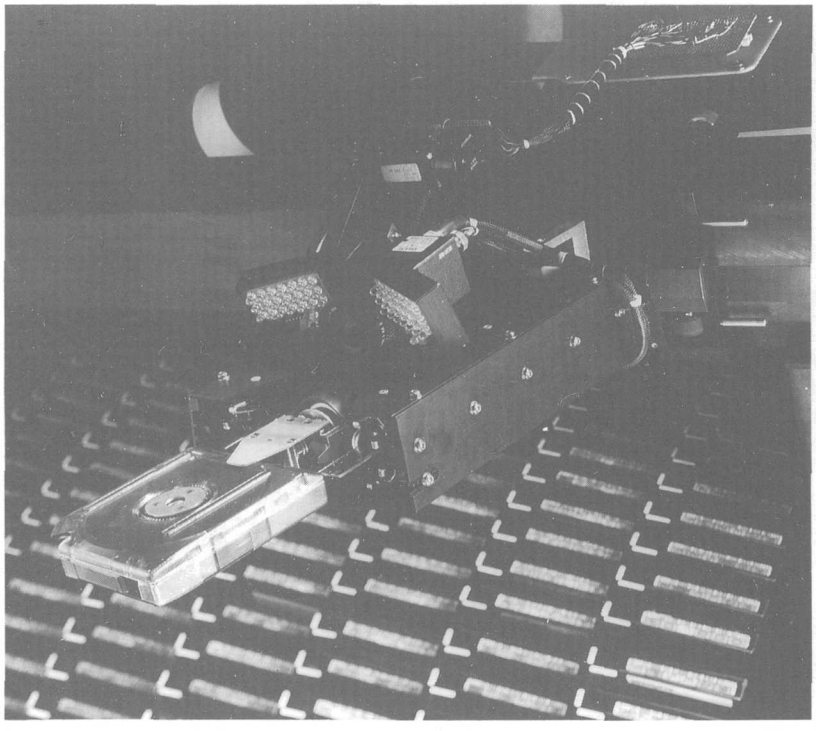


Diagram of a robotic arm assembly.

Relative Comparison of Storage Technology

	Online	Near-line	Archival
Technology type	Magnetic disk	Half-inch cartridge tape stored in robotic device.	Half-inch cartridge tape stored in library vault.
Storage capacity	Low	Medium	High
Speed of access to data	High	Medium	Low
Cost per gigabyte of storage	High	Medium	Low



A robotic arm locates a requested tape in a mass-storage system and then grasps, pulls, and mounts the tape on a tape reader.

automation techniques to store, manage, and automatically retrieve data stored on traditional tape cartridge media.

Using robotic tape library technology, a robotic arm with a camera "eye" spins around the interior of a compartment storing up to 6,000 half-inch cartridges until it finds the bar-coded serial number that matches a requested tape. The arm then automatically pulls and mounts the cartridge on a tape reader. This expanded file system will include a mainframe computer UNIX mass-storage and data-base environment with associated robot technology and read-write optical disk by 1997.

Techniques such as data compression and high-quality, rapid-access disk-drive technology will allow the total capacity of this mass-storage system to grow, by 1997, to approximately 100,000 offline archived tapes storing at least 10 terabytes (10 trillion units), near-line robot technology having capacities of 100 terabytes, and online disks providing instant access to 600 gigabytes (600 billion units) of data.

Tod Huffman
has managed USGS mainframe data center operations since 1990

For more information about data storage, please contact:

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between immediate access online and manual tape retrieval from the tape library. Starting in 1993 from a file system supporting approximately 800 gigabytes (800 billion units) of archived data on tape and 250 gigabytes of online magnetic disk storage, USGS data storage technology will be expanded to include near-line robot-managed tape and 8-millimeter helical scan tape in 1994. Near-line storage is data stored offline (in this case, on half-inch magnetic tape in an automated robotic device) that is accessible within seconds or minutes rather than the tens of minutes required to manually retrieve tape from a tape library vault. The near-line storage technology will employ advanced robotic technology and

Data Network Sharing

Recognizing that sharing equipment, circuitry, and personnel makes the best use of resources and reduces overall expenses, the USGS has long advocated sharing telecommunications resources within the Department of the Interior. Today, as in the past, communications circuitry constitutes the single most expensive portion of the communications utility. Because the usage patterns of data, voice, and video communications are sporadic and required on demand, services and circuitry can be shared among the bureaus. With award of the

GEONET-II contract in April 1993, the USGS can now acquire state-of-the-art high-speed switches and facilities to make such sharing easier. Several bureaus—the Fish and Wildlife Service, the Minerals Management Service, the National Park Service, and the Bureau of Indian Affairs—and the Washington and Denver Administrative Service Centers are interested in sharing facilities. This approach will provide more and better network integration, shared circuitry, and lower communications costs.

Elaine Stout
has over 20 years of computer and communications experience and currently manages USGS telecommunications activities

GEONET-II—WHAT IS IT?

- GEONET-II is a high-speed network based on cell relay switches to support voice, video, and data (so-called multimedia services).
- The key to GEONET-II is the cell-relay-switching architecture, which allows for full use of the expensive telecommunications bandwidth and is a near-perfect solution for the bursty local-area and wide-area network traffic. (Bursty traffic is data streams that are high volume and sustained for brief periods of time and occur on a random basis throughout the work day.)
- The GEONET-II contract, awarded in April 1993, is a $27.3 million contract with Sprint Communications Corporation that can be used by all Department bureaus and offices to facilitate the sharing of the extensive high-speed circuitry.
- GEONET-II will allow Department bureaus to perform file transfers, electronic mail, and interactive sessions between bureaus that heretofore could be done only within the same bureau.

For more information about telecommunications, please contact:

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Information Systems Policy Development

The USGS conducts research and supports efforts to enhance delivery of earth-science information and to develop policy and procedures for the automated data processing security program.

A Crucial Component of the National Information Infrastructure

To make it easier for researchers and the public to find and retrieve earth-science information, the Federal Government is promoting the establishment of the Government Information Locator Service (GILS). GILS establishes a standard approach for agency-based locators of data and information. A locator is a machine-readable data base that identifies different information resources—such as data bases, libraries, clearinghouses, guides, and lists of resources—and describes the information available in those resources. GILS will be a crucial component of the National Information Infrastructure, which is envisioned as providing public access to information and other communications media throughout the country.

GILS will use Internet as its primary electronic dissemination medium, but GILS contents will also be available via electronic mail, bulletin board systems, and information kiosks in public places and in offline media such as floppy disks, CD-ROM (Compact Disc-Read Only Memory), and printed publications.

GILS pilot operations will likely begin in spring 1994, and most of the Government may be participating within a year or two. Because its promotion of the standards for information search and retrieval and its leadership role in interagency forums such as the Federal Geographic Data Committee and the Interagency Working Group on Data Management for Global Change, the USGS was invited to take a leadership role in establishing GILS under the auspices of the Office of Management and Budget and the Administration's Information Infrastructure Task Force.

Eliot Christian
is a USGS computer specialist working with the Office of Management and Budget and the Administration's Information Infrastructure Task Force

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Internet echristi@usgs.gov

Computer Security in the Event of an Emergency

What would happen to the USGS mainframe computing capability in Reston, Va., if a major fire, tornado, or hurricane severely damaged or destroyed the data center? This very large computing facility provides significant financial and scientific support to the USGS and

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Internet dwatson@usgs.gov

other Department bureaus throughout the United States and its possessions. To augment the security of the Reston mainframe capability, the USGS awarded a contract to provide an alternate processing site in the event of such an emergency situation. All mainframe operations, including all necessary telecommunications links, can be switched quickly to another location, with minimal disruption of the user community.

The awarding of this contract was the culmination of an 18-month effort that included a functional impact analysis of all mission-critical applications that run on the mainframe computer, such as the Federal Financial System and the National Digital Cartographic Data Base, and visits to companies that provide disaster recovery services. These companies have large facilities that contain multiple computers running 24 hours a day for the express purpose of being immediately available if a client's computer operations are interrupted.

An integral part of the bureau's ongoing computer security program, this effort will help guarantee continued operation of the mainframe computer in Reston, Va., and bring the USGS into compliance with Federal computer security regulations. With contractor assistance, the USGS will be able to recover full operational capability within 48 hours of a disaster with minimum impact on the user. To help ensure that these goals are met, several mock disaster recovery tests will be conducted each year. A typical test will involve going to the alternate processing site, loading the operating system and utilities from backup tapes that were stored at an offsite location, and conducting tests of the operating system software. If all systems check out, selected applications will be loaded and computer analysts from the offices responsible for the applications will conduct remote tests to determine if everything functions correctly. Other computer specialists will revise the current mainframe contingency plan to reflect the use of a contractor-supplied recovery site.

With contractor assistance, the USGS will be able to recover full operational capability within 48 hours of a disaster. . .

Don Watson
is the manager of the USGS computer security program

Geologists discuss attributes of different visualization techniques.

Support of Scientific and Technical Systems

The USGS designs and develops computer software systems for USGS and Departmentwide applications; evaluates hardware and software to assess applicability; provides technical advice to scientists and managers in information technology areas including high-performance computing and scientific visualization; reviews and makes recommendations regarding approval of all

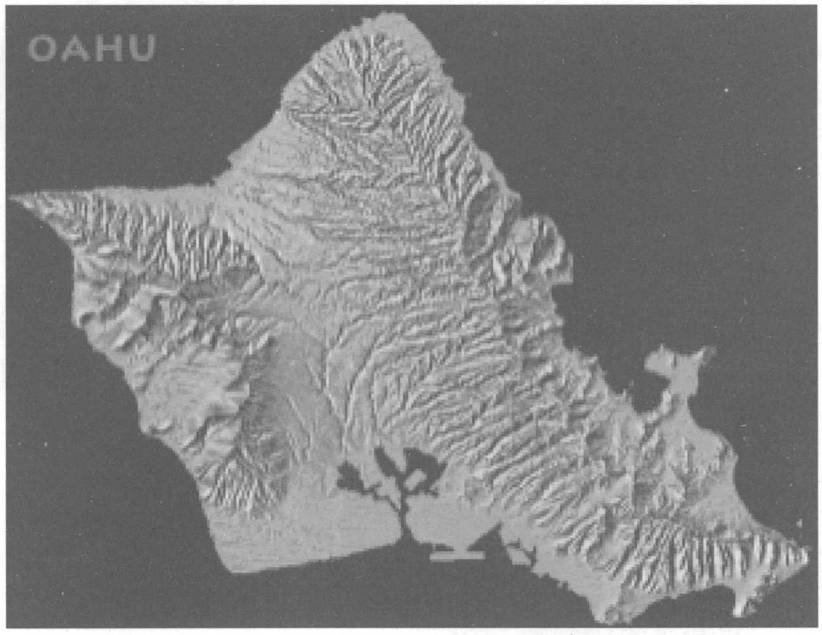
requests for acquisition of information systems resources; provides first-level customer assistance for computer and communications technologies; provides computer-related training; and publishes an automated data processing (ADP) technical journal and a mainframe user's manual.

ADP service centers in Denver, Colo., Flagstaff, Ariz., and Menlo Park, Calif., provide a full range of comprehensive user and ADP services to all USGS employees in their service areas.

Scientific Visualization

Scientific visualization is the visual or graphic representation of scientific data in a format that enables users to interact with, analyze, and study data and may lead to insights that are not possible through more traditional methods or techniques. Sharing information about these visualization techniques and the corresponding findings or products allows scientists to learn more about the technologies and techniques available to foster scientific endeavors and also enables the USGS to more effectively display the results of its investigations to the public and to customers of USGS data and products.

A scientific visualization workshop held in Menlo Park, Calif., on September 15, 16, and 17, 1993, provided both an internal and a public forum to stimulate interest in exploring applications of this powerful technology. Scientists from the USGS and collaborating organizations such as NASA's Jet Propulsion Laboratory, the Monterey Bay Aquarium Research Institute, the Naval Postgraduate School, the University of California at Santa Cruz, and the Environmental Protection Agency participated. The workshop provided exposure to a vast array of computer technologies and special-purpose tools used to study and show phenomena such as the hydrodynamic properties of San Francisco Bay and Massachusetts Bay waters, the volcanic structure underlying the island of Hawaii, the evolution of landforms, the properties of rock in situ 1,000 feet under El Capitan in Yosemite Park, and the distribution of earthquakes worldwide in near-real time. The USGS will sponsor another scientific visualization workshop in New Orleans, La., in April 1994.



Multidirectional shaded relief map of Oahu generated in ARC/INFO for the 1993 Menlo Park workshop on scientific visualization.

Carol Lawson
served as coordinator of the USGS-sponsored scientific visualization workshop held in Menlo Park, Calif., in 1993

For more information about scientific visualization, please contact:

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Parallel Virtual Machine

Parallel Virtual Machine (PVM) is a parallel processing application environment that allows scientists to take advantage of excess computer power in their computing environment. PVM runs on several UNIX platforms including the Sun Microsystem's Sun, IBM's RISC, Data General's AViiON, and Silicon Graphics' IRIS across both local-area and wide-area networks. The USGS has loaded PVM onto several machines and begun experimenting with its capabilities.

To determine PVM's relevance to the USGS's application programs, scientists throughout the bureau have begun a number of collaborative projects. Computer scientists are working with hydrologists to move existing water resources applications such as Phreeqm, a FORTRAN IV computer program designed to model geochemical reactions, into the PVM environment. In a separate

For more information about PVM, please contact:

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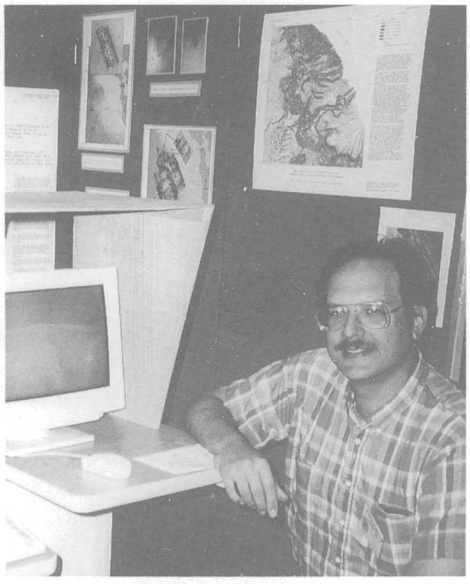
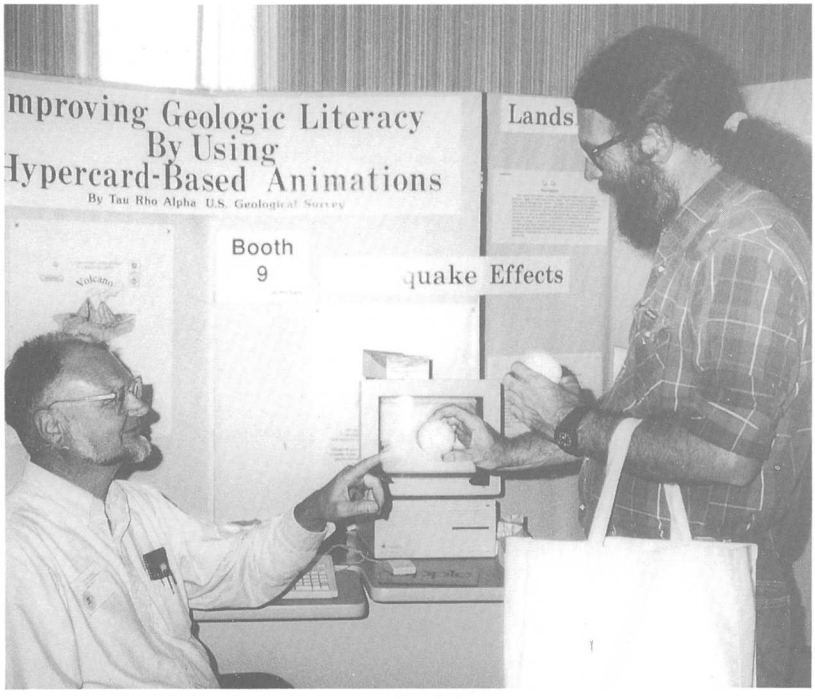
A USGS geophysicist describes a data overlay showing imagery of the Monterey Bay Marine Sanctuary.



A USGS data manager demonstrates "fly-by" tools on a personal computer.



A USGS research cartographer describes a technique for developing earth globes showing tectonic plates for use as an education tool.

prototype development project, computer scientists worked with cartographers to move ADAPSM (adaptive smoothing algorithm), an image-processing mapping application, into the PVM environment. This algorithm modifies values in an image by means of a computer program.

Scientists are now working together to quantitatively determine how much computer time has been saved by these moves to a PVM environment. These prototypes will help judge how useful PVM will be in handling a variety of complex earth-science computing applications.

Lisa Burgess
is a computer scientist exploring parallel processing and its possible benefits to USGS scientists

Administrative Support

The principal administrative programs of the USGS include personnel management, financial management, procurement and contracts management, facilities and management services, and systems management.

Financial Management

The Office of Financial Management controls and implements accounting policy and procedures and administers the Chief Financial Officer (CFO) function. Fiscal services include accurate and timely processing of vouchers and claims, fulfilling financial reporting systems requirements, developing alternative methods for data entry and exchange, and providing other general support. FY 1993 accomplishments include:

- Implementing a quality improvement program to upgrade the overall level of support provided to the program divisions.
- Developing the first bureau CFO Financial Statement.
- Realigning traditional financial functions to a process-oriented structure.
- Installing imaging technology to archive and retrieve fiscal documents.

Personnel Management

The USGS Personnel Management program includes recruitment; employee and labor management relations; employee development; classification and position management; processing of personnel actions; and conduct of personnel management evaluations. FY 1993 accomplishments include:

- Developing a USGS Executive, Managerial, and Supervisory Development program to prepare a pool of qualified candidates for executive, managerial, and supervisory positions through rotational assignments, details, and formal developmental training opportunities. This intensive 1-year training program will qualify graduates for one noncompetitive promotion.
- Offering mentoring seminars at key field centers to encourage interest in and support for the establishment of informal and formal mentoring programs. Specific interest has been expressed by women's groups within the USGS.
- Developing and issuing guidelines to employees in administrative and technical occupations. These guidelines provide a systematic approach to career planning and include job analysis information, a self-assessment exercise, a guide for setting performance goals, and tips on how to accomplish goals.
- Purchasing training materials for the three USGS Career and Management Resource Centers, including books, audio cassettes, and videotapes related to a variety of subjects, such as career development, self development, supervision, management, work force diversity, and Total Quality Management. Any USGS employee may borrow these training materials.
- Offering training in sexual harassment prevention. All employees were required to attend this onsite training, which included classes and commercial videotape programs. The USGS also developed a videotape on preventing sexual harassment for distribution and use throughout the bureau.

Procurement and Contracts Management

The Procurement and Contracts Management program coordinates, integrates, awards, and administers numerous procurement, grant, and cooperative agreement programs. In addition to operational procurement in support of USGS missions, principal functions include formulating and implementing policy procedures and technical guidance; sponsoring bureauwide procurement training; and determining procurement and contracts system requirements. FY 1993 accomplishments include:

- Awarding a contract to support the Department of the Interior Electronic Acquisition System (IDEAS) project, which will install a computerized acquisition system in each bureau of the Department to enhance the productivity of the acquisition workforce, substantially eliminate duplicate data entries and reduce paperwork, and interface with other administrative management systems.

• Awarding production contracts that, over the next 3 years, will provide for the production of 30,000 digital orthophoto quadrangles for the USGS National Mapping Program.

Facilities and Management Services

The Facilities and Management Services program provides staff advice, direction, and guidance in space and facilities management, security, property management, safety management, supply management, paperwork management, and other administrative services. FY 1993 accomplishments include:

• Working with the General Services Administration to replace cooling towers and underground fuel tanks and install energy-efficient lighting, a new fire alarm and suppression system, and other energy-saving retrofits at the USGS National Center in Reston, Va.

• Adding cardboard and grade 2 paper to the headquarters recycling program, reaching a total waste-stream reduction of 80 percent.

• Eliminating 55 USGS forms that were in little or no demand and reissuing the Forms Facsimile Handbook to reflect the changes.

• Adopting standard, networked forms-completion software and issuing electronic versions of over 100 forms.

• Overseeing construction of a new $7.1-million advanced systems center building at the National Center. The new facility was completed on time and under budget.

• Instituting cost savings in mail usage that led to a 36-percent cost reduction in international mail costs and lowered costs for U.S. Postal Service Express Mail.

• Developing and distributing a safety orientation guide for new collateral duty safety officers.

• Completing an in-depth analysis of accidents occurring throughout the bureau for the 10 most populous occupational codes.

• Launching a major initiative to introduce alternative-fuel vehicles into the motor vehicle fleet as a concrete step to protect the environment and reduce dependence on imported petroleum, in accordance with the bureau's energy reduction plan.

• Restructuring personal property accountability levels to ensure management involvement and to improve internal controls. Also, implementing a bureauwide excess reporting system to streamline the reporting process and promote reuse of available property.

• Designating every USGS position on the basis of an assessment of public trust responsibilities and national security sensitivities.

• Completing background investigations and providing suitability certifications for permanent contractors performing building services at the USGS National Center in Reston, Va.

Systems Management

The USGS uses a variety of administrative automated data processing (ADP) systems and resources in support of its programs. The Systems Management program manages administrative systems and the ADP resources of the Administrative Division. It seeks to improve administrative functions by applying ADP techniques and technologies; standardize and integrate ADP systems and manage their costs efficiently; plan for both short- and long-range administrative ADP needs; and design, develop, and acquire automated administrative information systems. FY 1993 accomplishments include:

• Assisting the National Park Service and the U.S. Fish and Wildlife Service in implementing the departmentwide

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. . .the new software will. . .improve the capability to manage large map and book inventories.

AVADS (Automated Vacancy Announcement Distribution System), increasing to nine the number of participating Department of the Interior bureaus. AVADS collects and distributes job-opening information to personnel offices throughout DOI and to the general public.

- Initiating software development to replace the order processing and inventory management system for USGS map product sales. Designed as a subsystem of the Federal Financial System (FFS) Inventory Control Subsystem, the new software will eliminate accounting differences, reduce manual processing, closely integrate product sales billing and receivables information with the FFS, and improve the capability to manage large map and book inventories.
- Initiating the redesign of an existing automated time-and-attendance (T&A) system with a paperless T&A system that will be capable of running on nearly every type of hardware, network, operating system, or data-base management system at the USGS.
- Began to replace the current USGS Property Management System with the FFS Fixed Assets Subsystem, an integrated component of the Departmental financial system. The new system will increase access to property information, streamline workflow by incorporating electronic signatures and transfers of property records, and resolve accounting discrepancies.

Washington Administrative Service Center

As one of two departmental administrative service centers, the Washington Administrative Service Center (WASC) supports finance and accounting, procurement and contracts, personnel, property, and other general administrative functions. In support of all Department of the Interior bureaus (and other agencies as negotiated), the WASC provides systems analysis, design, development or acquisition, implementation, training, and operations and maintenance support. FY 1993 accomplishments include:

- Installing software enhancements to the Federal Financial System (FFS). Version 5.0.1.D includes features and capabilities that improved overall FFS performance. The enhancements benefit users throughout the Department of the Interior and represent a cooperative effort of the FFS Software Advisory Board, an interbureau workgroup.

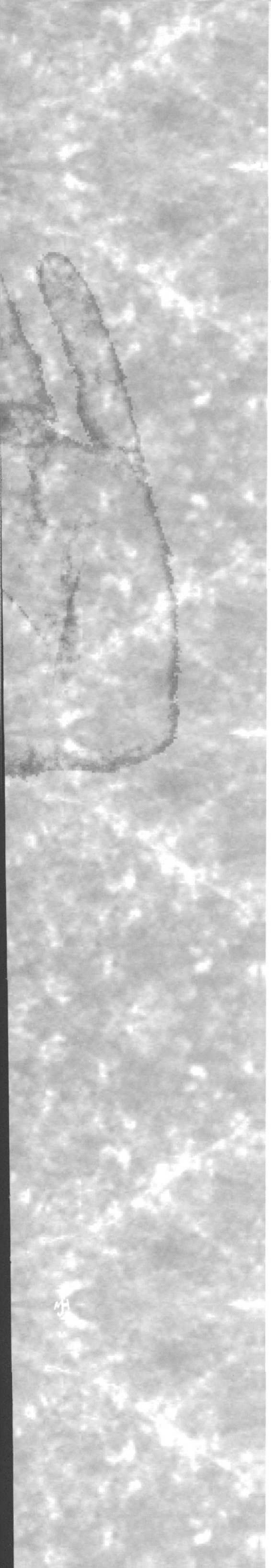
The WASC installed software enhancements that will benefit users throughout the Department of the Interior. . .

- Providing analysis and design of FFS release 5.1.1 enhancements for all Department of the Interior bureaus, including the design of a generic microcomputer-based FFS module.
- Acquiring the Interior Department Electronic Acquisition System (IDEAS) software as part of Departmentwide efforts to standardize and automate procurement activities in all bureaus. Activities also included preparations for acceptance testing and coordination with all Department bureaus regarding IDEAS planning.
- Initiating operational support for the General Services Administration's governmentwide Federal Procurement Data System and operating the Interior Procurement Data System for the Department.
- Beginning to develop a standard Department of the Interior accounting manual.

At Work Across the Nation for People and Special Initiatives

Mission

The USGS is a people-oriented organization. Individual USGS scientists and technicians are vitally involved in doing the best science possible and then looking at ways in which theory and technology can be applied to earth-science issues and problems. USGS employees feel empowered and vital to the mission of the organization. The USGS was one of the first major U.S. organizations to experiment with and adopt alternative work schedules, and it supports a growing network of Federal day-care centers. This organizational mindset means that people who work for the USGS feel that they are part of the USGS team. Employees tend to stay with the USGS throughout their careers. At annual awards ceremonies, for example, it is not unusual to see large numbers of 30- and 40-year service awards, and 50-year awards are not unheard of. Once retired, many employees continue their relationship with the USGS as unpaid volunteer docents at visitor centers or in professional pursuits. Through its programs and its people, the USGS meets the earth-science challenges of a modern technology-oriented society.



Personnel

Honors and Awards

Each year, USGS employees receive awards and honors that range from certificates of excellence and monetary awards to recognition of their achievements by election to membership or office in professional societies.

Meritorious Service

The Meritorious Service Award is the second highest award granted by the Department of the Interior and is given for significant contributions to the earth sciences and to management and administration of USGS scientific programs. Recipients in 1993 were:

Fred Barker, Daniel B. Brothers, Joseph D. Camp, Charles G. Cunningham, James A. Davis III, Pamela S. Detra, Thomas P. Dinardo, Patricia P. Dunham, Robert W. Fleming, Albert J. Froelich (posthumous), Gale K. Fullerton, Judy A. George, Joseph E. Graham, Stephen C. Guptill, Aaron L. Higer, Tod E. Huffman, Robert M. Kosanke, Robert Y. Koyanagi, Robert P. Masse, Gary G. Metz, Mary G. Mortellaro, William A. Oliver, Jr., Ronald S. Oremland, Glenn L. Osick, James P. Owens, James A. Peterson, Charlene Hall Raphael, Henry R. Spall, Charles W. Spencer, Gail A. Wendt, Richard C. Williams, Gary R. Winkler.

Superior Service

The Superior Service Award is the third highest award granted by the Department of the Interior and is given for significant acts, services, or achievements that materially aid the accomplishment of the USGS mission. Recipients in 1993 were:

Ronald V. Allen, Carol J. Anderson, Claud H. Baker, Jr., Jerad D. Bales, Norman G. Banks, A. Edward Barr, Herta M. Bell, James M. Bettandorff, John P. Borland, Brian S. Bradley, Walter A. Brandner, Gaylia C. Brock, Debra P. Campbell, David E. Catts, Paul Willard Cole, Derrill J. Cowing, James Dee Craig, Michael P. Crane, Marvin A. Crist, Richard B. Delp, Michael Diggles, Michael E. Dorsey, Beth L. Duff, Mark A. Eaton III, Melvin Y. Ellis, Max M. Ethridge, Larry D. Fayard, John C. Fordham, Mark E. Gettings, Anthony B. Gibbons, Joseph G. Gorman, Martin E. Gurtz, Pixie A. Hamilton, Paul S. Hampson, Robert W. Harper, Thomas M. Holm, Dale R. Hughes, Barry N. Humphrey, Jeffrey L. Imes, John W. Jones, Lawrence C. King, J. Roger Knapton, Lee C. Koehn, Robert D. Lamke, Andrew G. Lamonds, Jr., Curtis E. Larsen, L. Rodney Larson, Thomas J. Lauterborn, Larry S. Leveen, Katherine F. Lins, Ronald C. Lowrimore, Barbara M. Ludwick, Sharon A. Maccini, Maxine J. Mannion, Priscilla A. Mawyer, Thomas A. McCulloch, Robert F. Middelburg, Jr., David M. Miller, Hope D. Miller, Deborah K. Moreland, Patrick W. Murphy, Karen A. Nelson, Nancy I. Ordazzo, Gregory B. O'Neill, Ronald C. O'Neill, Glenda D. Pearsall, Linda K. Peng, Ellie C. Price, Lois J. Rafalko, Carolyn L. Reid, Emeretta F. Rudy, Robert D. Sapp, Dwight L. Schmidt, John C. Scott, Fletcher C. Sedberry, Truman D. Seiber, Wallace F. Shelton, Michael V. Shulters, Gayle A. Sisler, Connie L. Smith, Hezekiah Smith, Charles W. Smoot, David R. Soller, Ronnie D. Steger, James A. Sturdevant, Nancy R. Teed, Nancy M. Thurman, Richard M. Tosdal, Deborah H. Weldon, Linda G. Wenri, Michael G. Williams, Clara C. Wilson, Linda A. Witmer.

Unit Awards for Excellence of Service

The 1992 National Center Open House Team received a Unit Award from the Department of the Interior for organizing the Open House, held at USGS headquarters in Reston, Va., and attended by about 12,000 visitors on April 24 and 25, 1992. The 32 individuals recognized in the award coordinated the efforts of about 400 USGS employees who worked long hours to assist in nearly every aspect of the Open House. Thanks to the outstanding work of the Open House Team, the event was well conceived, well planned, and well organized and provided the public with an opportunity to learn about the USGS and its primary mission of providing "Earth Science in the Public Service."

Denver Open House Team

Members of the Steering Committee for the 1993 Open House in Denver, Colo., were recognized for their outstanding contributions to the success of that event. Committee members were Lisa Bader, Deborah S. Boles, Linda J. Britton, Beverly A. Clyncke, Jill J. Cress, Gerald L. Dinkel, Sally J. Dyson, John C. Fordham, William R. Hotchkiss, Ginger Peltz, Larry Volkening, and Richard M. Wells. (See p. 96 for photo montage.)

The USGS was presented a Unit Award by the Interior Department for exceeding all of the Fiscal Year 1992 Business and Economic Development goals as well as making significant contract awards to small, minority, and women-owned businesses; for participating in many procurement and minority business conferences and trade fairs; and for giving a presentation to the contracting personnel of the Small Business Administration.

Awards and Honors Received by USGS Employees in 1993

Francis H. Chapelle received the Award for Excellence in Science and Engineering from the National Ground Water Association for writing the textbook "Ground Water Microbiology and Geochemistry."

Bonnie B. Claus received the Safety Management Award in 1993 for her efforts to raise the level of employee safety awareness in the Branch of Petroleum Geology and throughout the USGS Central Region. She established an ergonomics training program and developed a workshop to train teams in ergonomic issues at several USGS locations.

Philip Cohen received the C.V. Theis Award of the American Institute of Hydrology for career-long contributions to the science of hydrogeology, for strengthening and expanding the USGS Federal-State Cooperative program, and for establishing the USGS National Water Quality Assessment.

G. Brent Dalrymple was elected to the National Academy of Sciences and was awarded an honorary doctorate from Occidental College, Los Angeles, Calif., for significant career-long contributions to the earth sciences,

Lucy E. Edwards was elected president of the American Association of Stratigraphic Palynologists, the leading worldwide organization for the study of pollen, spores, and algae.

George E. Ericksen was honored by the three principal geological and mining societies of Peru, in three separate ceremonies in July 1993, for his work in Peru on a range of earth-science topics including the evaluation of earthquake damage, analyses of Peru's metallic mineral deposits, and studies of desert landforms.

Timothy L. Gauslin won the Best Windows Application in the Government award at Windows World '93, a computer show of Windows software and custom applications, for his Wide-Area Information Server application.

Robert J. Gilliom was named Engineer of the Year for the USGS, Department of the Interior, by the National Society of Professional Engineers.

James L. Hott received an award from the Commissioner of the General Services Administration for his outstanding work as chairperson of the Price of FTS 2000 Committee.

Cliff R. Hupp received the W.S. Cooper Award of the Ecological Society of America for contributions in ecology with special emphasis on geobotany, physiographic ecology, plant succession, and plant distribution along environmental gradients.

Bruce Molnia was presented the Volunteer Service Award by the Department of the Interior in recognition of outstanding community leadership in a research project on the Bering Glacier in Alaska that relied heavily on volunteer support.

Charles D. Nethaway, Jr., received an award in recognition of his significant contributions to the success of the FTS 2000 Cost Effectiveness Comparison Project of the General Services Administration.

L. Niel Plummer received the O.E. Meinzer Award of the Geological Society of America for writing an outstanding paper in the field of hydrogeology.

Bruce Reed (deceased) received the Department of the Interior's Award of Excellence for Accident-Free Flying for 6,000 hours of safe flying to support mineral-resource fieldwork in remote Alaskan locations.

Victor C. Ruder received the San Francisco Bay Area 1992 Federal Employee of the Year Award (disabled category). Ruder began his career as an administrative clerk and is now a budget analyst.

Charles W. Spencer received the Public Service Award for 1993 from the American Association of Petroleum Geologists.

Marilyn M. Stark was selected to be a Fellow of the Special Libraries Association.

Charles Thompson received the Department of the Interior's Award of Excellence for Accident-Free Flying for 4,500 hours of safe flying in planes that are equipped with external geophysical devices and for flying grid-line surveys at low elevations.

Harry A. Tourtelot was honored as a Distinguished Alumnus by the Geology Department of the University of Nebraska.

Frank Whitmore received the Arnold Guyot Memorial Award of the National Geographic Society for outstanding achievements in geology and paleontology.

Philip L. McKinney, **Richard M. Comerford**, and **Clarence L. Smith** (Department of the Interior) were presented a 1992 Federal Leadership Award for giving leadership and direction to the Department of the Interior's initiative to acquire and implement a single departmentwide accounting and payment system throughout the 10 Interior bureaus. The new system replaced a number of obsolete and incompatible financial management systems and is expected to accrue substantial savings to the Government.

Philip L. McKinney, **Richard M. Comerford**, **Clarence L. Smith** (Department of the Interior), **Barbara L. Whitford**, **John L. Walbert**, and **Anthony B. Queern** were awarded the Financial Management Service Award by the Department of the Treasury for exceptional achievements in the standardization of Interior's accounting and payment systems and payroll system. Their work has become a standard for other Federal agencies in improving their financial management procedures.

The Branch of Telecommunications of the Information Systems Division received the General Services Administration's Management Excellence Award for positive contributions to the smooth transition from the old FTS network to the new FTS 2000 network. The branch was cited for developing innovative approaches to integrating voice, video, and data over long-haul circuits, analyzing FTS 2000 usage data, effecting a smooth transition to the new system at over 200 locations, and challenging network service costs that resulted in Governmentwide lowering of FTS 2000 charges.

USGS employees received Honorable Mention awards in the 1993 Blue Pencil competition, sponsored by the National Association of Government Communicators:

Pixie A. Hamilton, **Joan M. Rubin**, and **Robert J. Shedlock**, for "Are Fertilizers and Pesticides in the Ground Water?"

Wayne B. Solley, **Robert R. Pierce**, and **Howard A. Perlman**, for "Estimated Use of Water in the United States in 1990."

Stephen Vandas and **Frank Farrar**, commercial artist, for "Wetlands: Water, Wildlife, Plants, and People."

Jane B. Russell and **John M. Watson**, for "Earthquakes and Volcanoes, Vol. 22, No. 6, 1990."

Public Service Recognition

Special awards were presented by the USGS to nine employees for their outstanding contributions as public servants. Those receiving Public Service Recognition Awards were:

Amy L. Berger, for coordinating the first-ever Department of the Interior Conference on Accessible Technology, which has provided guidance to other agencies and bureaus in recruiting, retraining, and promoting employees with disabilities.

Sherri A. Craun, for her ability to accomplish many difficult tasks simultaneously while maintaining a high level of professionalism and for establishing a work ethic that is an inspiration to her co-workers.

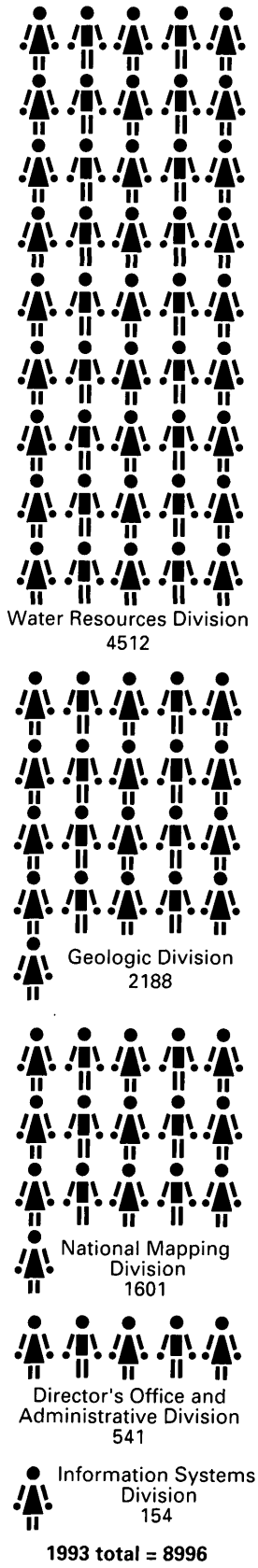
Karen Franczyk, for her educational outreach efforts to public schools, to international visitors, and to fellow professionals in industry and academia.

Barbara Herring, for exceptional management of the official records and correspondence of the Director of the USGS.

Mary T. Krupa, for her commitment to the creation of a diverse workforce through educating minority organizations and academia about the mission of the USGS and its interest in attracting minority students.

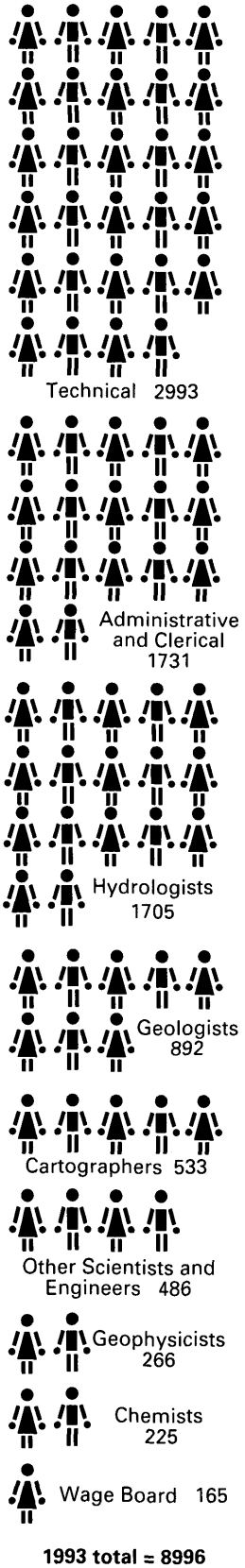
George B. Madill, for his devotion to the development and operation of the national earth-science information network that links 11 USGS Earth Science

Personnel, by Division



1993 total = 8996

Personnel, by Occupation



1993 total = 8996

Information Centers, 64 State agencies, and 2 Federal agencies to provide earth-science information to the public.

Leslie Ogrosky, for development of software that allowed the USGS to convert to a new format for producing digital cartographic data that resulted in more accurate maps.

Larry R. Shelton, for designing and developing new field equipment for use in difficult terrains and for superior recruitment and training of new technicians, resulting in a highly qualified and efficient technical staff.

A. Wesley Ward, Jr., for exceptional leadership in inspiring minorities to pursue careers in science.

Exemplary Act Awards

Gary Huffman of Lansing, Mich., rushed to the aid of an elderly man after his truck skidded, rolled, and landed on the driver's side. Huffman turned off the vehicle's ignition, pulled the man to safety, and directed traffic around the vehicle until rescue assistance arrived.

William M. Kappel of Ithaca, N.Y., provided technical assistance to local police and emergency personnel in the immediate aftermath of a landslide. By drawing on his knowledge of the geology of the area, he provided valuable advice concerning possible shifts in the slide, evacuation of homeowners, and closure of roads.

Charles R. Thompson, of Golden, Colo., saved the life of a choking flight-crew member by applying the Heimlich maneuver.

Ethics Awards

An Ethics Award was presented to the USGS by the Department of the Interior in recognition of the career-long work of **Jane H. Wallace**, Ethics Counselor, and **Maxine C. Millard**, Chief of Personnel, in designing and implementing an outstanding ethics program for the USGS and for providing expert advice and counsel to other ethics offices in Department of the Interior bureaus.

Members of the USGS Ethics Committee were presented the Ethics Program Award for writing the Ethics Handbook for USGS employees on bureau policies and procedures regarding ethics and outside activities. Committee members are **Gabriel Paone**, Departmental representative from the Office of the Solicitor; **Philip M. Bethke**; **William J. Carswell, Jr.**; **Jack F. Evernden**; **William F. Gossman, Jr.**; **Maxine C. Millard**; **Randle W. Olsen**; **Frederick B. Sower**; **John R. Swinnerton**; **Jane H. Wallace**; and **Isaac J. Winograd**.

John Wesley Powell Awards

Each year, the USGS presents the John Wesley Powell Awards to persons or groups outside the Federal Government for voluntary actions that result in significant gains or improvements in the efforts of the USGS to provide "Earth Science in the Public Service."

The award is named in honor of John Wesley Powell, the second director of the USGS (1881–84), geologist, Civil War hero, Native American ethnographer, and pioneer explorer of the Colorado River. Powell Award recipients for 1993 were:

The California Department of Transportation (CalTrans) received the Powell Award for Achievement by a State or Local Government in recognition of significant contributions to USGS marine investigations of earthquake faults in the San Francisco Bay area. In 1991, the Department provided several boats and operators to work with USGS scientists in the daily deployment and retrieval of sensitive instruments along the edges of the dredged channels in San Francisco, San Pablo, and Suisun bays. Thanks to this support from CalTrans, the USGS was able to obtain unprecedented state-of-the-art seismic reflection data in an urban region of active geologic faulting.

InterNetwork, Inc., received the award for Achievement in Industry for working with the USGS on development of an exceptional and innovative data and information system to disseminate global change information. The partnership produced the first electronic science journal and is encouraging the research community to discover new ways of communicating the results of scientific investigations to nontechnical audiences,

especially primary- and secondary-school children.

James F. Pankow, Chairman of the Department of Environmental Science and Engineering at the Oregon Graduate Institute of Science and Technology, received the Powell Award for Achievement in an Educational Institution. Pankow was cited for many direct contributions to the USGS organization and operations, particularly in the reorganization of the National Water Quality Laboratory, and for working with a team of USGS scientists in the design and field comparison of several ground-water sampling devices.

Minority Business Enterprise Award

The USGS received the Minority Business Enterprise Award for the third time in the past 4 years from the Department of the Interior in recognition of commitment to the goals and objectives of the Department's Minority Business Enterprise program.

Antarctic Service Medal

Roger Barlow, **John C. Campbell**, and **Gordon H. Shupe** were awarded the Antarctic Service Medal for their participation in the USGS's long-standing Antarctic research efforts in cooperation with other Federal agencies and foreign nations. The award was established by Congress to honor individuals who have served as members of a U.S. expedition to Antarctica.

Special Initiatives

The future composition of the USGS workforce is an important issue. Significant attention is being given to ensuring that the USGS workforce is diverse and reflects society as a whole. Special programs target women and minorities to ensure that they are aware of and consider careers in the earth sciences. The USGS has one of the Department of the Interior's highest employment rates for persons with disabilities and is continuing its efforts to make career opportunities accessible. Volunteerism, another area in which the USGS has a strong program, seeks to augment the workforce and to provide interesting and informative work experiences for volunteers. USGS employees continue to be involved in the communities in which they work by making classroom presentations, participating in community outreach programs, and establishing partnerships with local schools.

Volunteer for Science Program

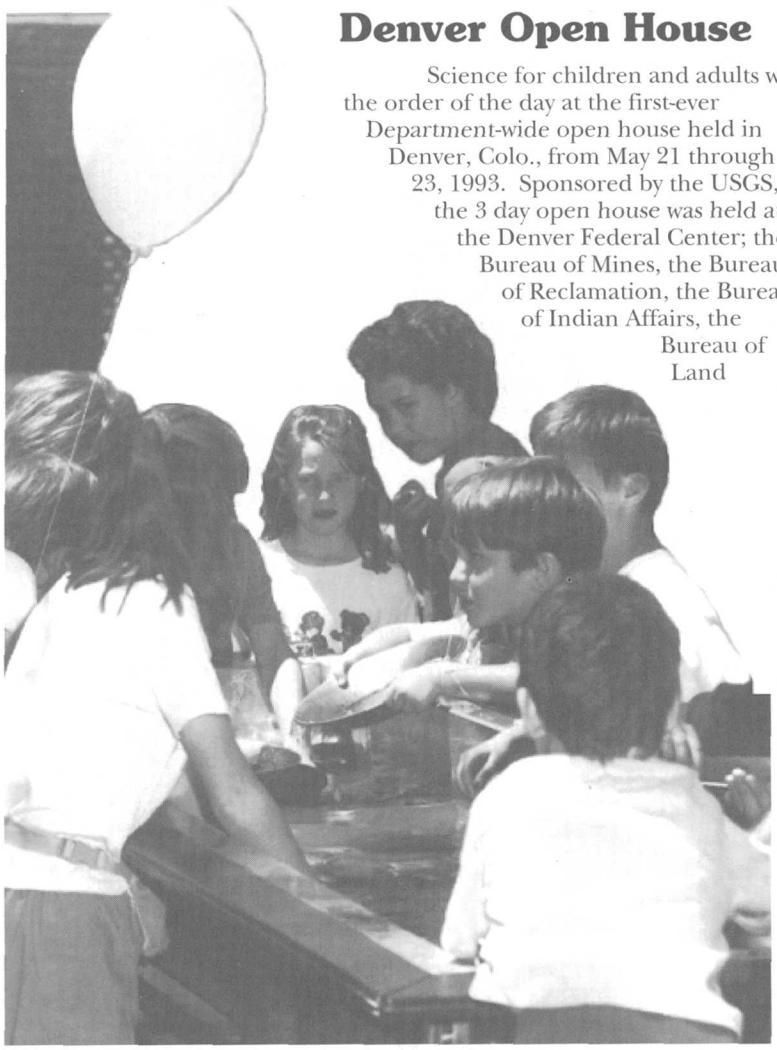
The Volunteer for Science program continues to be a success in communities across the Nation where USGS offices are located. For example, the program allowed several students with disabilities from public schools in Fairfax County, Va., to acquire basic job experience by volunteering as clerical assistants at USGS headquarters, doing filing, photocopying, and mailing in several offices.

In the program's 7 years, 4,900 persons from all walks of life have donated more than 1 million hours of service to the USGS, a contribution worth an estimated $12 million. Interest in the program continues to grow each year. In FY 1993, nearly 500 individual requests for information on the Volunteer for Science program were received. The *Volunteer/Intern/Teacher Opportunities Handbook*, a guide to volunteer opportunities throughout the USGS, was mailed to 1,000 colleges and universities and 400 teachers and other professionals. An additional 5,000 copies were distributed at career fairs, science and education conferences, the USGS Open House in Denver, volunteer conferences, and public libraries. On August 10, 1993, the Seventh Annual Volunteer Recognition Ceremony honored more than 250 volunteers who served in Reston, Va., during the past year.

Denver Open House

Science for children and adults was the order of the day at the first-ever Department-wide open house held in Denver, Colo., from May 21 through 23, 1993. Sponsored by the USGS, the 3 day open house was held at the Denver Federal Center; the Bureau of Mines, the Bureau of Reclamation, the Bureau of Indian Affairs, the Bureau of Land Management, the Minerals Management Service, the National Park Service, the Office of Surface Mining, and the Fish and Wildlife Service also participated. Nine Federal Center buildings were opened to the public, and four tents filled with exhibits were erected. Eight hundred USGS employees provided volunteer assistance to the more than 12,000 visitors who attended.

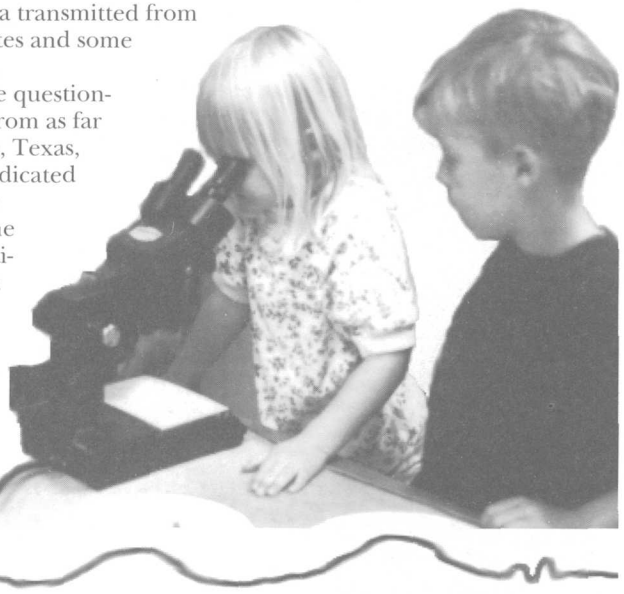
Friday was reserved for school tours. More than 1,400 students from the Denver area toured the exhibits at half-hour intervals. Friday was also designated "Employees Day," so that employees from

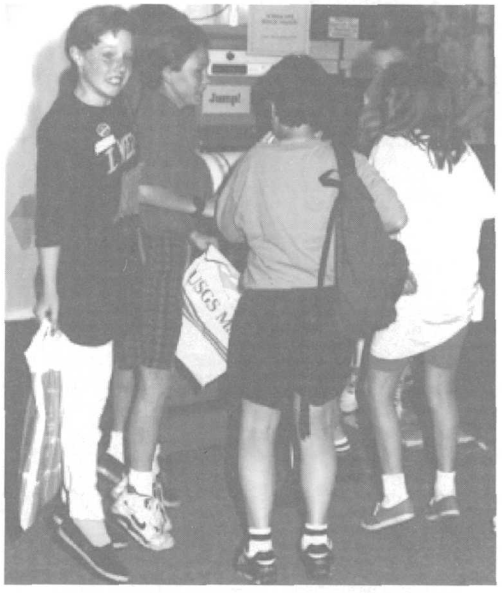


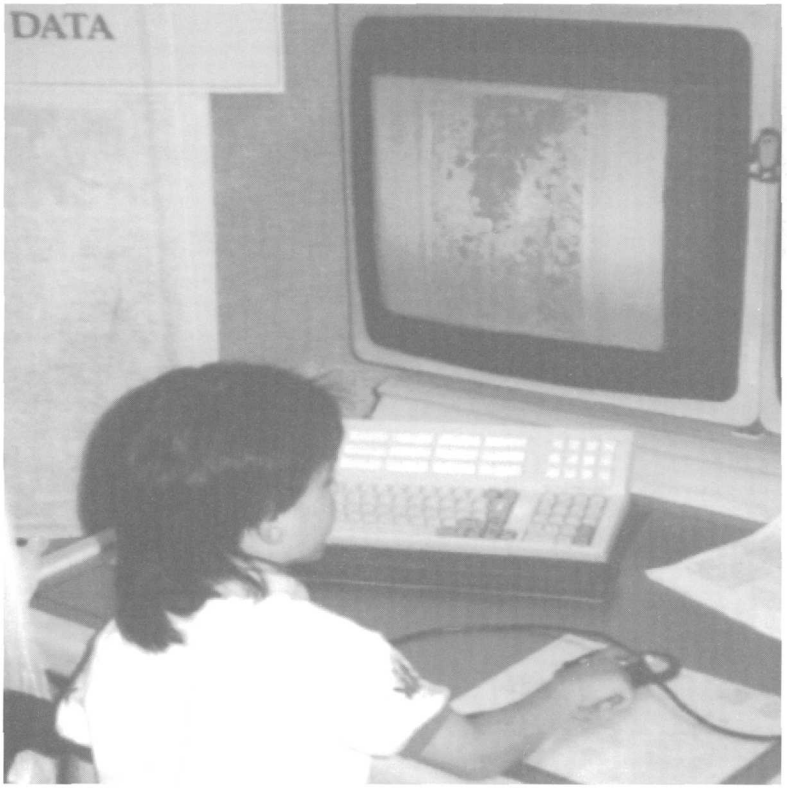
all Department of the Interior bureaus could view and learn more about their counterpart bureaus.

Among the most popular of the more than 200 USGS exhibits were panning for gold, making fossil casts and molds, looking at rocks under a microscope, reading a map and using a compass, and investigating the chemistry of liquid nitrogen. Additional highlights included images of the sea floor arranged in a 160-foot-long mosaic, laboratory tours, electron microprobe instruments, and mobile laboratories where visitors could see for themselves how rock samples are analyzed in the field. Telephone lines extended to a tent allowed the public to view real-time geomagnetic data transmitted from six USGS field sites and some Canadian sites.

Attendee questionnaires received from as far away as Montana, Texas, and New York indicated that visitors were delighted with the exhibits and gratified to learn that tax dollars are being applied to such useful work.







Community Outreach

USGS employees at all locations exhibited a strong commitment to meeting the social and educational needs of their communities in FY 1993. They supported activities for homeless and disadvantaged persons, visited schools, assisted the victims of natural disasters, participated in environmental cleanup projects, and responded to local community issues relating to the understanding of natural resources.

Education Efforts

Nazlini Boarding School

To teach Navajo children in Arizona how to use computers and remotely sensed data, the USGS and the Bureau of Indian Affairs conducted an educational outreach project to supply remotely sensed data on a CD-ROM (compact disc-read only memory) to the Nazlini Boarding School. The CD-ROM contains map, aerial, and satellite image data of the school, which is on the Navajo reservation, and surrounding areas. Using the school's computers, students in grades 4 through 6 studied the natural resources in their own backyard and learned the fundamentals of image processing by analyzing the local geology, vegetation, and soils. Dealing with images of their own community is seen as a way to encourage the students to think about resource management issues and perhaps someday make a contribution toward resolving environmental issues on the reservation.

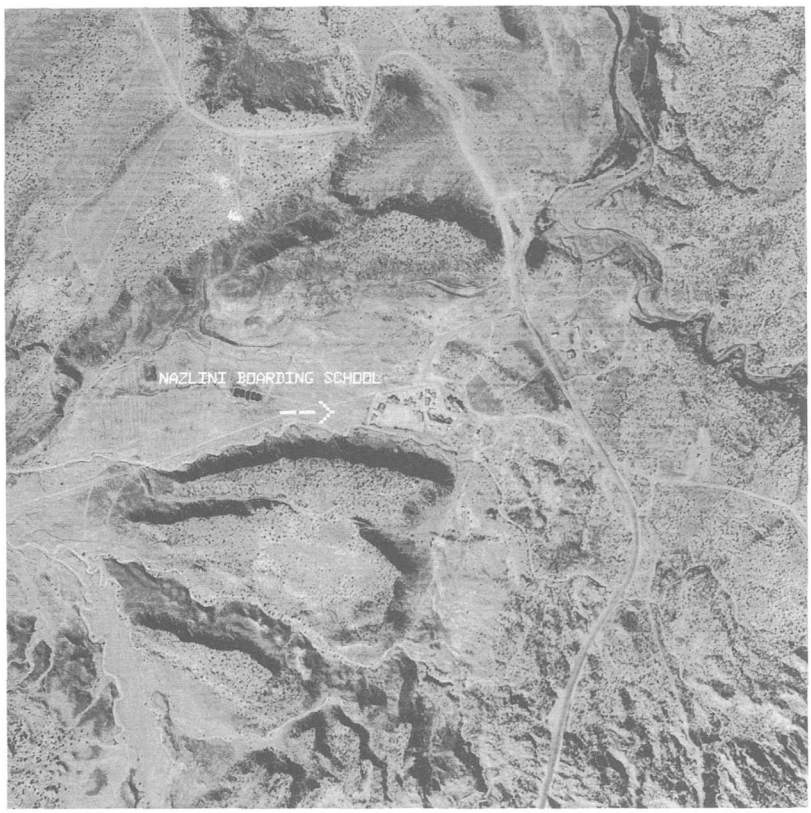
"For the first time, students are seeing and understanding the real-world usefulness of school work. In my entire career, I have never seen so much excitement in the classroom. Even though they are very young, some of the students have expressed an interest in pursuing a career in the earth sciences 'when they grow up'," said teacher Keith Franklin, coordinator of the Nazlini project.

The success of the Nazlini project is leading to a multiple-volume CD-ROM set including multimedia presentations of reservation culture and history, remotely sensed data showing the Navajo and Hopi reservations, instructional material on basic digital image processing procedures, and examples of using scientific data for research purposes, with emphasis placed on geology, land use, vegetation, archeology, and hydrology.

For more information about the Nazlini Boarding School, contact:

Mail Keith Franklin
Nazlini Boarding School
Ganado, AZ 86505

Linda Bellisime
U.S. Geological Survey
2255 N. Gemini Drive
Flagstaff, AZ 86001



Hands-On Learning Center in Rock Creek Park

In an innovative effort to bring a greater understanding of water resources and the environment to students and visitors, the University of the District of Columbia (UDC), the National Park Service (NPS), and the USGS signed an agreement in 1993 to work together to turn a USGS stream-gaging station in the District's Rock Creek Park into a water learning center for students and volunteers. The station, which monitors the flow of Rock Creek, will provide educational opportunities for students who are interested in learning about hydrology in an urban environment.

Under the agreement, the USGS will operate the station, which will present demonstrations to park visitors and furnish real-time hydrologic information to the Water Resources Research Center at

Shown signing the USGS-UDC-NPS agreement are (left to right) James Hannahan, associate director of UDC's Water Resources Research Center; Robert G. Stanton, regional director of the National Capital Region of the NPS; and Dallas L. Peck, then-director of the USGS.

UDC for classroom use. UDC will work with the USGS in planning equipment and instruments for the data-collection facilities at the park. USGS and NPS volunteers will be part of the outreach program at the UDC center and will also promote water resources activities with the National Association for Equal Opportunity in Higher Education.

Educational Outreach to the Ethnic Minority Community

USGS ethnic minority employees have identified educational outreach in their communities as a primary activity of the Geologic Division's Ethnic Minority Advisory Committee. During 1993, committee members participated in numerous outreach projects in schools across the country.

In Flagstaff, Ariz., USGS personnel collaborated with the Resource Center for Environmental Education, a nonprofit organization that works with school districts in northern Arizona. Four elementary schools populated predominantly by minority students were selected for the program, which introduced students and teachers to basic remote-sensing and earth-science concepts. Program accomplishments included educating teachers about CD-ROM technology, remote-sensing and image-processing concepts, and the wealth of resource materials available for classroom education; providing role models for students by having ethnic minority professionals present the technical material; and placing computers in classrooms, where they are available for additional teacher training and use.

In Menlo Park, Calif., USGS ethnic minority employees are providing role models and heightening the awareness and interest of pre-college ethnic minority students in technical and scientific careers through modular, hands-on programs presented by ethnic minority professionals. The employees developed a day-long program covering plate tectonics, seismology, faulting, and geologic maps. Perhaps the most popular module was one in which students made their own "earthquake" by using seismometers, an online computer display, and a drum recorder. The large number of requests for classroom presentations indicates the success of this program.

Ethnic minority employees visited several schools in the San Francisco Bay area and surrounding communities to present computer programs on the earth sciences. More than 120 students in an inner city high school in Portland, Oreg., participated in 2 days of talks and demonstrations about the earth sciences. Members of the USGS Ethnic Minority Advisory Committee presented workshops on earthquake monitoring and plate tectonics to about 1,000 middle- and high-school students (and accompanying teachers and parents) from Colorado and Wyoming. The students were participating in a 1-day fair on career opportunities in the geosciences, sponsored by the Colorado School of Mines and the Colorado Minority Engineering Association.

Partnerships in Education

The USGS supports Partnerships in Education agreements with school districts across the country. This program allows the USGS to use its resources to enhance earth-science education, encourage scholarship, and build students' self-esteem. Employees give presentations in classrooms, lead field trips, judge science fairs, serve one-on-one as mentors or tutors, and provide materials for displays and demonstrations. In many locations, employees provide similar resources under informal agreements with neighborhood schools. Highlights of these partnerships in FY 1993 include:

- Horace Mann Middle School, Denver, Colo.: Students, teachers, and USGS scientists worked together on National Disaster Awareness Day. Enactments of disasters and correct responses to them were demonstrated.
- Grandview Heights Public Schools, Columbus, Ohio: Scientists spoke at school career days, emphasizing the professional opportunities available for women in the sciences and at the USGS. Study units on geology, including methods of determining the age of rocks and fossils, were presented to fourth graders and middle-school students.
- Dogwood Elementary School, Reston, Va.: About 100 sixth graders participated in a year-long "Bucket and Broom" hydrology project that involved collecting and analyzing surface- and ground-water samples. USGS employees also donated children's books and collected grocery receipts toward the purchase of computers for the school.
- Langston Hughes Middle School, Reston, Va.: Scientists gave presentations on a range of earth-science topics, including chemistry and the environment, geography and its use in the study of acid rain damage, and hydrology and the impact of herbicides on water quality. Hughes students mounted an art exhibit at USGS headquarters in Reston with the theme "Science and Technology are Everywhere."
- Cole Elementary School, Cheyenne, Wyo.: A USGS hydrologist judged a science fair at the school, and students toured the Cheyenne office laboratory and learned how sediment samples are collected and analyzed.

Sigrid Asher-Bolinder and **William Earl Brooks** were honored in a ceremony at the Colorado Governor's Mansion for earth-science outreach to students in the Denver public school system.

Women, Minorities, and Persons with Disabilities

Making Technology—and Jobs—Accessible

The first Department of the Interior Conference on Disability Awareness and Accessible Technology was held at the USGS National Center in Reston, Va., in October 1992, to show how computer technology can be adapted to help people with disabilities function and excel in the workplace. The conference showcased the latest in adaptive technology and included keynote speakers and panel sessions on specific accessibility issues. Exhibits featured computers having both speech and Braille output, auxiliary listening devices, keyboard enhancements for people with mobility impairments, computers that can recognize speech, and the latest in TDD (Telecommunications Device for the Deaf) technology.

A Disability Awareness Fair held in Menlo Park, Calif., in August 1993 provided information on Canine Companions, the California Relay Service, and the Department of Veterans Affairs Blind Rehabilitation and Auditory Services. A highlight of the fair was entertainment by a deaf poet and a dance troop of both wheelchair and able-bodied dancers. The fair was well attended by employees, people with disabilities from the community, and representatives of agencies that provide services to people with disabilities.

Another conference was held in Denver, Colo., in September 1993. People with disabilities who also have successful and productive careers in both Govern-

ment and private industry (one with multiple sclerosis, one with lupus, and one who is blind) spoke about their experiences. An organization in Denver that is dedicated to helping people become more aware and accepting of people with disabilities presented a panel discussion. A motivational speaker and trainer spoke to attendees on beliefs about and reactions to hiring and working with people with disabilities. The conference also presented information on Government regulations and accommodations for the disabled and exhibits by service organizations and vendors of adaptive equipment.

These conferences have not only helped to disseminate information but have also provided an increased awareness of the role of persons with disabilities in the workplace. Encouraging people to question their assumptions and change their perceptions will perhaps dispel some of the skepticism, fear, and apprehension directed toward people with disabilities.

The USGS Selective Placement Program Committee promotes disability awareness by approving requests for equipment that employees with disabilities need to successfully do their work and enhance their opportunities for advancement. Some of the equipment that was approved and purchased in FY 1993 included computer equipment for visually impaired employees, text typewriters (TTY) for the deaf and hearing impaired, new or replacement monitors that allow employees having poor vision to more efficiently use their computer workstations, and specialized telephone handsets for individuals who have difficulty hearing the spoken word over the telephone.

The committee provided funding for the conferences on employees with disabilities that were held in Reston, Va.; Denver, Colo.; and Menlo Park, Calif. The committee also funded sign language interpreters so that hearing-impaired employees could have an equal chance to participate in the Government-sponsored training that is required to update their knowledge and skills.

Career Planning

The USGS provided bureau employees with long- and short-term career and managerial development opportunities from both internal and external training sources and academic institutions. Emphasis was placed on women, minorities, and persons with disabilities.

A career planning manual was developed for use by employees who are pursuing career growth and advancement. The manual includes a personal guide for career planning, including job information, a self-assessment exercise, a guide to setting performance goals, and tips on developmental activities to facilitate goal accomplishments. The manual should be particularly useful for women, minorities, and persons with disabilities.

The manual encourages the concept of "mentoring" by providing opportunities for employees to interact with their supervisors. It can also be a tool for helping employees make informed career decisions and for setting goals to reach career objectives.

Training and educational opportunities provided to women and minorities by all USGS divisions in FY 1993 were wide ranging and included technical, academic, and administrative types of training. Academic courses taken by employees included undergraduate and graduate courses in engineering, physics, and isotope hydrology. Technical training included Government contract law and accounting courses. Administrative training was also provided in management and supervision, Total Quality Management, communication skills, and Equal Employment Opportunity counselor training.

During FY 1993, the Women's Advisory Committee (WAC) focused on a number of projects to help Geologic Division employees. Task forces studied training for first-line supervisors, methods used in other Government agencies to resolve workplace conflicts, and problems associated with fair promotions for women. One group has begun a statistical analysis of the career patterns of women and men in scientific and technical positions in the Office of Mineral Resources

over the last decade. Another group has developed a pilot program for mentoring in which 28 employees are participating. A report on alternative work schedules and flexiplace was presented to Division management; work on those recommendations continues. Recommendations of the task force charged with studying the classification of secretarial, administrative, and editorial assistant positions are being implemented; some secretarial positions have been upgraded; and others are being reviewed. Revised guides for administrative and editorial assistant positions are expected to be approved soon. Another task force is beginning to study the standards for physical science technicians to see if outmoded and inaccurate job descriptions are hampering employee promotions in this series.

Sexual Harassment Questionnaire and Response

A confidential questionnaire was developed by the Women's Advisory Committee and distributed to all Geologic Division employees. The results indicated a need for education on sexual harassment, and a contract was awarded to conduct training nationwide. A significant benefit of the training was the opportunity for male and female co-workers to spend a full day discussing their (often very different) opinions regarding sexual harassment in the workplace.

Managing Diversity in the Workplace

The USGS is working toward a better understanding of the challenges of a diverse workforce and is attempting to move toward accepting and managing diversity as it relates to USGS human resources initiatives and goals. As the composition of the USGS workforce continues to change, the bureau is focusing on providing training in the critical area of workforce diversity, including awareness of cultural, disability, and gender diversity, to all employees, especially supervisors and managers.

The major emphasis this fiscal year was on providing employees with sexual harassment awareness and prevention training. This training helped employees learn and understand the legal definition of sexual harassment, recognize the indicators of harassing behavior, and distinguish between appropriate and inappropriate behavior.

The USGS recognizes that many changes are occurring in the workplace and that it is the responsibility of each employee to meet the challenges that these changes present with common sense, respect, and honest communication. To assist employees in this regard and to ensure a nonthreatening work environment and avoid sexual harassment in the USGS, all employees were required to receive sexual harassment prevention training.

Student Employment Programs

The Cooperative Education, Federal Junior Fellowship, and Stay-In-School programs continue to serve as a significant pipeline for the entry of minorities and women into the USGS work force, as the following numbers from the end of FY 1993 indicate:

Program	Total	Women	Minorities
Cooperative Education	258	85	40
Federal Junior Fellowship	52	27	11
Stay-In-School	272	141	102

As these numbers indicate, human resources programs continue to use significant numbers of women and minority employees.

Recruitment Outreach and Recruitment Initiatives

USGS efforts in personnel outreach target specific organizations and institutions having major programs related to the earth sciences. As in previous years, emphasis was placed on maintaining partnerships with Historically Black Colleges and Universities (HBCU) and the Hispanic Association of Colleges and Universities (HACU) as well as on developing relationships with new participants in these programs. USGS personnel participated in career fairs and education association conferences nationwide in order to provide information to qualified students at, among others, Alabama State University in Montgomery, Ala.; Tennessee State University in Nashville, Tenn.; Gallaudet University in Washington, D.C.; the University of Missouri in Rolla; the University of Texas in El Paso; the University of New Mexico in Las Cruces; and the New Mexico Institute of Mining and Technology in Socorro.

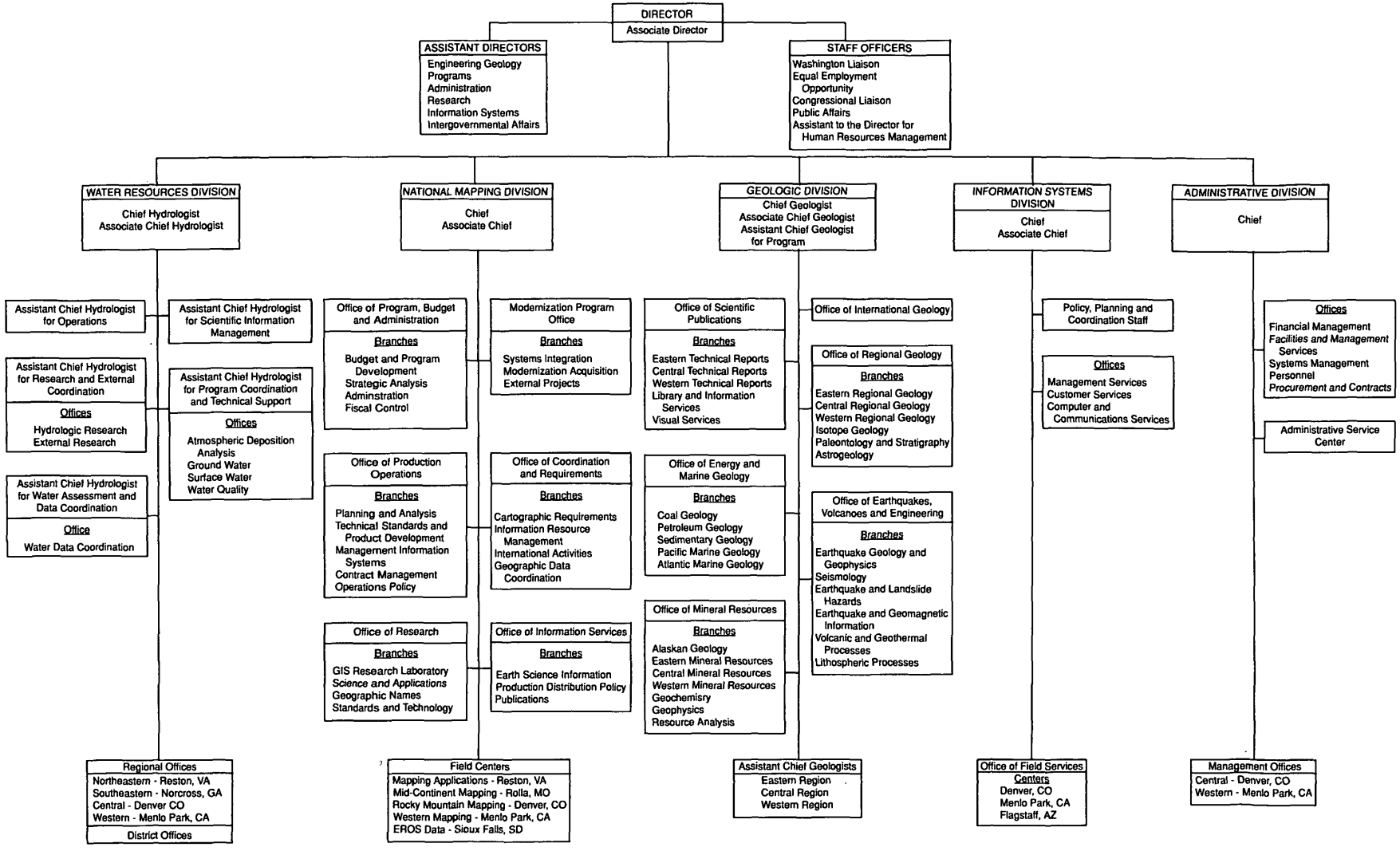
The USGS has a long-standing program of cooperation with and support of HBCU. Continuing that tradition, the USGS sponsored a seminar for faculty members of HBCU schools from July 26 through August 6, 1993, at the USGS offices at the Stennis Space Center in Bay St. Louis, Miss. The 2-week seminar was designed to assist HBCU schools in devel-

oping academic programs in earth-science research. The seminar included hands-on training in the Global Positioning System (GPS), geographic information systems (GIS), remote sensing, and CD-ROM applications.

Another highlight of the year's activities was a 1-week hydrology training class on basic ground-water concepts, the hydrologic cycle, surface-water data collection and computation, and an introduction to the USGS that was presented as part of a 6-week water resources technician training program sponsored by the Bureau of Indian Affairs for Native American youth in Las Cruces, N. Mex. Other examples of interactions with HBCU and HACU schools in FY 1993 include:

- Langston University, Langston, Okla.: Provided funding to support a guest lecture series on computer-applied hydrology.
- Gateway Community College, Phoenix, Ariz.: Provided funding for a new hydrologic technician curriculum that will prepare students for future employment opportunities in field offices in New Mexico and Arizona.
- Elizabeth City State University, Elizabeth City, N.C.: Participated in a college career fair and promoted student employment opportunities, participated in an earth-science lecture series, and worked with faculty members to develop new projects.
- Hampton University, Hampton, Va.: Participated in career fairs, continued to promote student employment opportunities, established a computer network on campus, and continued to train students in computer systems maintenance.
- Fort Valley State College, Fort Valley, Ga.: Began a consortium relationship with Fort Valley, the University of Nevada-Las Vegas, and the University of Oklahoma in support of minority students who are studying civil engineering and geophysical sciences and hired three students for summer employment.
- Lincoln University, Jefferson City, Mo.: Established a memorandum of understanding to provide training to increase the number of qualified candidates available for computer science and information systems positions in the USGS.
- Southern University, Baton Rouge, La.: Provided support for minority students through Stay-in-School and other student employment opportunities. The Louisiana field office in Baton Rouge became a "training district" for Southern students, allowing them to complete procurement, training, and travel-related work in the administrative office.

ORGANIZATION OF THE U.S. GEOLOGICAL SURVEY
U.S. Department of the Interior



Budget Information

Cooperative agreements with more than 1,000 Federal, State, and local agencies and the academic community support a large share of research and investigations. In fiscal year 1993, the USGS had obligational authority for $862 million, $582.8 million of which came from direct appropriations, $6.7 million from estimated receipts from map sales, and $272.7 million from reimbursements. The USGS was reimbursed for work performed for other Federal, State, and local agencies whose needs for earth-science expertise complement USGS program objectives. Work for State, county, and municipal agencies is most often conducted on a cost-sharing basis.

USGS budget authority for fiscal year 1993, by appropriation, for surveys, investigations, and research (SIR)

[Dollars in thousands]

Activity/Subactivity/Program element	Fiscal year 1993 enacted
National Mapping, Geography, and Surveys	**$126,092**
National Map and Digital Data Production	49,454
Cartographic Data and Map Revision	41,742
Thematic and Special Data	5,007
National Map and Digital Data Cooperative Program	2,209
SLAR (Side-Looking Airborne Radar)	496
Information and Data Systems	19,127
National Data Base Management	7,228
Information Dissemination Services	4,469
Global Change Data Systems	7,430
Research and Technology	18,843
Cartographic and Geographic Research	8,545
National Cartographic Requirements, Coordination, and Standards	4,601
Geographic and Spatial Information Analysis	5,697
Advanced Cartographic Systems	38,668
Geologic and Mineral Resource Surveys and Mapping	**222,444**
Geologic Hazards Surveys	68,025
Earthquake Hazards Reduction	50,146
Volcano Hazards	15,528
Landslide Hazards	2,351
Geologic Framework and Processes	36,626
National Geologic Mapping	21,982
Deep Continental Studies	2,795
Geomagnetism	1,823
Coastal and Wetlands Processes	10,026
Global Change Research	10,873
Global Change and Climate History	10,873
Offshore Geologic Surveys	26,935
Offshore Geologic Framework	26,935
Mineral Resource Surveys	48,282
National Mineral Resource Assessment Program	26,396
Strategic and Critical Minerals	8,796
Development of Assessment Techniques	13,090
Energy Geologic Surveys	31,703
Evolution of Sedimentary Basins	6,422
Coal Investigations	8,977
Oil and Gas Investigations	8,015
Oil Shale Investigations	597
Uranium and Radon Investigations	1,968
Geothermal Investigations	4,893
World Energy Resource Assessment	831
Water Resources Investigations	**$187,161**
National Water Resources Research and Information System—Federal Program	117,468
Data Collection and Analysis	27,108
National Water Information Clearinghouse	2,742
Coordination of National Water Data Activities	997
Regional Aquifer System Analysis	6,175
Core Program Hydrologic Research	10,277
Improved Instrumentation	1,169
Water Resources Assessment	1,589
Toxic Substances Hydrology	14,428
Nuclear Waste Hydrology	1,331
Acid Rain	2,922
Scientific and Technical Publications	2,343
National Water-Quality Assessment Program	38,260
Global Change Hydrology	6,707
Truckee-Carson Program	1,420
National Water Resources Research and Information System—Federal-State Cooperative Program	63,488
Data Collection and Analysis, Areal Appraisals, and Special Studies	59,438
Water Use	4,050
National Water Resources Research and Information System—State Research Institutes and Research Grants Program	6,205
State Water Resources Research Institutes	5,529
Program Administration	676
General Administration	**24,506**
Executive Direction	7,494
Administrative Operations	14,550
Reimbursements to the Department of Labor	2,462
Facilities	**22,684**
National Center—Rental Payments to GSA	19,549
National Center—Facilities Management	3,135
Total, SIR	**$582,887**

USGS budget for fiscal years 1990 to 1993 (in obligations), by activity and sources of funds[1]

[Dollars in thousands; totals may not add because of rounding]

Budget activity	1990	1991	1992	1993
Total	**$723,137**	**$802,538**	**$851,979**	**862,335**
Direct program	501,510	575,044	586,699	[1]582,891
Reimbursable program	221,628	227,494	265,280	279,444
States, counties, and municipalities	74,113	87,415	89,950	91,299
Miscellaneous non-Federal sources	15,151	13,499	14,609	14,842
Other Federal agencies	132,363	126,580	160,721	173,303
National Mapping, Geography, and Surveys	**141,069**	**162,421**	**164,981**	**156,898**
Direct program	111,528	132,395	132,612	126,092
Reimbursable program	29,542	30,026	32,369	30,806
States, counties, and municipalities	2,132	2,366	3,028	3,219
Miscellaneous non-Federal sources	10,278	9,722	10,633	10,562
Other Federal agencies	17,131	17,938	18,708	17,025
Geologic and Mineral Resource Surveys and Mapping	**241,739**	**261,513**	**267,642**	**261,089**
Direct program	200,472	225,112	225,383	222,565
Reimbursable program	41,267	36,401	42,259	38,524
States, counties, and municipalities	1,917	2,661	3,077	1,609
Miscellaneous non-Federal sources	2,022	1,260	536	834
Other Federal agencies	37,328	32,480	38,646	36,081
Water Resources Investigations	**295,128**	**333,238**	**363,287**	**384,467**
Direct program	152,904	177,969	184,489	186,933
Reimbursable program	142,224	155,269	178,798	197,534
States, counties, and municipalities	70,064	82,388	83,845	86,471
Miscellaneous non-Federal sources	2,839	2,503	3,424	3,440
Other Federal agencies	69,321	70,378	91,529	107,623
General Administration	**21,493**	**21,528**	**25,028**	**25,886**
Direct program	18,081	21,206	23,883	24,506
Reimbursable program	3,412	322	1,145	1,380
Miscellaneous non-Federal sources	1	1	1	1
Other Federal agencies	3,411	321	1,144	1,379
Facilities	**18,502**	**18,314**	**20,304**	**23,111**
Direct program	18,502	18,314	20,304	22,750
Reimbursable program	0	0	0	361
Computer and Administrative Services	**5,183**	**5,476**	**10,709**	**10,839**
Reimbursable program	5,183	5,476	10,709	10,839
Miscellaneous non-Federal sources	11	13	15	5
Other Federal agencies	5,172	5,463	10,694	10,834
Operation and Maintenance of Quarters	**23**	**48**	**28**	**45**
Direct program	23	48	28	45

[1] Total direct program includes actual obligations of $579,337 for FY 1993 year, $112 for no year, $3,386 for multiyear Emergency supplementals for hurricanes and floods, and $10 for Contributed funds.

USGS reimbursable funds from other Federal agencies for fiscal years 1990 to 1993, by agency

[Dollars in thousands; figures in parentheses are included in Department of the Interior totals]

Budget activity	1990	1991	1992	1993
Department of Agriculture	$ 3,379	$ 3,464	$ 3,714	$ 2,697
Department of Commerce	281	323	9	103
National Oceanic and Atmospheric Administration	1,448	2,258	5,146	1,630
Department of Defense	41,257	42,002	56,461	64,518
Department of Energy	29,574	28,521	30,679	33,651
Bonneville Power Administration	358	159	217	445
Department of the Interior	12,728	12,533	12,451	12,090
Bureau of Indian Affairs	(2,018)	(1,834)	(1,347)	(881)
Bureau of Land Management	(1,239)	(1,256)	(1,508)	(1,797)
Bureau of Mines	(24)	(0)	(0)	(0)
Bureau of Reclamation	(6,119)	(6,259)	(5,990)	(6,495)
Minerals Management Service	(32)	(76)	(207)	(107)
National Park Service	(883)	(1,036)	(1,107)	(1,111)
Office of the Secretary	(1,343)	(1,549)	(1,551)	(1,298)
Office of Surface Mining	(106)	(67)	(8)	(22)
U.S. Fish and Wildlife Service	(964)	(456)	(733)	(379)
Department of State	8,144	8,279	10,524	13,333
Department of Transportation	362	299	661	605
Environmental Protection Agency	5,279	4,302	6,414	7,671
National Aeronautics and Space Administration	5,607	6,270	9,589	10,108
National Science Foundation	2,328	625	1,838	2,096
Nuclear Regulatory Commission	1,917	1,441	539	1,087
Tennessee Valley Authority	217	200	275	417
Miscellaneous Federal agencies	19,484	15,904	22,204	22,852
Total	**$132,363**	**$126,580**	**$160,721**	**$173,303**

Guide to Information and Publications

Earth Science Information Centers

To obtain information on cartographic data and on earth-science programs, publications, and services, or to obtain copies of reports and maps, write or visit U.S. Geological Survey Earth Science Information Centers at the following addresses:

Alaska:
Room 101
4230 University Dr.
Anchorage, AK 99508–4664

Box 12, New Federal Bldg.
101 12th Ave.
Fairbanks, AK 99701

California:
Bldg. 3, Room 3128
345 Middlefield Rd., Mail Stop 532
Menlo Park, CA 94025

Colorado:
Bldg. 25, Room 1813
Box 25046
Denver Federal Center, Mail Stop 504
Denver, CO 80225–0046

District of Columbia:
Main Interior Bldg., Room 2650
1849 C St., NW.
Washington, DC 20240
(When visiting, use E St. entrance.)

Mississippi:
Bldg. 3101
Stennis Space Center, MS 39529

Missouri:
Room 231
1400 Independence Rd.
Rolla, MO 65401–2602

South Dakota:
EROS Data Center
Sioux Falls, SD 57198

Utah:
2222 West 2300 South
Salt Lake City, UT 84119

Virginia:
Room 1C–402
507 National Center
12201 Sunrise Valley Dr.
Reston, VA 22092

Washington:
U.S. Post Office Bldg., Room 135
W. 904 Riverside Ave.
Spokane, WA 99201–1088

Gateway to Earth Science and Environmental Information on the Internet

As part of a pilot project, selected USGS information and products are available on the Internet at the following Universal Resource Locator:

http://info.er.usgs.gov

Additional information on Mosaic may be obtained by e-mailing questions to:

webmaster@info.er.usgs.gov

USGS Library System

The USGS Library system is one of the largest earth-science collections in the world and contains more than one million monographs, serial publications, maps, and microforms. The collection covers all aspects of the geological sciences and related subjects. An online catalog provides public access. The library honors the standard interlibrary loan request forms as well as requests received online from the Interlibrary Loan System of the On-Line Computer Library Center. Information and reference services are available from the following library locations:

USGS Library
950 National Center
Reston, VA 22092–0001

USGS Library
Mail Stop 955 (Bldg. 5, Room 507)
345 Middlefield Rd.
Menlo Park, CA 94025–3591

USGS Library
2255 N. Gemini Dr.
Flagstaff, AZ 86001–1698

USGS Library
Box 25046, Mail Stop 914
Denver Federal Center
Denver, CO 80225–0046

Water Information

Sources of Water Data

To obtain assistance in locating sources of water data, identifying sites at which data have been collected, and obtaining specific information, write:

National Water Data Exchange
U.S. Geological Survey
421 National Center
Reston, VA 22092

Water-Data Aquisition Activities

To obtain information on ongoing and planned water-data acquisition activities of all Federal agencies and many non-Federal organizations, write:

Office of Water Data Coordination
U.S. Geological Survey
417 National Center
Reston, VA 22092

Water Resources of Specific Areas

To obtain information on water resources in general and about the water resources of specific areas of the United States, write:

Hydrologic Information Unit
U.S. Geological Survey
419 National Center
Reston, VA 22092

Geologic Information

General Geology

To obtain information on geologic topics such as earthquakes and volcanoes, energy and mineral resources, the geology of specific areas, and geologic maps and mapping, write:

Geologic Inquiries Group
U.S. Geological Survey
907 National Center
Reston, VA 22092

Mineral Resources

To obtain information on mineral resources, write or visit:

Minerals Information Office*
Main Interior Bldg., Room 2647
1849 C St., NW.
Washington, DC 20240

*Joint venture of the USGS and the U.S. Bureau of Mines.

Minerals Information Office, USGS
Corbett Bldg.
340 N. 6th Ave.
Tucson, AZ 85705–8325

Minerals Information Office, USGS
Box 25046, Mail Stop 936
Bldg. 20, Room B1324
Denver Federal Center
Denver, CO 80225–0046

Minerals Information Office, USGS
c/o Mackay School of Mines
University of Nevada, Reno
Reno, NV 89557–0047

Minerals Information Office, USGS
Post Office Bldg., Room 133
W. 904 Riverside Ave.
Spokane, WA 99201–1087

Maps and Books

To buy topographic and thematic maps of all areas of the United States, to request USGS catalogs, pamphlets, leaflets, and circulars (limited quantities free), and to buy USGS book publications, write or visit:

USGS Map Distribution
Box 25286, Bldg. 810
Denver Federal Center
Denver, CO 80225

Open-File Reports

To buy USGS open-file reports or to obtain information on the availability of microfiche or paper-duplicate copies of open-file reports, write:

USGS Open-File Report Sales
Box 25286, Bldg. 810
Denver Federal Center, Mail Stop 517
Denver, CO 80225

Periodicals

New Publications

To get on the mailing list for the monthly list of *New Publications of the U.S. Geological Survey* (free), write:

USGS New Publications
582 National Center
Reston, VA 22092

Earthquakes & Volcanoes

To subscribe to *Earthquakes & Volcanoes*, a bimonthly, nontechnical digest that provides up-to-date information on earthquakes, volcanoes, and related natural hazards around the world, write:

Superintendent of Documents
Government Printing Office
Washington, DC 20402

Memoranda of Understanding: FY 1993

Domestic Agreements

Counterpart Organization(s)	Description
• 93–01 Central State University, Wilberforce, Ohio	To exchange technical and educational information; to conduct cooperative research; to share facilities; to generate cooperative training programs in the earth sciences.
• 93–02 Washington Department of Natural Resources	To achieve a Federal/State partnership for scientific, technical, and educational cooperation.
• 93–03 Department of Agriculture: Economic Research Service, National Agricultural Statistics Service, Soil Conservation Service	To provide a framework for collaborative efforts for the Area Studies Program, a component of the President's Water Quality Initiative.
• 93–04 First Miss Gold, Inc., Pinson Mining Company, Winnemucca, Nev.	To provide the mechanism to conduct joint research and development for hydrogeochemical studies and development for hydrogeochemical gold in the vicinity of buried mineral deposits.
• 93–05 Lincoln University, Jefferson City, Mo.	To create an educational partnership for the development of computer science and information systems professionals.
• 93–06 Bureau of Reclamation, Fish and Wildlife Service, Bureau of Indian Affairs	To expedite the Department of the Interior's National Irrigation Water Quality Program for FY 1993.
• 93–07 U.S. Army Corps of Engineers, Soil Conservation Service, National Park Service, U.S. Air Force.	To continue the development of software for the public domain Geographic Resources Analysis Support System.
• 93–08 U.S. Air Force	To coordinate research, technology transfer, evaluation, and education for management of cleanup and reduction of hazardous wastes at U.S. Air Force installations.
• 93–09 University of the District Columbia, National Park Service	To promote and strengthen the University of the District of Columbia's educational water resource programs in the Washington, D.C., metropolitan area.
• 93–10 Bureau of Land Management	To facilitate the production and exchange of cartographic products and services.
• 93–11 National Oceanic and Atmospheric Administration, U.S. Department of Commerce	To establish the framework for scientific and technical coordination for earth-science and environmental studies.
• 93–12 National Aeronautics and Space Administration	To define the USGS role in the archiving, processing, and distribution of NASA-generated Landsat 7 data.
• 93–13 Bureau of Reclamation	To extend the existing Cooperative Stream Gaging Agreement for a 5-year period.
• 93–14 Aquatic Habitat Institute, Richmond, Calif.	To conduct a demonstration project to monitor water quality and the ecological status of San Francisco Bay.
• 93–15 U.S. Forest Service, Department of Agriculture	To provide joint graphic and content standards to maintain overall coordination of the single-map primary-series map program.
• 93–16 Langston Hughes Middle School, Reston, Va.	To support, promote, and enhance the school's curriculum as it relates to USGS missions and initiatives.

U.S. Geological Survey Offices

[Information current as of April 1994]

Headquarters Offices	Central Region	Western Region
National Center **12201 Sunrise Valley Drive** **Reston, VA 22092**	**Denver Federal Center** **Box 25046** **Denver, CO 80225**	**345 Middlefield Rd.** **Menlo Park, CA 94025**

Office of the Director

Acting Director	Robert M. Hirsch	(703) 648–7411	101 National Center
Acting Associate Director	Bonnie McGregor	(703) 648–7412	102 National Center
Special Assistant (Washington Liaison) and Deputy Ethics Counselor	Jane H. Wallace	(202) 343–3888	Rm. 2648, Interior Bldg. Washington, DC 20240
Assistant Director for Research	Stephen E. Ragone	(703) 648–4450	104 National Center
Assistant Director for Engineering Geology	James F. Devine	(703) 648–4423	106 National Center
Assistant Director for Administration	Jack J. Stassi	(703) 648–7200	201 National Center
Assistant Director for Programs	Peter F. Bermel	(703) 648–4430	105 National Center
Assistant Director for Intergovernmental Affairs	John J. Dragonetti	(703) 648–4427	109 National Center
Assistant Director for Information Systems	James E. Biesecker	(703) 648–7108	801 National Center
Congressional Liaison Officer	Talmadge W. Reed	(703) 648–4457	112 National Center
Chief, Public Affairs Office	Donovan B. Kelly	(703) 648–4460	119 National Center
Equal Employment Opportunity Officer	Bruce D. Palmer	(703) 648–4417	116 National Center
Special Assistant to the Director for Human Resources	J. Lynn Smith	(703) 648–7111	115 National Center
Director's Representative—Central Region	Harry A. Tourtelot	(303) 236–5438	911 Denver Federal Center
Director's Representative—Western Region	George Gryc	(415) 329–4002	Western Region, Stop 144
Special Assistant to the Director for Alaska	Paul D. Brooks	(907) 271–4138	4230 University Drive, Suite 120 Anchorage, AK 99508

Administrative Division

Chief	Jack J. Stassi	(703) 648–7200	201 National Center
Administrative Officer	Louie Pectol	(703) 648–7204	203 National Center
Office of Personnel, Chief	Maxine C. Millard	(703) 648–7442	215 National Center
Office of Procurement and Contracts, Chief	John K. Peterson	(703) 648–7373	205 National Center
Office of Financial Management, Chief	Joseph L. Murphy	(703) 648–7604	270 National Center
Office of Facilities and Management Services, Chief	William F. Gossman, Jr.	(703) 648–7338	207 National Center
Office of Systems Management, Chief	Phillip L. McKinney	(703) 648–7256	206 National Center
Washington Administrative Service Center, Chief	Phillip L. McKinney	(703) 648–7256	206 National Center
Central Regional Management Officer	F.B. Sower	(303) 236–5900	201 Denver Federal Center
Western Regional Management Officer	George F. Hargrove, Jr.	(415) 329–4150	Western Region, Stop 211

Information Systems Division

Chief	James E. Biesecker	(703) 648–7108	801 National Center
Deputy Chief	Wendy A. Budd	(703) 648–7103	801 National Center
Office of Customer Services, Chief	Richard A. MacDonald	(703) 648–7120	804 National Center
Office of Information Resources Management Coordination, Chief	Virginia L. Ross	(703) 648–7178	805 National Center
Office of Computer and Communications Services, Chief	Charles D. Nethaway	(703) 648–7077	807 National Center
Office of Field Services, Chief	Doug R. Posson	(303) 236–4944	801 Denver Federal Center

National Mapping Division

Chief	Allen H. Watkins	(703) 648–5748	516 National Center
Associate Chief	Roy R. Mullen	(703) 648–5745	516 National Center
Assistant Division Chief for Research	Joel L. Morrison	(703) 648–4640	519 National Center
Assistant Division Chief for Program, Budget and Administration	Richard E. Witmer	(703) 648–4611	514 National Center
Assistant Division Chief for Information and Data Services	Gary W. North	(703) 648–5780	508 National Center
Assistant Division Chief for Coordination and Requirements	Gene A. Thorley	(703) 648–5742	590 National Center
Assistant Division Chief for Production Management	James R. Plasker	(703) 648–4146	511 National Center
Eastern Mapping Center, Chief	K. Eric Anderson	(703) 648–6002	567 National Center
Mid-Continent Mapping Center, Chief	Merle E. Southern	(314) 341–0880	1400 Independence Rd., Rolla, MO 65401
Rocky Mountain Mapping Center, Chief	Randle W. Olsen	(303) 236–5825	510 Denver Federal Center
Western Mapping Center, Chief	John R. Swinnerton	(415) 329–4254	Western Region, Stop 531
Earth Resources Observation Systems Data Center, Chief	Donald T. Lauer	(605) 594–6123	EROS Data Center Sioux Falls, SD 57198

Geologic Division

Chief Geologist	Benjamin A. Morgan	(703) 648–6600	911 National Center
Associate Chief Geologist	David P. Russ	(703) 648–6601	911 National Center
Assistant Chief Geologist for Program	Bonnie McGregor	(703) 648–6640	910 National Center
Administrative Officer	Elwood H. Like	(703) 648–6611	912 National Center
Human Resources Officer	John D. McGurk	(703) 648–6628	911 National Center
Office of Scientific Publications, Chief	John M. Aaron	(703) 648–6077	904 National Center
Office of Regional Geology, Chief	Mitchell W. Reynolds	(703) 648–6960	908 National Center
Office of Earthquakes, Volcanoes, and Engineering, Chief	Robert L. Wesson	(703) 648–6714	905 National Center
Office of Energy and Marine Geology, Chief	Gary W. Hill	(703) 648–6472	915 National Center
Office of Mineral Resources, Chief	Willis H. White	(703) 648–6100	913 National Center
Office of International Geology, Chief	A. Thomas Ovenshine	(703) 648–6047	917 National Center
Assistant Chief Geologist, Eastern Region	Nancy Milton	(703) 648–6660	953 National Center
Assistant Chief Geologist, Central Region	Harry A. Tourtelot	(303) 236–5438	911 Denver Federal Center
Assistant Chief Geologist, Western Region	William R. Normark	(415) 329–5101	Western Region, Stop 19

Water Resources Division

Chief Hydrologist	Philip Cohen	(703) 648–5215	409 National Center
Associate Chief Hydrologist	John N. Fischer	(703) 648–5216	408 National Center
Assistant Chief Hydrologist for Scientific Information Management	James F. Daniel	(703) 648–5699	440 National Center
Assistant Chief Hydrologist for Operations	William B. Mann IV	(703) 648–5031	441 National Center
Assistant Chief Hydrologist for Research and External Coordination	Robert M. Hirsch	(703) 648–5041	436 National Center
Office of Hydrologic Research, Chief	Roger G. Wolff	(703) 648–5043	436 National Center
Office of External Research, Chief	John E. Schefter	(703) 648–6800	424 National Center
Assistant Chief Hydrologist for Program Coordination and Technical Support	Verne R. Schneider	(703) 648–5229	414 National Center
Office of Atmospheric Deposition Analysis, Chief	Ranard J. Pickering	(703) 648–6874	416 National Center
Office of Ground Water, Chief	William M. Alley	(703) 648–5001	411 National Center
Office of Surface Water, Chief	Charles W. Boning	(703) 648–5301	415 National Center
Office of Water Quality, Chief	David A. Rickert	(703) 648–6862	412 National Center
Assistant Chief Hydrologist for Water Assessment and Data Coordination	David W. Moody	(703) 648–6856	407 National Center
Office of Water Data Coordination, Chief	Nancy C. Lopez	(703) 648–5019	417 National Center

Water Resources Division—Continued

Northeastern Region, Acting Chief	William J. Carswell, Jr.	(703) 648–5817	433 National Center
New England Programs, Chief	Ivan C. James II	(508) 490–5002	28 Lord Rd., Suite 280 Marlborough, MA 01752
Mid-Atlantic Programs, Chief	Herbert J. Freiberger	(410) 828–1535	208 Carroll Bldg. 8600 La Salle Rd. Towson, MD 21204
Mid-East Programs, Chief	Donald E. Vaupel	(609) 771–3902	810 Bear Tavern Rd., Suite 206 West Trenton, NJ 08628
Ohio Valley Programs, Chief Western Great Lakes Programs, Chief	Daniel P. Bauer	(608) 274–3535	6417 Normandy Ln. Madison, WI 53719
Southeastern Region, Chief	James L. Cook	(404) 409–7700	Suite 160 Spalding Woods Office Park Norcross, GA 30092
Southeast Programs, Chief	Michael W. Gaydos	(404) 409–7700	Suite 160 Spalding Woods Office Park Norcross, GA 30092
Lower Mississippi Programs, Chief	Wanda C. Meeks	(501) 378–6391	2301 Federal Office Bldg. 700 W. Capitol Ave. Little Rock, AR 72201
Florida-Caribbean Programs, Chief	Irwin H. Kantrowitz	(904) 681–7631	227 N. Bronough St., Suite 3015 Tallahassee, FL 32301
Central Region, Chief	James F. Blakey	(303) 236–5920	406 Denver Federal Center
Midwest Programs, Chief	James E. Kircher	(913) 832–3567	4821 Quail Crest Pl. Lawrence, KS 66049
North Central Programs, Chief	William J. Herb	(612) 783–3107	2280 Woodale Dr. Mounds View, MN 55112
Rocky Mountain Programs, Chief	Charles A. Pascale	(303) 236–4882	415 Denver Federal Center Box 25046 Denver, CO 80225
Southwest Programs, Chief	Charles R. Burchett	(512) 873–3004	8011 Cameron Rd., Bldg. 1 Austin, TX 78753
Western Region, Chief	T. John Conomos	(415) 329–4403	Western Region, Stop 470
Pacific Northwest Programs, Chief	Marvin O. Fretwell	(206) 593–6510	1201 Pacific Ave., Suite 600 Tacoma, WA 98402
Pacific Southwest Area Programs, Chief	John M. Klein	(916) 978–5529	Rm. W–2234 Federal Bldg. 2800 Cottage Way Sacramento, CA 95825
District Offices			
Alabama	Hillary H. Jeffcoat	(205) 752–8104	520 19th Ave. Tuscaloosa, AL 35401
Alaska	Gordon L. Nelson, Acting	(907) 786–7110	4230 University Dr., Suite 201 Anchorage, AK 99508
Arizona	Garald G. Parker, Jr., Acting	(602) 670–6671	375 S. Euclid Ave. Tucson, AZ 85719
Arkansas	E. Eugene Gann	(501) 324–6391	2301 Federal Office Bldg. 700 W. Capitol Ave. Little Rock, AR 72201
California	Michael V. Shulters	(916) 978–5529	Rm. W–2234 Federal Bldg. 2800 Cottage Way Sacramento, CA 95825
Colorado	David J. Lystrom	(303) 236–4882	415 Denver Federal Center Box 25046 Denver, CO 80225
Connecticut	Chester E. Thomas, Jr.	(203) 240–3060	Rm. 525 Abraham A. Ribicoff Federal Bldg. 450 Main St. Hartford, CT 06103

Water Resources Division—Continued

District Offices—Continued

Delaware (See Maryland)			
District of Columbia (See Maryland)			
Florida	John Vecchioli	(904) 942–9500	227 N. Bronough St., Suite 3015 Tallahassee, FL 32301
Georgia	Timothy W. Hale	(404) 903–9100	Suite 130, Peachtree Business Center 3039 Amwiler Rd. Atlanta, GA 30360
Hawaii	William Meyer	(808) 541–2653	677 Ala Moana Blvd., Suite 415 Honolulu, HI 96813
Idaho	Jerry L. Hughes	(208) 334–1750	230 Collins Rd. Boise, ID 83702
Illinois	Stephen F. Blanchard	(217) 398–5350	102 E. Main St., 4th Floor Urbana, IL 61801
Indiana	Jo Ann Macy	(317) 290–3333	5957 Lakeside Blvd. Indianapolis, IN 46278
Iowa	Norwood B. Melcher	(319) 337–4191	P.O. Box 1230 Rm. 269, Federal Bldg. 400 S. Clinton St. Iowa City, IA 52244
Kansas	Johnette C. Shockley, Acting	(913) 832–3505	4821 Quail Crest Pl. Lawrence, KS 66049
Kentucky	Alfred L. Knight	(502) 582–5241	2301 Bradley Ave. Louisville, KY 40217
Louisiana	Edward H. Martin	(504) 389–0281	3535 S. Sherwood Blvd., Suite 120 Baton Rouge, LA 70816
Maine	Derrill J. Cowing	(207) 622–8201	26 Ganneston Dr. Augusta, ME 04330
Maryland	James G. Peters	(410) 828–1535	208 Carroll Bldg. 8600 La Salle Rd. Towson, MD 21204
Massachusetts	Michael C. Yurewicz	(508) 490–5003	28 Lord Rd., Suite 280 Marlborough, MA 01752
Michigan	Cynthia Barton	(517) 377–1608	6520 Mercantile Way, Suite 5 Lansing, MI 48911
Minnesota	George Garklavs	(612) 783–3100	2280 Woodale Dr. Mounds View, MN 55112
Mississippi	Gerald L. Ryan	(601) 965–4600	Suite 710, Federal Bldg. 100 W. Capitol St. Jackson, MS 39269
Missouri	Marvin G. Sherrill	(314) 341–0825	1400 Independence Rd., Stop 200 Rolla, MO 65401
Montana	Joe A. Moreland	(406) 449–5302	Drawer 10076, Rm. 428, Federal Bldg. 301 S. Park Ave. Helena, MT 59626
Nebraska	Linda S. Weiss	(402) 437–5082	Rm. 406, Federal Bldg. 100 Centennial Mall, North Lincoln, NE 68508
Nevada	Jon O. Nowlin	(702) 887–7600	333 W. Nye Ln., Rm. 224 Carson City, NV 89706
New Hampshire	Brian Mrazik	(603) 225–1611	525 Clinton St. Bow, NH 03304
New Jersey	Janice R. Ward	(609) 771–3931	810 Bear Tavern Rd., Suite 206 West Trenton, NJ 08628
New Mexico	Russell K. Livingston	(505) 262–5301	Pinetree Office Park, Suite 200 4501 Indian School Rd., NE. Albuquerque, NM 87110
New York	L. Grady Moore	(518) 472–6567	P.O. Box 1669 343 U.S. Post Office and Courthouse Albany, NY 12201

Water Resources Division—Continued

District Offices—Continued

North Carolina	James F. Turner	(919) 571–4044	3916 Sunset Rd. P.O. Box 30728 Raleigh, NC 27622
North Dakota	William F. Horak, Jr.	(701) 250–4601	821 E. Interstate Ave. Bismarck, ND 58501
Ohio	Steven M. Hindall	(614) 469–5553	975 W. Third Ave. Columbus, OH 43212
Oklahoma	Kathy D. Peter	(405) 843–7570	202 N.W. 66th, Bldg. 7 Oklahoma City, OK 73116
Oregon	Dennis D. Lynch	(503) 251–3200	10615 S.E. Cherry Blossom Dr. Portland, OR 97216
Pennsylvania	David E. Click	(717) 730–6910	840 Market St. Lemoyne, PA 17043
Puerto Rico	Allen L. Zack	(809) 749–4433	P.O. Box 364424 GSA Center, Bldg. 652 Hwy. 28, Km. 7.2, Pueblo Viejo San Juan, PR 00936
Rhode Island (See Massachusetts)			
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South Dakota	Kenneth L. Lindskov	(605) 394–1781	1608 Mountain View Rd. Rapid City, SD 57702
Tennessee	Harold C. Mattraw, Jr.	(615) 736–5424	810 Broadway, Suite 500 Nashville, TN 37203
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Vermont (See New Hampshire)			
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Washington	Carl R. Goodwin	(206) 593–6510	1201 Pacific Ave., Suite 600 Tacoma, WA 98402
West Virginia	David P. Brown	(304) 347–5131	603 Morris St. Charleston, WV 25301
Wisconsin	Warren A. Gebert	(608) 276–3801	6417 Normandy Ln. Madison, WI 53719
Wyoming	Barney D. Lewis	(307) 772–2728	2617 E. Lincolnway, Suite B Cheyenne, WY 82001

1993 Yearbook Staff

The staff of the USGS Yearbook appreciates comments from readers. If there are features that you particularly enjoy reading or information that you would like to have, but is not included, please let us know. Write to Managing Editor, USGS Yearbook, 119 National Center, Reston, VA 22092.

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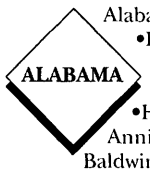
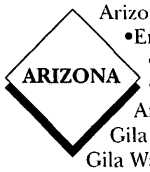
n—National Mapping Division
w—Water Resources Division



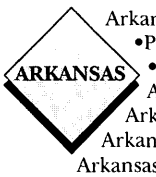
Alabama Department of—
•Economic and Community Affairs (w)
•Emergency Management (w)
•Environmental Management (w)
•Highways, Departments No. 1, 2, and 6 (w)
Anniston, City of (w)
Baldwin County Commission (w)
Birmingham, City of (w)
Coffee County Commission (w)
Geological Survey of Alabama (n,w)
Huntsville, City of (w)
Jefferson County Commission (w)
Mobile, City of (w)
Montgomery, City of (w)
Parrish, Town of (w)
Sumter, County of (w)
Tuscaloosa, City of (w)

Alaska Department of—
•Fish and Game (w)
•Natural Resources, Division of Water (w)
•Transportation (w)
Alaska Energy Authority (w)
Anchorage, Municipality of (w)
Annette Islands Reserve Tribal Government (g)
Cordova, City of (w)
Juneau, City and Borough of (w)
Kenai Peninsula Borough (w)
Sitka, City and Borough of (w)
University of Alaska, Fairbanks (w)

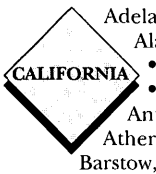
Environmental Protection Agency of American Samoa (w)
Power Authority (w)



Arizona Department of—
•Environmental Quality (w)
•Game and Fish (w)
•Water Resources (w)
Arizona State University (g)
Gila Valley Irrigation District (w)
Gila Water Commissioner, Office of (w)
Havasupai Tribe (w)
Hualapai Indian Tribe (w)
Hopi Tribe Department of Natural Resources (w)
Maricopa County Flood Control District (w)
Metropolitan Water District of Southern California (w)
Navajo Nation (w)
Petrified Forest Museum Association (g)
Pima County Department of Transportation (w)
Safford, City of, Water, Gas, and Sewer Department (w)
Salt River Project (w)
Show Low Irrigation Company (w)
Tucson, City of (g, w)
University of Arizona (g)

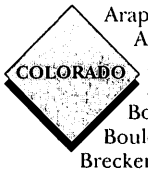


Arkansas Department of—
•Parks and Tourism (w)
•Pollution Control and Ecology (w)
Arkansas Game and Fish Commission, Fisheries Division (w)
Arkansas Geological Commission (n,w)
Arkansas Soil and Water Conservation Commission (w)
Arkansas State Highway and Transportation Department (w)
Arkansas-Oklahoma: Arkansas River Compact Commission (w)
Fort Smith, City of (w)
Independence, County of (w)
Little Rock—
•Municipal Water Works (w)
•Public Works Department (w)
Rogers, City of, Water Utilities Department (w)
University of Arkansas—
•at Fayetteville (w)
•at Little Rock (w)



Adelanto, City of (w)
Alameda County—
•Flood Control and Water Conservation District (Hayward) (w)
•Water District (w)
Antelope Valley-East Kern Water Agency (w)
Atherton, City of (w)
Barstow, City of (w)
California Department of—
•Boating and Waterways (w)
•Conservation (w)
•Parks and Recreation (w)
•Transportation (w)
•Water Resources (w)
California Polytechnical University, San Luis Obispo (w)
California Water Resources Control Board (w)—
•Division of Water Rights (w)
•Division of Water Quality (w)
Calleguas Municipal Water District (w)
Carpinteria County Water District (w)
Casitas Municipal Water District (w)
Coachella Valley Water District (w)
Contra Costa County Flood Control and WaterConservation District (w)
Contra Costa Water District (w)
Crestline-Lake Arrowhead Water Agency (w)
Desert Water Agency (w)
East Bay Municipal Utility District (w)
Eastern Municipal Water District (w)
Georgetown Divide Public Utility District (w)
Great Basin Unified Air Pollution Control District (g)
Hopland Band of Pomo Indians (w)
Humboldt Bay Municipal Water District (w)
Imperial County Department of Public Works (w)
Imperial Irrigation District (w)
Indian Wells Valley Water District (w)
Los Angeles, County of (w)
Louisiana State University and A&M College (w)
Madera Irrigation District (w)
Marin Municipal Water District (w)
Mendocino County Water Agency (w)
Merced, City of (w)
Merced Irrigation District (w)
Mojave Water Agency (g, w)
Mono, County of (w)
Montecito Water District (w)
Monterey County Water Resources Agency (w)
Monterey Peninsula Water Management District (w)
Morongo Band of Mission Indians (w)
Moss Landing Marine Labs, Consortium of Schools (g)
Orange County Water District (w)
Palmdale, City of (w)

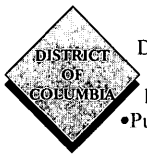
Palo Alto, City of (w)
Pechanga Indian Reservation (w)
Riverside County Flood Control and Water Conservation District (w)
Sacramento Municipal Utility District (w)
Sacramento County Department of Public Worksm(w)
San Benito County Water District (w)
San Bernardino County Flood Control District (w)
San Bernardino Valley Municipal Water District (w)
San Diego, City of (w)
San Diego County Department of Public Works(w)
San Francisco, City and County of (w)
San Francisco Water Department (w)
San Luis Obispo County Engineering Department (w)
San Mateo County Department of Public Works (w)
Santa Barbara, City of, Department of Public Works (w)
Santa Barbara County—
•Flood Control and Water Conservation District (w)
•Water Agency (w)
Santa Clara Valley Water District (w)
Santa Cruz, City of (w)
Santa Cruz County Flood Control and Water Conservation District (w)
Santa Maria Valley Water Conservation District (w)
Santa Ynez River Water Conservation District (w)
Scotts Valley Water District (w)
Sonoma County—
•Planning Department (w)
•Water Agency (w)
Tulare County Flood Control District (w)
Turlock Irrigation District (w)
United Water Conservation District (w)
University of California, Berkeley (g)
•Lawrence Livermore National Laboratory (g)
Ventura County Public Works Agency (w)
Water Master—Santa Margarita River Watershed (w)
Water Replenishment District of Southern California (w)
Woodbridge Irrigation District (w)
Yolo County Flood Control and Water Conservation District (w)
Yuba County Water Agency (w)



Arapahoe County Water and Wastewater (w)
Arkansas River Compact Administration (w)
Aspen, City of (w)
Aurora, City of (w)
Boulder, City of (w)
Boulder, County of (w)
Breckenridge, Town of (w)
Centennial Water and Sanitation District (w)
Cherokee Water and Sanitation District (w)
Colorado Department of—
•Health (w)
•Minerals and Geology (w)
•Natural Resources, Oil and Gas Conservation Commission (w)
•Transportation (w)
Colorado Division of Wildlife (w)
Colorado Office of the State Engineer (w)
Colorado River Water Conservation District (w)
Colorado Springs, City of—
•Department of Public Utilities (w)
•Engineering Division (w)
Colorado Water Conservation Board (w)
Delta County Board of Commissioners (w)
Denver Board of Water Commissioners (w)
Eagle County Board of Commissioners (w)
East Cherry Creek Valley Water and Sanitation District (w)
East Grand County Water Quality Board (w)
Englewood, City of (w)
Evergreen Metropolitan District (w)
Fort Collins, City of, Water and Wastewater (w)
Fountain Valley Authority (w)
Fremont Sanitation District (w)
Garfield, County of (w)
Glendale, City of (w)
Glenwood Springs, City of (w)
Jefferson County Board of Commissioners (w)
Lakewood, City of (w)
Lamar, City of (w)
Las Animas, City of (w)
Littleton-Englewood Bi-City Wastewater Treatment Plant (w)
Longmont, City of (w)
Loveland, City of (w)
Lower Fountain Water-Quality Management Association (w)
Metropolitan Wastewater Reclamation District (w)
Moffat, County of (w)
Northern Colorado Water Conservation District (w)
Pueblo Board of Water Works (w)
Pueblo, City of, Department of Utilities (w)
Pueblo County Commissioners (w)
Pueblo West Metropolitan District (w)
Rio Blanco, County of (w)
Rio Blanco Water Conservation District (w)
Rio Grande Water Conservation District (w)
Rocky Ford, City of (w)
Routt, County of (w)
St. Charles Mesa Water District (w)
Southern Ute Indian Tribe (g,w)
Southeastern Colorado Water Conservancy District (w)
Southwestern Colorado Water Conservation District (w)
Steamboat Springs, City of, Public Works Department (w)
Teller-Park Soil Conservation District (w)
Thornton, City of (w)
Trinchera Water Conservation District (w)
Uncompahgre Valley Water Users Association (w)
Upper Arkansas Council of Governments (w)
Upper Arkansas River Water Conservation District (w)
Upper Eagle Regional Water Authority (w)
Upper Gunnison River (w)
Upper Yampa Water Conservancy District (w)
Urban Drainage and Flood Control District (w)
Ute Mountain Indian Tribe (w)
Vail Valley Conservation Water District (w)
Westminster, City of (w)
Willows Water District (w)
Yellow Jacket Water Conservancy District (w)

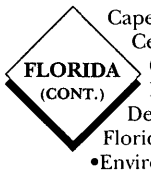
Connecticut Department of—
•Environmental Protection (g,n,w)
•Transportation, Bureau of Engineering and Highway Operations (w)
Fairfield, Town of, Conservation Department (w)
Lake Waramaug—
•Interlocal Commission (w)
•Task Force, Inc. (w)
Meriden, City of (w)
New Britain, City of, Board of Water Commissioners (w)
South Central Connecticut Regional Water Authority (w)
Torrington, City of (w)

Delaware River Basin Commission (w)
Geological Survey (n,w)
University of Delaware (w)



Department of—
•Consumer and Regulatory Affairs, Environmental Control Division (w)
•Public Works (w)

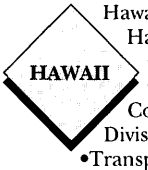
Bay County Utilities (w)
Boca Raton, City of (w)
Bradenton, City of (w)
Broward, County of—
•Natural Resources Protection (w)
•Water Resources Management Division (w)



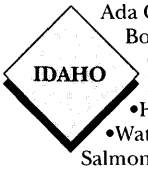
Cape Coral, City of (w)
Century, City of (w)
Cocoa, City of, Utilities and Public Works (w)
Daytona Beach, City of (w)
Deerfield Beach, City of (w)
Florida Department of—
•Environmental Protection (g, n,w)
•Natural Resources (w)—
Bureau of Marine Resource and Evaluation (w)
Division of Survey and Mapping (n)
•Transportation (n,w)
Florida Keys Aqueduct Authority (w)
Fort Lauderdale, City of (w)
Game and Freshwater Fish Commission (w)
Hallandale, City of (w)
Highland Beach, Town of (w)
Hillsborough, County of (w)
Hollywood, City of (w)
Jacksonville, City of, Department of Public Utilities (w)
Jacksonville Electric Authority (w)
Joshua Water Control District (w)
Lake, County of, Water Authority (w)
Lake Mary, City of, Public Works (w)
Lee, County of (w)
Manatee County—
•Board of County Commissioners (w)
•Environmental Action Commission (w)
Metropolitan Dade County (w)
Miami-Dade Water and Sewer Authority (w)
North Port Water Control District (w)
Northwest Florida Water Management District (w)
Orange County Public Works Division (w)
Perry, City of (w)
Pinellas, County of (w)
Pompano Beach, City of (w)
Reedy Creek Improvement District (w)
Sarasota, City of (w)
Sarasota, County of (w)
South Florida Water Management District, Department of Research and Evaluation (w)
Southwest Florida Water Management District (w)
St. Johns River Water Management District (g, w)
St. Petersburg, City of (w)
Stuart, City of (w)
Suwannee River Water Management District (w)
Tallahassee, City of—
•Electric Department (w)
•Water Quality Laboratory (w)
Tampa, City of (w)
Tampa Bay Regional Planning Council (w)
University of Florida (g)
Volusia, County of (w)
Walton, County of (w)
West Coast Regional Water Supply Authority (w)
Winter Park, City of (w)

Albany Water, Gas, and Light Commission (w)
Athens-Clarke County (w)
Attapulgus, City of (w)
Bibb, County of (w)
Blairsville, Town of (w)
Brunswick, City of (w)
Chestatee-Chattahoochee Resource Conservation and Development Center (w)
Clayton County Water Authority (w)
Coastal Georgia Regional Development (w)
Covington, City of (w)
De Kalb County Public Works Department (w)
Georgia Department of—
•Natural Resources—
Water Quality Management Program (w)
Geologic Survey (w)
•Transportation (w)—
at Atlanta (w)
at Forest Park (w)
Georgia Forestry Commission (w)
Georgia Mountain Regional Development Center (w)
Gwinnett, County of, Preconstruction Division (w)
Helena, City of (w)
Macon Water and Sewage Authority (w)
Monroe Water, Light, and Gas Commission (w)
Moultrie, City of (w)
South Florida Water Municipal Department (w)
Springfield, City of (w)
St. Johns River Water Municipal Department (w)
Thomaston, City of (w)
Thomasville, City of (w)
Tift County Commission (w)
Tifton, City of (w)
Valdosta, City of (w)

Guam, Government of, Environmental Protection Agency (w)



Hawaii, County of, Department of Water Supply (w)
Hawaii Department of—
•Agriculture, Division of Agriculture Resource Management (w)
•Land and Natural Resources (g)—
Commission on Water Resources Management (w)
Division of Forestry and Wildlife (n,w)
•Transportation (w)
Honolulu, City and County of—
•Board of Water Supply (w)
•Department of Public Works (w)
Kauai, County of, Department of Water Supply (w)
Maui, County of, Department of Water Supply (w)
University of Hawaii (g)



Ada County Highway District (w)
Boise, City of (w)
Coeur d'Alene Tribe of Idaho (w)
Idaho Department of—
•Health and Welfare (w)
•Water Resources (w)
Salmon River Canal Co., Ltd. (w)
Shoshone-Bannock Indian Tribes (w)
Shoshone, County of (w)
Southwest Irrigation District (w)
Teton County Board of Commissioners (w)
Water District No. 01 (Idaho Falls) (w)
Water District No. 31 (Dubois) (w)
Water District No. 32D (Dubois) (w)

Bloomington and Normal Sanitary District (w)
Boneyard Creek Commission (w)
Cook County Forest Preserve District (w)
Danville Sanitary District (w)
Decatur, City of (w)
DeKalb, City of, Public Works Department (w)
DuPage County Forest Preserve, Planning and Development Section (w)
DuPage County Department of Environmental Concerns (w)
Illinois Department of—
•Conservation, Planning Division (w)
•Energy and Natural Resources—
Geological Survey Division (n)
State Water Survey (w)
•Transportation—
Division of Highways (n)
Division of Water Resources (n,w)
Illinois Environmental Protection Agency (w)
Kane, County of—
•Development Department, Stormwater Management (w)
•Forest Preserve Commission (w)

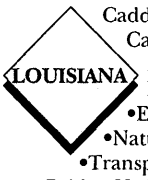
Kankakee Soil and Water Conservation District (w)
Lake County Stormwater Management Commission (w)
Metropolitan Water Reclamation District of Greater Chicago (w)
Monticello City Services (w)
Springfield, City of (w)
Vermilion County Conservation District (w)
Winnebago County Department of Public Works (w)
Wisconsin Department of Natural Resources (w)

Carmel, Town of, Utilities (w)
Elkhart, City of, Water Works (w)
Indiana Department of—
•Environmental Management (g,w)
•Natural Resources (n)—
Division of—
Transportation (w)
Water (w)
Indiana Office of the State Chemist (w)
Indianapolis, City of, Department of Public Works (w)
Muncie Sanitary District, Bureau of Water Quality (w)
Purdue University (w)
St. Joseph River Basin Commission (w)

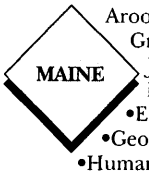
Ames, City of (w)
Cedar Rapids, City of, Engineering Department (w)
Clinton, City of (w)
Davenport, City of (w)
Des Moines, City of (w)
Fort Dodge, City of (w)
Iowa Department of—
•Transportation, Highway Division (w)
•Natural Resources, Geological Survey Bureau (n,w)
Iowa State University (w)
Muscatane Water and Light Board (w)
University of Iowa—
•Department of Preventive Medicine (w)
•Institute of Hydraulic Research (w)
•Hygienic Laboratory (w)

Arkansas River Compact Administration (w)
Brazos River Authority (w)
Cameron, City of (w)
Emporia, City of, Department of Public Works (w)
Equus Beds Groundwater Management District No. 2 (w)
Harvey County Conservation Distict (w)
Hays, City of (w)
Iowa Tribe of Kansas and Nebraska (w)
Johnson, County of (w)
Kansas Department of Transportation (w)
Kansas Geological Survey (n,w)
Kansas Highway Commission (w)
Kansas State Board of Agriculture, Division of Water Resources (w)
Kansas State Conservation Commission (w)
Kansas State University Department of Agronomy (w)
Kansas University Center for Research, Inc. (w)
Kansas Water Office (w)
Sac and Fox Tribe of Missouri (w)
University of Iowa (w)
Wichita, City of (w)

Bullitt, County of (w)
Campbellsville Municipal Water (w)
Elizabethtown, City of (w)
Georgetown, City of (w)
Glasgow Water Company (w)
Kentucky Department of—
•Health Services (w)
•Natural Resources and Environmental Protection Cabinet (w)
Kentucky State University (w)
Kentucky Tourism Cabinet, Department of Fish and Wildlife Resources (w)
Metropolitan Sewer District (w)
Middleboro, City of (w)
Owensboro, City of (w)
University of Kentucky, Kentucky Geological Survey (g,n)
University of Louisville (w)

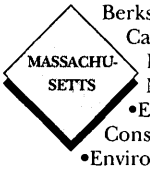


Caddo Parish (w)
Capital-Area Groundwater Conservation Commission (w)
East Baton Rouge Parish (w)
Louisiana Department of—
•Environmental Quality, Office of Water Resources (w)
•Natural Resources, Coastal Restoration Division (w)
•Transportation and Development (w)—
Bridge Hydraulics (w)
Office of Public Works (n)
Louisiana Geological Survey (n)
Minden, City of (w)
Plaquemines Parish (w)
Sabine River Compact Administration (w)
St. John the Baptist Parish (w)
Terrebonne Parish (w)
West Monroe, City of (w)

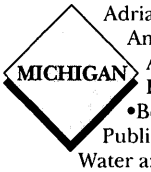


Aroostock County Water and Soil Management Board (w)
Greater Portland Council of Governments (w)
Jay, Town of (w)
Maine Department of—
•Environmental Protection
•Geological Survey (w)
•Human Services (w)
•Transportation (w)
•State Forest Service (n)
North Kennebec Valley Regional Planning Commission (w)
Northern Maine Regional Planning Commission (w)
Penobscot Indian Nation (w)
University of Maine (w)

Baltimore, City of, Water Quality Management (w)
Delaware Geological Survey (w)
Hyndman, Borough of (w)
Interstate Commerce Commission (w)
Maryland Department of the Environment (w)
Maryland Energy Administration (w)
Maryland Geological Survey (n,w)
Maryland State Highway Administration (w)
Prince Georges County Government (w)
Salisbury, City of (w)
University of Maryland (g)



Berkshire, County of (w)
Cape Cod Commission (w)
Executive Office of Environmental Affairs (n)
Massachusetts Department of—
•Environmental Management, Division of Resources Conservation (w)
•Environmental Protection—
Division of Water Pollution Control (w)
Division of Water Supply (w)
Bureau of Waste Site Cleanup (w)
Massachusetts Highway Department (w)
Massachusetts Water Resources Authority (g)
Metropolitan District Commission—
•Parks, Engineering and Construction Division (w)
•Watershed Management Division (w)
University of Rhode Island (w)



Adrian, City of (w)
Ann Arbor, City of (w)
Antrim County Drain Commission (w)
Battle Creek, City of (w)—
•Board of—
Public Utilities (w)
Water and Light (w)
Beaverton, City of (w)

Cadillac, City of, Wastewater Treatment Plant (w)
Clare, City of (w)
Cliffs Mining Services Co. (w)
Consumers Power Company (w)
Delta Charter Township (w)
Elsie, Village of, Department of Public Works (w)
Flint, City of, Water Plant (w)
French Paper Company (w)
Huron-Clinton Metropolitan Authority (w)
Huron County Board of Commissioners (w)
Imlay, City of (w)
Indiana Michigan Power Co. (w)
Kalamazoo, City of, Department of Public Works (w)
Keweenaw Bay Indian Community (w)
Macomb, County of (w)
Mead Paper Company (w)
Michigan Department of—
•Natural Resources (w) Office of Budget and Federal Aid (w)
•Transportation (w) Design Division (w)
Michigan Power Company (w)
Negaunee, City of, Water and Wastewater Treatment Plant (w)
Norway, City of (w)
Oakland County Drainage Commission (w)
Otsego County Road Commission (w)
Portage, City of (w)
Portland, City of (w)
Roscommon County Board of Commissioners (w)
Schoolcraft County Board of Commissioners (w)
Southeast Michigan Council of Governments (w)
STS Hydropower, Ltd. (w)
Sturgis, City of (w)
Tri-County Regional Planning Commission (w)
Upper Peninsula Power Company (w)
Wayne, County of, Division of Environmental Health (w)
Wisconsin Electric Power Company (w)
Wolverine Hydroelectric (w)
Wolverine Power Supply Cooperative (w)
Ypsilanti Community Utility Authority (w)

Beltrami County SWCD (w)
Elm Creek Conservation Management and Planning Commission (w)
Grand Portage Reservation Government (w)
Hubbard County Soil and Water (w)
Land Management Information Center (n)
Lower Red River Watershed Management Board (w)
Mille Lacs Reservation Band Government (w)
Minnesota Department of—
•Natural Resources (g,w)
•Transportation (w)
Minnesota Pollution Control Agency (w)
Minnesota State Planning Agency (n)
Northwest Minnesota Ground Water Steering Committee (w)
Pine County Soil and Water Conservation District (w)
Snake River Watershed Planning Committee (w)
University of Minnesota, Department of Soil Science (w)

Harrison County Development Commission (w)
Jackson, City of (w)
Jackson County Port Authority (w)
Mississippi Department of—
•Agriculture and Commerce (w)
•Environmental Quality
Office of Land and Water Resources (w)
Office of Pollution Control (w)
•Transportation (w)
Pat Harrison Waterway District (w)
Pearl River Basin Development District (w)
Pearl River Valley Water Supply District (w)
Yazoo Mississippi Delta Joint Water Management District (w)

Cape Girardeau, City of (w)
Cass County Soil and Water Conservation District (w)
Columbia, City of (w)
Independence, City of (w)
Jackson County Parks and Recreation (w)
Mid-America Regional Council (w)
Missouri Department of—
•Conservation (n,w)
•Health (w)
•Natural Resources
Division of Environmental Quality (w)
Division of Geology and Land Survey (n)
Missouri Highway and Transportation Commission (w)
Rolla, City of (w)
Springfield, City of, City Utilities (w)
St. Francois County Environmental Corporation (w)
Watershed Commission of the Ozarks (w)

Beaverhead County Water and Sewer (w)
Blackfeet Nation (w)
Chippewa Creek Tribe of Rocky Boy's Reservation (g)
Fort Peck Reservation (w)
Greenfield Irrigation District (w)
Helena, City of (w)
Judith Basin Conservation District (w)
Lewis and Clark City-County Health Department (w)
Montana Bureau of Mines and Geology (w)
Montana Department of—
•Fish, Wildlife, and Parks (w)
•Health and Environmental Sciences (w)
•Natural Resources and Conservation (w)
•Transportation (w)
Northern Cheyenne Tribe (w)
Office of the Governor (w)
Salish and Kootenai Tribes of Flathead Reservation (w)
Wyoming State Engineer (w)

Central Platte Natural Resources District (w)
Kansas-Nebraska Blue River Compact Administration (w)
Lincoln, City of (w)
Little Blue Natural Resources District (w)
Lower Elkhorn Natural Resources District (w)
Lower Platte North Natural Resources District (w)
Lower Platte South Natural Resources District (w)
Lower Republican Natural Resources District (w)
Middle Republican Natural Resources District (w)
Nebraska Department of—
•Environmental Quality (w)
•Water Resources (w)
Nebraska Natural Resources Commission (w)
Nemaha Natural Resources District (w)
North Platte Natural Resources District (w)
Omaha, City of (w)
Papio-Missouri River Natural Resources District (w)
South Platte Natural Resources District (w)
University of Nebraska, Conservation and Survey Division (w)
Upper Elkhorn Natural Resources District (w)
Upper Loup Natural Resources District (w)
Upper Niobrara-White Natural Resources District (w)

Carson City/County Department of Public Works (w)
Clark County Regional Flood Control District (w)
Clark County Sanitation District (w)
Douglas, County of (w)
Duck Valley Reservation (w)
Henderson, City of (w)
Las Vegas Valley Water District (g,w)
Nevada Bureau of Mines and Geology (g,n,w)
Nevada Department of—
•Conservation and Natural Resources

Division of Environmental Protection (w)
Division of Water Resources (w)
•Transportation (w)
•Wildlife (w)
Summit Lake Paiute Indian Tribe (w)
Tahoe Regional Planning Agency (w)
Truckee-Carson Irrigation District (w)
Washoe County Planning Department (n)

Lincoln, Town of (w)
New Hampshire Department of—
•Environmental Services (g,w)
•Transportation (n)

Atlantic Highlands, Borough of (w)
Bergen, County of (w)
Brick Township Municipal Utility Authority (w)
Gloucester County Planning Commission (w)
Hackensack Meadowlands Development Commission (w)
Medford, Township of (w)
Mercer County Park Commission (w)
Morris County Municipal Utility Authority (w)
New Brunswick, City of (w)
New Jersey Department of—
•Environmental Protection (n,w)
•Transportation (w)
New Jersey Water Supply Authority (w)
North Jersey District Water Supply Commission (w)
Passaic Valley Water Commission (w)
Pinelands Commission (w)
Rutgers State University, Environmental Health and Safety (w)
Somerset County Board of Chosen Freeholders (w)
Washington Township Municipal Utility Authority (w)
West Windsor, Township of (w)

Albuquerque, City of—
•Public Works Department
Hydrology Division (w)
Utility Planning Division (w)
Waste Water Utility (w)
Albuquerque Metropolitan Arroyo Flood Control Authority (w)
Arizona Department of Environmental Quality (w)
Bernalillo, County of (w)
Canadian River Municipal Water Authority (w)
Costilla Creek Compact Commission (w)
Elephant Butte Irrigation District (w)
El Paso Water Board (w)
Jornada Reservation, Conservation and Development (w)
Las Cruces, City of, Water Department (w)
New Mexico Department of—
•Environment (w)
•Highways and Transportation (w)
New Mexico State University, Water Resources Research Institute (w)
Office of the State Engineer (w)
Pecos River Commission (w)
Picuris Pueblo (w)
Pueblo of Laguna (w)
Pueblo of Zuni (w)
Raton, City of (w)
Rio Grande Compact Commission (w)
Rio San Jose Flood Control District (w)
Ruidoso, Village of (w)
Santa Rosa, City of (w)
Texas Water Development Board (w)
University of New Mexico (n)

Amherst, Town of, Engineering Department (w)
Auburn, City of (w)
Central New York Regional Planning Board (w)
Chautauqua County Department of Planning and Development (w)
Cheektowaga, Town of (w)
Cornell University, Department of Utilities (w)
Cortland County Health Department (w)
Hudson-Black River Regulating District (w)
Kiryas Joel, Village of (w)
Monroe County Department of Environmental Health (w)
Nassau County Department of Public Works, Division of Sanitation and Water Supply (w)
New England Interstate Water Pollution (w)
New York City Department of Environmental Protection, Bureau of Water Supply (w)
New York State Department of—
•Environmental Conservation, Bureau of Monitoring and Assessment (w)
•Transportation (w)
New York State Energy Research Development Authority (w)
New York State Power Authority (w)
Nyack, Village of, Board of Water Commissioners (w)
Onondaga, County of—
•Department of Drainage and Sanitation (w)
•Water Authority (w)
Onondaga Lake Management Conference (w)
Orange County Water Authority (w)
Saratoga Springs, City of, Office of the Commissioner of Public Works (w)
State University of New York, Binghampton (w)
Suffolk, County of—
•Department of Health Services (w)
•Water Authority (w)
Ulster, County of (w)

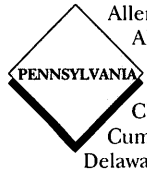
Appalachian State University (g)
Asheville, City of (w)
Bethel, Town of (w)
Brevard, City of (w)
Chapel Hill, Town of (w)
Charlotte, City of (w)
Danville, Virginia, City of (w)
Durham, City of (w)
Fayetteville, City of (w)
Gaston, County of (w)
Greensboro, City of (w)
Jackson, County of (w)
Lexington, City of (w)
Lumber River Council of Governments (w)
Mecklenburg, County of (w)
Morganton, City of (w)
North Carolina Cooperative Extension Service, Dallas and Raleigh (w)
North Carolina State Department of—
•Environment, Health, and Natural Resources (n,w)
•Transportation (w)
Orange, County of (w)
Raleigh, City of (w)
Rocky Mount, City of (w)
Triangle Area Water Supply Monitoring, Project Steering Committee (w)
University of North Carolina, Wilmington, (g)
Western Piedmont Council of Governments (w)

Devils Lake Sioux Tribe (w)
Dickinson, City of (w)
Lower Heart Water Resources District (w)
Minot, City of (w)
North Dakota Department of—
•Game and Fish (w)
•Health, Water Supply, and Pollution Control (w)
•Parks and Recreation (w)
•Transportation (w)
North Dakota Geological Survey (n)
State Water Commission (w)
Three Affiliated Tribes (w)

Akron, City of (w)
Canton, City of (w)
Columbus, City of (w)
Cuyahoga River Community Planning Organization (w)
Eastgate Development Company (w)
Franklin, County of (w)
Fremont, City of (w)
Lima, City of (w)
Madison, County of (w)
Miami Conservancy District (w)
N.E. Ohio Regional Sewer District (w)
Ohio Department of—
•Natural Resources (w)
•Transportation (n,w)
Ohio Environmental Protection Agency (w)
Ohio State University, Department of Agronomy (w)
Pickaway, County of (w)
Ross, County of (w)
Seneca Soil and Water District (w)
Sumit County Engineers (w)
University of Toledo (w)
Washington, County of (w)

Ada, City of (w)
Cheyenne and Arapaho Tribes (w)
McGee Creek Authority (w)
Oklahoma City, City of (w) Water Utilities Trust (w)
Oklahoma Conservation Commission (w)
Oklahoma Department of—
•Health (w)
•Transportation (n)
Oklahoma Geological Survey (w)
Oklahoma State University, Division of Agricultural Sciences (w)
Oklahoma Water Resources Board (w)
Sac and Fox Nation (w)

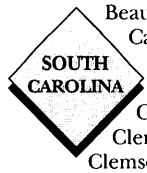
Albany, City of (w)
Ashland, City of (w)
Bend, City of (w)
Coos, County of (w)
Coos Bay-North Bend Water Board (w)
Douglas, County of (w)
Eugene, City of (w)
Gresham, City of (w)
Jackson, County of (w)
McMinnville, City of (w)
Metropolitan Service District (w)
Oregon Department of—
•Energy (w)
•Environmental Quality (w)
•Human Resources, State Health Division (w)
•Transportation, Highway Division (w)
•Water Resources (w)
Portland, City of—
•Bureau of—
Environmental Services (w)
Water Works (w)
•Department of Utilities (w)
Portland State University (w)
Tualatin Valley Water District (w)
Unified Sewerage Agency (w)
Warm Springs Tribal Council (w)



Allentown, City of, Engineering Department (w)
Alliance for the Chesapeake Bay (w)
Bethlehem, City of (w)
Bucks, County of (w)
Chester County Water Resources Authority (w)
Cumberland, City of (w)
Delaware County Solid Waste Authority (w)
Delaware River Basin Commission (w)
Doylestown Township Municipal Authority (w)
Harrisburg, City of, Department of Public Works (w)
Hazelton City Authority Water Department (w)
JPC Lehigh-Northampton Counties (w)
Letort Regional Authority (w)
Media Borough Water Department (w)
New York State Department of Environmental Conservation Planning and Restoration (w)
North Penn Water Authority (w)
North Wales Water Authority (w)
Philadelphia, City of, Water Department (w)
Pennsylvania Department of—
•Environmental Resources—
Bureau of—
Community Environmental Control (w)
Land and Water Conservation (w)
Mining and Reclamation (w)
Topographic and Geologic Survey (n,w)
Water Quality Management (w)
Water Resources Management (w)
Water Supply and Community Health (w)
•Transportation (w)
Pennsylvania State University (w)
Reading, City of, Department of Streets and Public Improvements (w)
Somerset Conservation District (w)
Sunbury, City of, Municipal Authority (w)
Susquehanna River Basin Commission (w)
Tinicum, Township of (w)
University Area Joint Authority (w)
University of Delaware, Geological Survey (w)
West Bradford, Township of (w)
Williamsport, City of (w)

Municipality of Manati (w)
Puerto Rico Aqueduct and Sewer Authority (w)
Puerto Rico Civil Defense (w)
Puerto Rico Department of Natural Resources (w)
Puerto Rico Electric Power Authority (w)
Puerto Rico Environmental Quality Board (w)
Puerto Rico Industrial Development Company (w)
Puerto Rico Mineral Resources Development Corporation (g)
Virgin Islands Water and Power Authority (w)

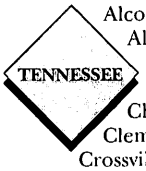
Narragansett Bay Commission (w)
Providence, City of, Water Supply Board (w)
Rhode Island State Department of Environmental Management,
Division of Water Resources (w)
State Water Resources Board (w)



Beaufort-Jasper County Water and Sewer Authority (w)
Camden, City of (w)
Charleston Harbor Project (w)
Charleston Public Works (w)
Clar/Sumter Soil and Water Conservation District (w)
Clemson, City of, Department of Engineering (w)
Clemson University, College of Agricultural Sciences (w)
Grand Strand Water and Sewer Authority (w)
Greer Commission of Public Works (w)
Land Resources Conservation Commission (n)
Myrtle Beach, City of (w)
Oconee County Sewer Commission (w)
South Carolina State—
•Department of—
Health and Environmental Control (w)
Highways and Public Transportation (w)
•Public Service Authority (w)
•Water Resources Commission (n,w)
•Wildlife and Marine Resources Department (w)
South Carolina Sea Grant Consortium (w)
Spartanburg Sanitary Sewer District (w)

Spartanburg Water System (w)
University of South Carolina Department of Environmental and Health Services (w)
Waccamaw Regional Planning and Development Council (w)
Western Carolina Regional Sewer Authority (w)

Area II Minnesota River Basin (w)
Belle Fourche Irrigation District (w)
Cheyenne River Sioux Tribe (w)
East Dakota Water Development District (w)
Lake Kampeska Water Project District (w)
Lower Brule Sioux Tribe (w)
Mellette, County of (w)
North Central Resource Conservation and Development (w)
Oglala Sioux Tribe Water Resources Division (w)
Pennington County Drainage Commission (w)
Rapid City, City of (w)
Rosebud Sioux Tribe (w)
Sioux Falls, City of—
•Utility Office (w)
•Water Purification Plant (w)
Sisseton-Wahpeton Sioux Tribe (w)
South Dakota Department of—
•Environment and Natural Resources
Environmental Regulation Division (w)
Geological Survey Division (w)
Water Resource Management Division (w)
Water Rights Division (w)
•Game, Fish and Parks (w)
•Transportation (w)
South Dakota School of Mines and Technology (w)
South Dakota State University (w)—
•Civil Engineering Department (w)
•Horticulture, Forestry, Landscape, and Parks Department (w)
Spearfish, City of (w)
Stanley County Conservation District (w)
Watertown, City of (w)
West Dakota Water Development District (w)
West River Water Development District (w)
Wyoming, State of (w)

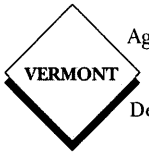


Alcoa, City of (w)
Alpha Talbott Utility District (w)
Bartlett, City of (w)
Camden, City of (w)
Chattanooga, City of, Department of Public Works (w)
Clemson University Department of Environmental Toxicology (w)
Crossville, City of (w)
Dickson, City of (w)
Eastside Utility District (w)
Franklin, City of (w)
Gatlinburg, City of (w)
Germantown, City of (w)
Hamilton County Office of Emergency Management (w)
Harriman Utility Board (w)
Harpeth Valley Utility District (w)
Johnson City, City of, Public Works Department (w)
Knoxville, City of (w)
Memphis, City of, Light, Gas, and Water Division (w)
Memphis State University (w)
Metropolitan Governments, Nashville, City of, and Davidson, County of (w)
Murfreesboro, City of, Water and Sewer Department (w)
Red Boiling Springs, Town of (w)
Rogersville, Town of (w)
Savannah Valley Utility District (w)
Sevierville, City of (w)
Shelby County Government (w)
Shelby County Soil Conservation District (w)
Tennessee Department of—
•Agriculture (w)
•Environment and Conservation, Office of Water Programs (w)
•Transportation—
Division of Planning (w)
Division of Structures (w)
Tennessee State Planning Office (w)
Tennessee Wildlife Resources Agency (w)
Tullahoma Utilities Board (w)
Union City, City of (w)
University of Tennessee (w)
Upper Duck River Development Agency (w)
Wartrace, City of (w)

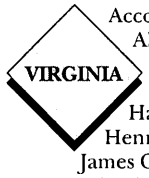
Abilene, City of (w)
Arlington, City of (w)
Austin, City of (w)
Barton Springs/Edwards Aquifer Conservation District (w)
Bexar-Medina-Atascosa Counties (w)
Brazos River Authority (w)
Canadian River Municipal Water Authority (w)
Coastal Water Authority (w)
Colorado River Municipal Water District (w)
Corpus Christi, City of (w)
Dallas, City of (w)
Dallas, City of, Public Works Department (w)
Edwards Underground Water District (w)
El Paso, City of, Public Service Board (w)
Fort Bend Subsidence District (w)
Fort Worth, City of (w)
Gainesville, City of (w)
Galveston, County of (w)
Garland, City of, Department of Public Works (w)
Georgetown, City of (w)
Graham, City of (w)
Greenbelt Municipal and Industrial Water Authority (w)
Guadalupe-Blanco River Authority (w)
Harris, County of, Flood Control District (w)
Harris-Galveston Coastal Subsidence District (w)
Houston, City of (w)
Houston-Galveston Area Council (w)
Lavaca-Navidad River Authority (w)
Lower Colorado River Authority (w)
Lower Neches Valley Authority (w)
Lubbock, City of (w)
Nacogdoches, City of (w)
North Central Texas Council of Governments (w)
North Central Texas Municipal Water Authority (w)
North Texas Municipal Water District (w)
North East Texas Municipal Water District (w)
Orange, County of (w)
Pecos River Commission (w)
Red River Authority of Texas(w)
Sabine River Authority of Texas (w)
Sabine River Compact Administration (w)
San Angelo, City of (w)
San Antonio, City of—
•Public Service (w)
•Water Systems (w)
San Antonio River Authority (w)
San Jacinto River Authority (w)
Somerville County Water District (w)
Tarrant, County of, Water Control and Improvement District No. 1 (w)
Texas Soil and Water Conservation Board (w)
Texas State Department of Highways and Transportation (w)
Texas Water Commission (w)
Texas Water Development Board (n,w)
Titus, County of, Fresh Water Supply District No. 1 (w)
Trinity River Authority (w)
University of Texas, Austin (g, w)
Upper Guadalupe River Authority (w)
Upper Neches River Municipal Water Authority (w)
West Central Texas Municipal Water District (w)
Wichita, County of, Water Improvement District No. 2 (w)
Wichita Falls, City of (w)

Commonwealth Utilities Corp., Saipan (w)
Northern Mariana Islands, Commonwealth of (w)—
•Division of Environmental Quality (w)
•Municipality of Tinian (w)
Office of the Governor, Saipan (w)
Ponape State Government (w)
Republic of Palau (w)

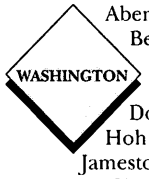
Bear River Commission (w)
Central Utah Water Conservation District (w)
Goshute Tribal Government (g)
Ogden River Water Users Association (w)
Salt Lake, County of, Division of Flood Control (w)
Tooele, City of (w)
University of Utah (w)
Utah Department of—
•Natural Resources—
Geological and Mineral Survey (n,w)
Oil, Gas, and Mining Division (w)
Water Resources Division (w)
Water Rights Division (w)
Weber Basin Water Conservancy District (w)
Weber River Water Users Association (w)



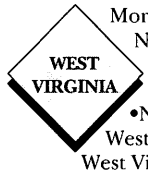
Agency of—
•Administration (n)
•Natural Resources (g,n)
Department of Environmental Conservation (w)



Accomack-Northampton Planning District Commission (w)
Alexandria, City of (w)
Danville, City of (w)
Delaware Geological Survey (w)
Hampton Roads Planning District Commission (w)
Henrico County Department of Public Utilities (w)
James City, County of (w)
Maryland, Department of—
•Environment (w)
•State Highway Administration (w)
Newport News, City of (w)
Northern Virginia Planning District Commission (w)
Prince William Health District (w)
Prince William Public Works (w)
Roanoke, City of (w)
Southeastern Public Service Authority of Virginia (w)
University of Virginia, Department of Environmental Sciences (w)
Virginia Department of—
•Environmental Quality (w)
•Mines, Minerals, and Energy, Division of Mineral Resources (n)
•Transportation (w)



Aberdeen, City of (w)
Bellevue, City of (w)
Chelan, County of, Public Utility District No. 1 (w)
Cowlitz, County of (w)
Douglas, County of, Public Utility District No. 1 (w)
Hoh Indian Tribe (w)
Jamestown S'Klallam Tribe (w)
Kent, City of (w)
King County Department of Public Works (w)
Lewis County Board of Commissioners (w)
Makah Indian Tribe (w)
Nisqually Indian Tribe (w)
Oregon Department of Fish and Wildlife (w)
Pacific, County of (w)
Pierce, County of (w)
Quileute Tribal Council (w)
Quinault Indian Business Committee (w)
Seattle, City of (w)
Skagit County Department of Public Works (w)
Skagit Conservation District (w)
Snohomish, County of—
•Board of Commissioners (w)
•Public Works (w)
Spokane County Commissioners (n)
Tacoma, City of, Department of—
•Public Utilities (w)
•Public Works (w)
Thurston County Department of Public Works (w)
Umatilla Indian Tribal Council (w)
University of Washington (g)
Washington Department of—
•Ecology (w)
•Fisheries (w)
•Information Services (n)
•Natural Resources (n,w)
•Transportation (w)
Washington State Community Development (w)
Yakima Indian Nation (w)



Morgantown, City of, Utility Board (w)
New Martinsville, City of (w)
West Virginia Department of—
•Highways (w)
•Natural Resources, Office of Water Resources (w)
West Virginia Division of Environmental Protection (w)
West Virginia Geological and Economic Survey (g, w)

Alma/Moon Lake District (w)
Balsam Lake Protection and Rehabilitation District (w)
Baraboo, Town of (w)
Barron, City of (w)
Bear Lake, Town of (w)
Beaver Dam, City of (w)
Big Muskego Lake District (w)
Brookfield, City of (w)
Brown County Planning Commission (w)
Cedar Lake, Town of (w)
Dane, County of—
•Department of Public Works (w)
•Lakes and Watershed Management (w)
•Regional Planning Commission (w)
Darboy Sanitary District #1 (w)
Delavan, Town of (w)
Druid Lake Inland Protection and Rehabilitation District (w)
Eagle Spring Lake Management (w)
East Central Wisconsin Regional Planning Commission (w)
Elkhart Lake Improvement Association (w)
Fond Du Lac, City of (w)
Fowler Lake Management District (w)
Geological Survey (w)
Green Bay Metropolitan Sewerage District (w)
Green Lake Sanitary District (w)
Hillsboro, City of (w)
Hills Lake Management District (w)
Hooker Lake District (w)
Hubbard, Township of (w)
Illinois Department of Transportation (w)
Kansasville, Town of (w)
Kaukauna Electric and Water Utilities (w)
Kimberly Water Works Department (w)
Lac Du Flambeau Indians (w)
Lake Keesus Management District (w)
Lake Nebagamon, Village of (w)
Little Arbor Vitae Protection and Rehabilitation District (w)
Little Chute, Village of (w)
Little Green Lake Protection and Rehabilitation District (w)
Little Muskego Lake District (w)
Little St. Germain Lake District (w)

WISCONSIN (CONT.)

Loon Lake/Wescot Management District (w)
Madison Engineering Department (w)
Madison Metropolitan Sewerage District (w)
Marinette County Soil and Water Conservation Department (w)
Mead, Township of (w)
Menasha, Town of, Sanitary District No. 4 (w)
Menominee Indian Tribe of Wisconsin (w)
Muskego, City of (w)
Norway, Town of (w)
Oconomowoc Lake, Village of (w)
Okauchee Lake Management District (w)
Oneida Indian Tribe of Wisconsin (w)
Park Lake Management District (w)
Peshtigo, City of (w)
Potters Lake Rehabilitation and Protection District (w)
Powers Lake Management District (w)
Pretty Lake Management District (w)
Rock, County of, Public Works Department (w)
St. Germain, Town of (w)
Southeastern Wisconsin Regional Planning Commission (w)
Sparta, City of (w)
Stockbridge-Munsee Indians (w)
Summit, Town of (w)
Thorp, City of (w)
Troy, Town of (w)
University of Wisconsin Extension, Geological and Natural History Survey (n)
Upper Nemahbin Lake Management District (w)
Waupun, City of (w)
Whitewater-Rice Lake Management District (w)
Wind Lake Management District (w)
Wisconsin Department of—
- •Justice (w)
- •Natural Resources (w)
- •Transportation (w)

Wittenberg, Village of (w)
Wolf Lake Management District (w)

WYOMING

Cheyenne, City of (w)
Colorado State University (w)
Evanston, City of (w)
Freemont County Weed and Pest Division (w)
Midvale Irrigation District (w)
Sheridan Water Supply Board (w)
Shoshone Tribe (g)
Star Valley Conservation District (w)
Teton, County of (w)
Water Development Commission (w)
Water Resources Research Institute (w)
Wind River Environmental Quality Commission (w)
Wyoming Department of—
- •Agriculture (w)
- •Environmental Quality (w)
- •Game and Fish (w)
- •Highways (w)

Wyoming State Engineer (w)

Federal Cooperators

Central Intelligence Agency (g)

Department of Agriculture
Agricultural Research Service (w)
Forest Service (g,n,w)
Soil Conservation Service (n,w)

Department of the Air Force (w)
Aeronautical Systems Command (w)
Air Combat Command (w)
Air Education and Training Command (w)
Air Force Academy (w)
Headquarters, AFTAC/AC (g)
Hill Air Force Base (w)
Kirtland Air Force Base (w)
Luke Air Force Base (w)
MacDill Air Force Base (w)
Patrick Air Force Base (g)
Tyndall Air Force Base (w)
Vandenberg Air Force Base (w)
Warren Air Force Base (w)
Wright-Patterson Air Force Base (w)

Department of the Army (w)
Aberdeen Proving Ground (w)
Army Aviation Center (w)
Army Construction Engineering Research Lab (w)
Army Environmental Center (w)
Army Materiel Command (w)
Corps of Engineers (g,n,w)
Engineer Topographic Laboratory (g,w)
Fort Bliss Military Reservation (w)
Fort Bragg Military Reservation (w)
Rocky Mountain Arsenal (w)

Department of Commerce (w)
Bureau of the Census (n)
National Institute of Standards and Technology (g)
National Marine Fish Service (w)
National Ocean Service (n)
National Oceanic and Atmospheric Administration (g,n,w)
National Weather Service (w)

Department of Defense Agencies
Defense Advanced Research Projects Agency (g,n)
Defense Intelligence Agency (g)
Defense Mapping Agency (n)
Defense Nuclear Agency (g)
National Guard Bureau (w)

Department of Energy (g,n,w)
Alaska Power Administration (w)
Bonneville Power Administration (w)
Hanford Project (w)
Health and Environmental Research (g)
Idaho Falls Operations Office (g,w)
Nevada Operations Office (g,w)
Oak Ridge Operations Office (g,w)
Pittsburgh Energy Technology Center (g)
Rocky Flats Operations Office (w)
Sandia National Laboratories (g)
Savannah River Operations Office (w)
Test Operations Office, Las Vegas, Nevada (g)
Yucca Mountain Project (g, w)

Department of Health and Human Services
Indian Health Service (w)

Department of Housing and Urban Development (g)

Department of the Interior
Bureau of Indian Affairs (g,n,w)
Bureau of Land Management (g,n,w)
Bureau of Mines (n)
Bureau of Reclamation (g,n,w)
Minerals Management Service (g,w)
National Park Service (g,n,w)
Office of the Secretary (w)
U.S. Fish and Wildlife Service (n,w)

Department of Justice (g, w)

Department of the Navy (w)
Naval Command, Contract asd Ocean Surveillance Center (w)
Naval Facilities Engineering Command (g)—
- •Atlantic Division (w)
- •Chesapeake Division (w)

•Northern Division (w)
•Pacific Division (w)
•Southwest Division (w)
Naval Oceanographic Office (g)
Naval Research Laboratory (g)
Naval Security Group Activity (w)
Naval Surface Warfare Center (w)
Naval Weapons Center, China Lake (g)
Navy Engineering and Logistics Office (g)
Northwest Engineering Activity (w)
Office of Naval Research (g)
U.S. Marine Corps (w)

Department of State (g)
Agency for International Development (g,n,w)
Foreign and Nonforeign Governments (g)
Government of Saudi Arabia (g)
International Boundary and Water Commission, U.S. and Mexico (w)
International Joint Commission, U.S. and Canada (w)

Department of Transportation
Federal Aviation Administration (w)
Federal Highway Administration (w)

Environmental Protection Agency (g,n,w)
Corvallis Environmental Research Laboratory (w)
Hazardous Waste Management Division (g)
Office of Radiation Programs (g)
Region IV, Florida Keys (g)
Robert S. Kerr Environmental Research Lab (w)

Federal Emergency Management Agency (g,w)

Federal Power Commission (w)

Federal Energy Regulating Commission Licenses (w)

National Aeronautics and Space Administration (g,n,w)

National Science Foundation (g,n,w)

Nuclear Regulatory Commission (g, w)

Smithsonian Institution (g)

Swedish Nuclear Power Inspection (w)

Tennessee Valley Authority (n,w)

Veterans Administration (w)

Other Cooperators and Contributors

American Society for Photogrammetry and Remote Sensing (n)
Boy Scouts of America (n)

United Arab Emirates (w)

United Nations (g,w)
Inter-America Development Bank (g)
United Nations Development Program (n)
UNESCO (w)

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural and cultural resources. This includes fostering wise use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in Island Territories under U.S. administration.