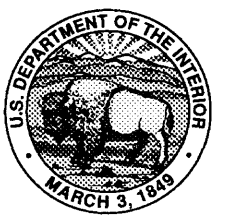
Activities of the Water Resources Division in Arizona, 1995–96

Compiled by JAMES R. MARIE, ELLEN K. VAN DE VANTER, and CAROLYN L. MOSS

U.S. GEOLOGICAL SURVEY
Open-File Report 95—772



Tucson, Arizona
1996

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

U.S. GEOLOGICAL SURVEY
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MESSAGE FROM THE DISTRICT CHIEF

The collection of hydrologic data and the investigation and assessment of the quantity, quality, and use of surface- and ground-water resources are major components of the mission of the Water Resources Division, U.S. Geological Survey. To accomplish this mission the Arizona District is organized into a district office in Tucson and field offices in Tempe, Flagstaff, and Yuma, Arizona. These offices are geographically located in the State to provide access and response to hydrologic events and to maintain liaison with cooperating State and Federal agencies. The Arizona District technical staff is organized into two major sections: (1) the Hydrologic Data Section, which maintains the systematic hydrologic-data programs for the State, and (2) the Hydrologic Investigations and Research Section, which investigates and assesses the quantity, quality, and use of the State's water resources.

The Hydrologic Data Section maintains a network of hydrologic data-collection sites and compiles hydrologic data collected from these sites for public distribution. These hydrologic data include records of (1) stage and discharge of principal river and tributaries; (2) chemistry and suspended-sediment concentration of selected rivers; (3) levels and quality of principal aquifers; and (4) surface- and ground-water use. Data from this network are compiled and entered in the Survey's National Water Information System data base, located in Reston, Virginia, and are published annually in the report series "Water Resources Data—Arizona." The Hydrologic Data Section has made substantial progress in developing a real-time hydrologic data base. Surface- and ground-water data at selected sites are transmitted to the Arizona District's central hydrologic data base at regular intervals using satellite telemetry. This information is accessible to scientists or water managers to assess current hydrologic conditions.

The Water Resources Division (WRD) will implement the National Water Information System-II (NWIS-II) during 1995. This data-base system will replace the data-base systems currently in use. NWIS-II will provide data-handling and data-storage procedures that are uniform across all disciplines of WRD, will serve as an archive for all data used in published products, will provide a national water data base and index, and will comply with industry software and data standards.

The investigation and assessment of the surface- and ground-water resources of Arizona is accomplished through a series of projects conducted by the Hydrologic Investigations and Research Section. Each project is managed by a designated project chief who is responsible for managing the investigative aspects of the project, maintaining a project budget, and providing public access to the findings of the project. Program emphasis for the Arizona District in 1995–96 is to provide timely, objective hydrologic information to Federal, Tribal, State, and local agencies regarding water-supply availability, water-source identification, and water-resource management. Programs are expected to grow in the Lower Colorado River region where a method of accounting for ground-water withdrawal from wells is being implemented by the Bureau of Reclamation. Native Americans in the State are working to understand and protect the water resources within their reservation boundaries. The District is working cooperatively with several Tribes to assist them in their efforts to manage their water resources.

The San Pedro and Verde River basins are rapidly growing in population and are particularly water-scarce regions of the State. Significant controversy exists between water users as to whether ground-water withdrawals are diminishing the flow of water in the adjacent rivers. Ground-water studies employing modeling and geochemical techniques are proposed for both the San Pedro and Verde River basins. Population growth and industrial expansion along the international border with Mexico is placing demands upon a limited water supply and this may be affecting the quality of ground and surface waters. Studies of transboundary aquifers and the movement of contaminated ground water are proposed to begin in FY 1995–96. Intensive pumping of ground water for irrigation and municipal use in Arizona continues to cause the land surface to subside in alluvial basins. The greatest measured land subsidence in the State of Arizona has occurred near Luke AFB west of Phoenix. Land subsidence has gained renewed attention as a geohydrologic hazard and more study of the processes and potential means of mitigation are expected.

Work will continue on the study of the effects of releases of water from Glen Canyon Dam through the Grand Canyon National Park. A large controlled release of water is planned during FY 1996 to determine the effects of the flow on the beaches and other sediment-transport processes in the canyon. This work is critical for the future management of Glen Canyon Dam and the preservation of Grand Canyon National Park.

Utilizing the energy and interests of the Arizona District staff, the Arizona District will continue to assist cooperating agencies and the public by providing accurate and timely hydrologic information. I look forward to continuing partnerships that will provide the basis for the management and beneficial use of Arizona's water resources.

Nick B. Melcher
District Chief
U.S. Geological Survey
Tucson, Arizona

OUTREACH INITIATIVE

As part of the U.S. Geological Survey outreach initiative, the Arizona District staff participates in community programs that serve to increase public understanding of the Earth Sciences. This participation includes an emphasis on information transfer using general-audience reports and presentations at symposiums and conferences, information release using videotapes and the Internet, and participation in local education and community functions. In response to the increasing public awareness and concern for water issues, it is imperative that the scientific findings and knowledge of the U.S. Geological Survey be the basis for the development of public policy. Commitment to the district outreach program will help to facilitate this goal for Arizona.

Outreach students learning about water-sampling and measuring techniques

CONTENTS

CONTENTS

FIGURES

CONVERSION FACTORS

Multiply	By	To obtain
inch (in.)	25.4	millimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
acre	4,047	square meter
square mile (mi^2)	2.590	square kilometer
acre-foot (acre-ft)	0.001233	cubic hectometer
cubic foot per second (ft^3/s	0.02832	cubic meter per second
gallon per minute (gal/min)	0.06308	liter per second
million gallons per day (Mgal/d)	0.04381	cubic meter per second

Fiscal Year and Water Year: Both comprise the 12-month period from October 1 through September 30 and are designated by the year in which that period ends (for example, Fiscal Year 1986 began October 1, 1985, and ended September 30, 1986).

ORIGIN OF THE U.S. GEOLOGICAL SURVEY

The U.S. Geological Survey (USGS) was established by an act of Congress on March 3, 1879, 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 national domain." An integral part of that original mission includes publishing and disseminating the earth-science information needed to understand, to plan the use of, and to manage the Nation's energy, land, mineral, and water resources.

Since 1879, the research and fact-finding role of the USGS has grown and been modified to meet the changing needs of the Nation it serves. As part of that evolution, the USGS has become the Federal Government's largest earth-science research agency, the Nation's largest civilian mapmaking agency, the primary source of data on the Nation's surface- and ground-water resources, and the employer of the largest number of professional earth scientists. Today's programs serve a diversity of needs and users. Programs include:

- Conducting detailed assessments of the energy and mineral potential of the Nation's land and offshore areas.
- Investigating and issuing warnings of earthquakes, volcanic eruptions, landslides, and other geologic and hydrologic hazards.
- Conducting research on the geologic structure of the Nation.
- Studying the geologic features, structure, processes, and history of the other planets of our solar system.
- Conducting topographic surveys of the Nation and preparing topographic and thematic maps and related cartographic products.
- Developing and producing digital cartographic data bases and products.
- Collecting data on a routine basis to determine the quantity, quality, and use of surface and ground water.
- Conducting water-resource appraisals in order to describe the consequences of alternative plans for developing land and water resources.
- Conducting research in hydraulics and hydrology and coordinating all Federal water-data acquisition.
- Using remotely sensed data to develop new cartographic, geologic, and hydrologic research techniques for natural-resources planning and management.
- Providing earth-science information through an extensive publications program and a network of public-access points.

Along with its continuing commitment to meet the growing and changing earth-science needs of the Nation, the USGS remains dedicated to its original mission to collect, analyze, interpret, publish, and disseminate information about the natural resources of the Nation—providing "Earth science in the public service."

BASIC MISSION AND PROGRAM OF THE WATER RESOURCES DIVISION

The mission of the Water Resources Division, which supports the overall mission of the U.S. Department of the Interior and the Geological Survey, is to provide the hydrologic information and understanding needed for the best use and management of the Nation's water resources for the benefit of the people of the United States.

The mission of the Division is accomplished through programs supported by the U.S. Geological Survey independent of, or in cooperation with, other Federal and non-Federal agencies. These programs include the following:

- Collecting, on a systematic basis, data needed for the continuing determination and evaluation of the quantity, quality, and use of the Nation's water resources.
- Conducting analytical and interpretive water-resource appraisals of the occurrence, availability, and the physical, chemical, and biological characteristics of surface water and ground water.
- Conducting basic problem-oriented research in hydrology to improve the scientific basis for investigations and measurement techniques, and to predict quantitatively the response of hydrologic systems to stress.
- Disseminating water data and the results of investigations and research through reports, maps, computerized information services, and other forms of public releases.
- Coordinating the activities of Federal agencies in the acquisition of water data for streams, lakes, reservoirs, estuaries, and ground water.
- Providing scientific and technical assistance in hydrology to other Federal, State, and local agencies; to licensees of the Federal Power Commission; and to international agencies on behalf of the Department of State.

ARIZONA DISTRICT

Water-resources activities of the U.S. Geological Survey in Arizona consist of collecting water-resources data and conducting interpretive hydrologic investigations and research. The water-resources data and the results of the interpretive investigations and research are published or released by the U.S. Geological Survey or by cooperating agencies. This report describes the data-collection activities and water-resources investigations in Arizona for fiscal years 1995–96 (October 1, 1994, to September 30, 1996). Reports published in fiscal years 1992–94 are included in the back of this report to provide a complete list since the last activities report, which included reports published in fiscal years 1984–91.

Organization

The Arizona District, which is headquartered in Tucson, is under the direction of the District Chief, Nick Melcher. Hydrologic investigations and data-collection activities are conducted from offices in Tucson, Tempe, Flagstaff, and Yuma. At the end of fiscal year 1994, the Arizona District employed a total of about 100 persons (89 full time and 11 other than full time)—15 in Flagstaff, 21 in Tempe, 57 in Tucson, and 7 in Yuma. The location of Water Resources Division offices and the organization of the Arizona District are shown on figure 1. Inquiries regarding projects described in this report may be directed to one of the offices listed in figure 1.

Funding and Cooperating Agencies

The hydrologic investigations and data-collection efforts in the Arizona District are supported by services and joint funding provided by State and local agencies on a 50-50 basis with Federal monies (cooperative program); by funds transferred from other Federal agencies (OFA), such as the U.S. Army Corps of Engineers (OFA program); and by funds appropriated directly to the U.S. Geological Survey (Federal program). In fiscal year 1995, the financial support for these programs in Arizona was about $7.8 million, which was distributed as shown in figure 2. Agencies that supported water-resources investigations through cooperative agreements are listed below:

Local and State Agencies

Arizona Department of Environmental Quality
Arizona Department of Water Resources
Arizona Game and Fish Department
Arizona Municipal Water Users' Association
Central Arizona Water Conservation District
City of Flagstaff
City of Safford
City of Tucson
Cochise County Flood Control District
Flood Control District of Maricopa County
Gila Valley Irrigation District
Gila Valley Water Commission
The Hopi Tribe
The Hualapai Tribe
The Havasupai Tribe
The Navajo Nation
Metro Water District
Metropolitan Water District of Southern California
Pima County Board of Supervisors
Salt River Valley Water Users' Association
San Carlos Irrigation and Drainage District
Show Low Irrigation Company
Tohono O'Odham Nation
University of Arizona
The Yavapai Tribe

Federal Agencies

Federal Energy Resource Commission (Arizona Public Service and Phelps Dodge Corporation)
U.S. Department of Agriculture
    Forest Service
U.S. Department of the Interior
    Bureau of Indian Affairs
    Bureau of Land Management
    Bureau of Reclamation
    Fish and Wildlife Service
    National Park Service
    Office of the Secretary
U.S. Department of Defense
    U.S. Army Corps of Engineers
    U.S. Air Force
    U.S. Army

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375 South Euclid Avenue
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520 670–6671

Office for Northern Arizona Program
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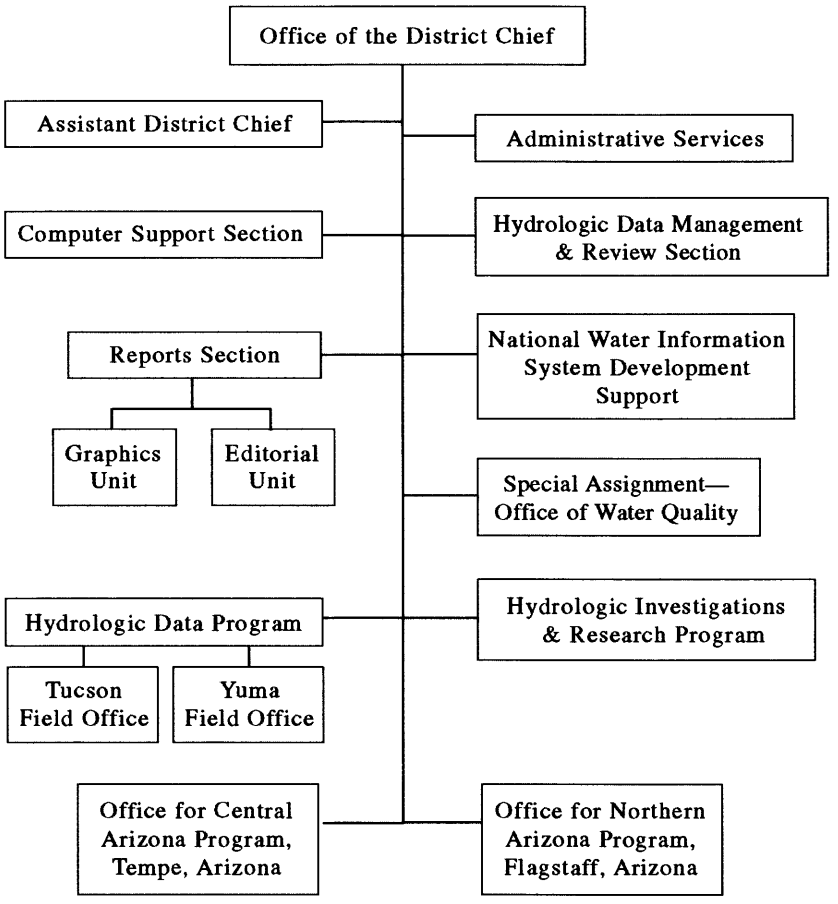
Flagstaff, Arizona 86001
520 556–7136

Office for Central Arizona Program
1545 West University Drive
Tempe, Arizona 85281
602 379–3086

Yuma Field Office
1940 South Third Avenue
Yuma, Arizona 85364
520 782–6024



November 1995

Figure 1. Location of Water Resources Division offices and organization of the Arizona District, 1995.

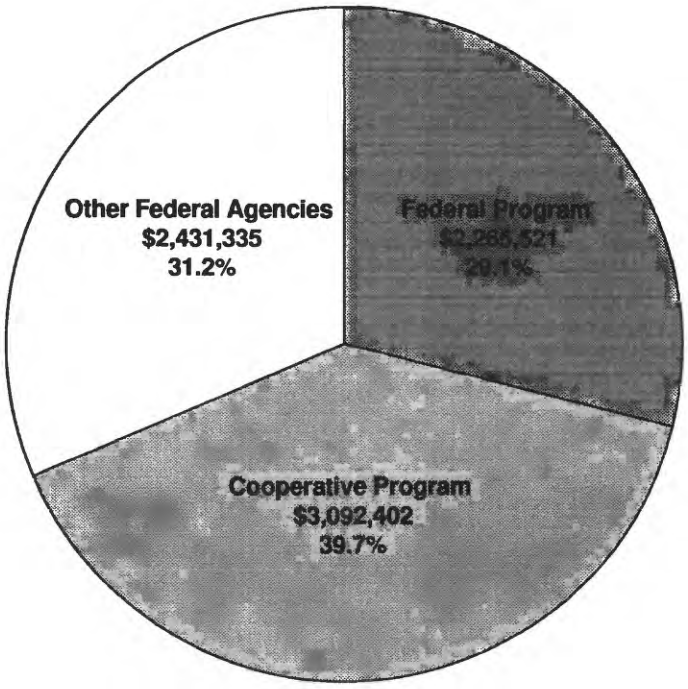


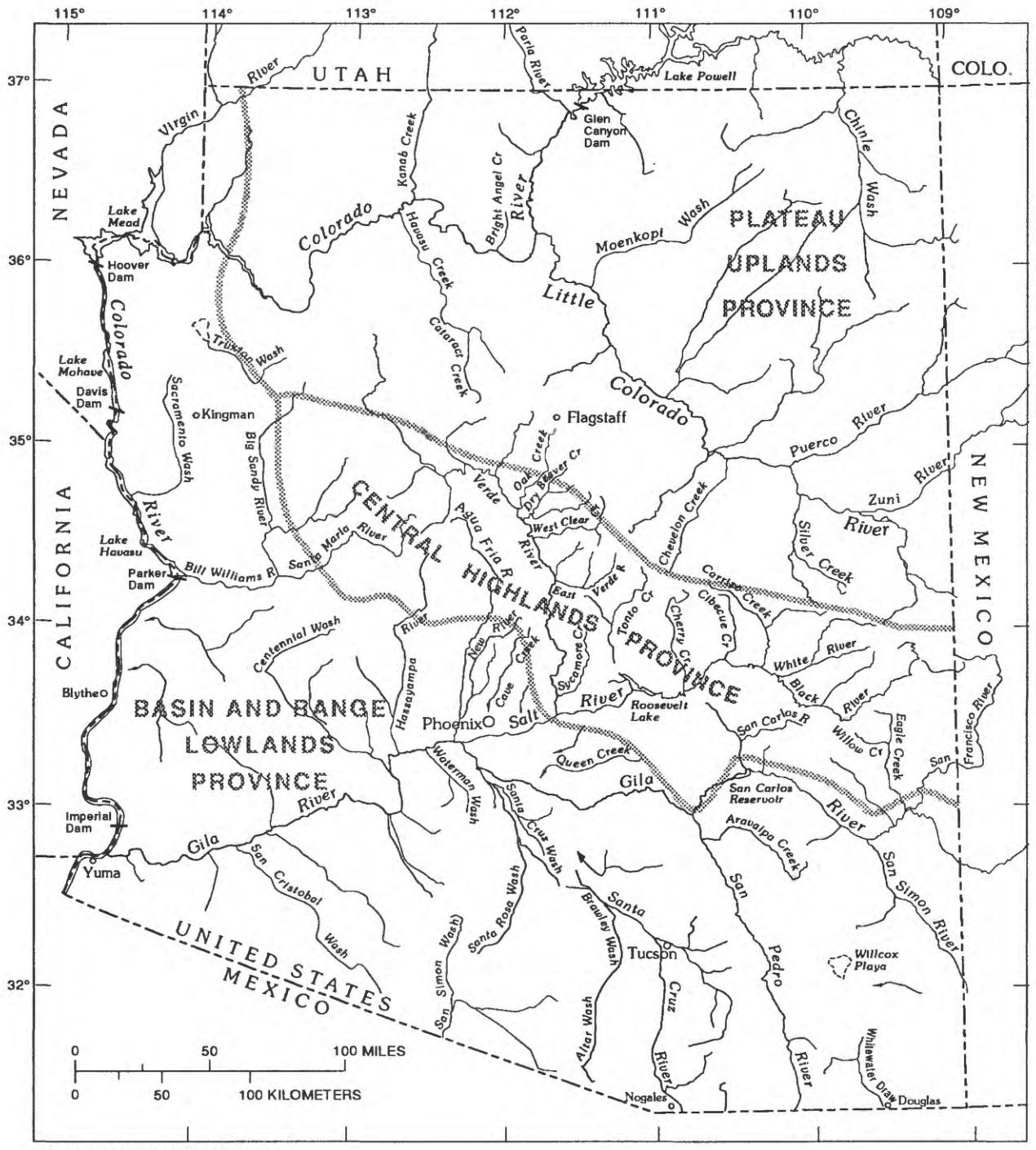
Figure 2. Distribution of funding of the U.S. Geological Survey in Arizona, fiscal year 1995.

WATER CONDITIONS IN ARIZONA

The two major physiographic provinces of the southwestern United States, the Colorado Plateau province and the Basin and Range province, are separated across much of the State by the mountainous region to the south of the Mogollon Rim. The separated physiographic provinces form three distinct water provinces—the Plateau uplands province in the northern part of the State and the Central highlands province and the Basin and Range lowlands province in the southern and southwestern parts of the State (fig. 3). The Plateau uplands water province has many arid rock benches separated by slopes and valleys. Annual precipitation ranges from 10 to 25 inches. The Central highlands water province is bounded on the north by the Mogollon Rim escarpment and consists of rugged mountains. Annual precipitation ranges from about 15 to 30 inches. The Basin and Range lowlands water province is characterized by arid base-level plains separated by steep high mountains. Annual precipitation in the basins ranges from 4 to 12 inches.

Surface Water

The Colorado River enters Arizona from the north and flows westward and southward to the southwest corner of the State. Nearly all streams in Arizona are tributary to the Colorado, although the quantity of tributary inflow is small because of the intensive use and storage within the State. Major tributaries to the Colorado River that drain large parts of Arizona are the Little Colorado, Bill Williams, and Gila Rivers. A few small streams drain to Mexico. Streamflow data are collected at a network of streamflow-gaging stations (figs. 4, 5, and 6).

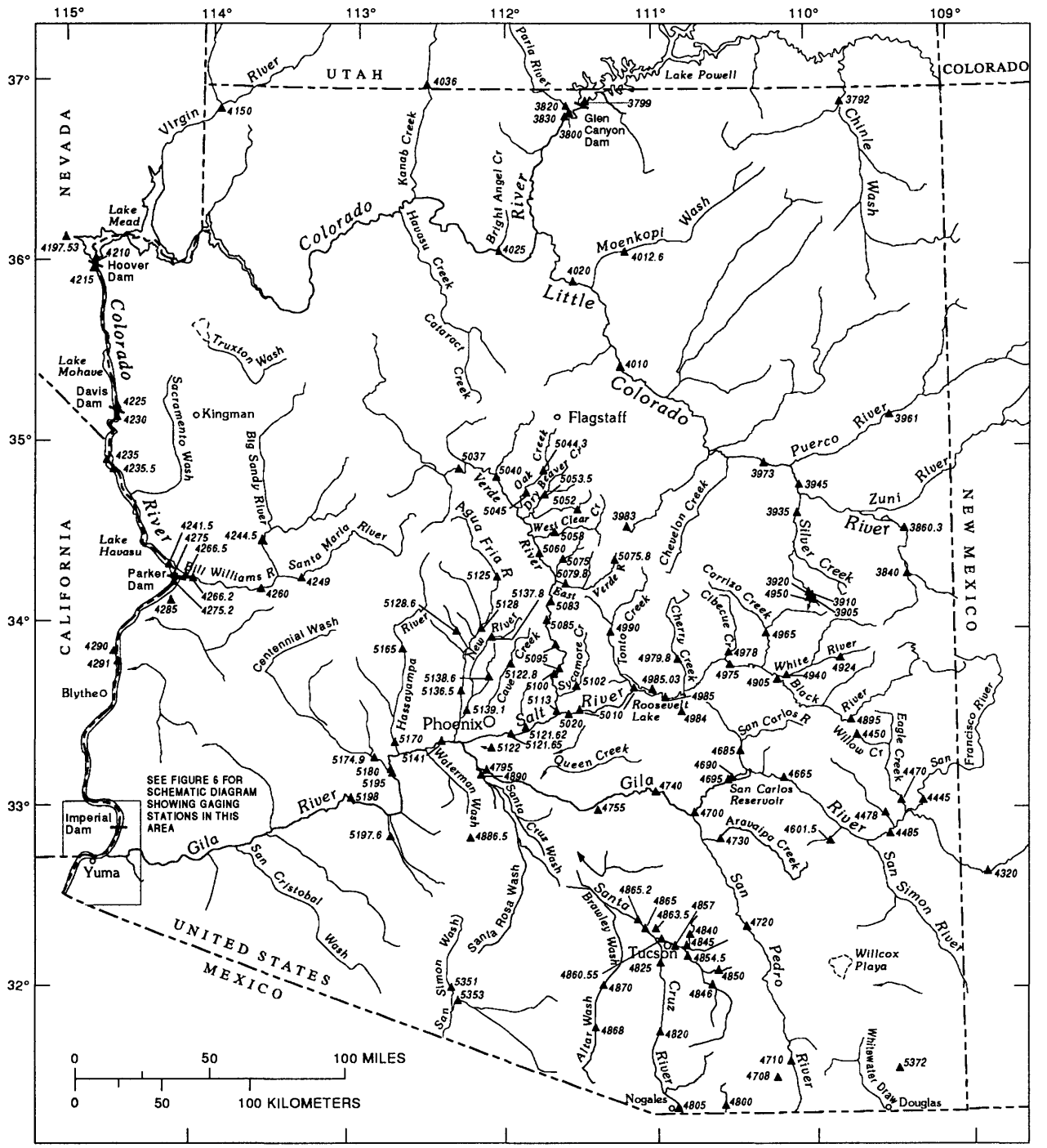


Base from U.S. Geological Survey
State base maps, 1:500,000,
Arizona, 1974; Nevada, 1965;
New Mexico, 1965; and Utah, 1959

EXPLANATION

BOUNDARY OF WATER PROVINCE

Figure 3. Water provinces of Arizona.

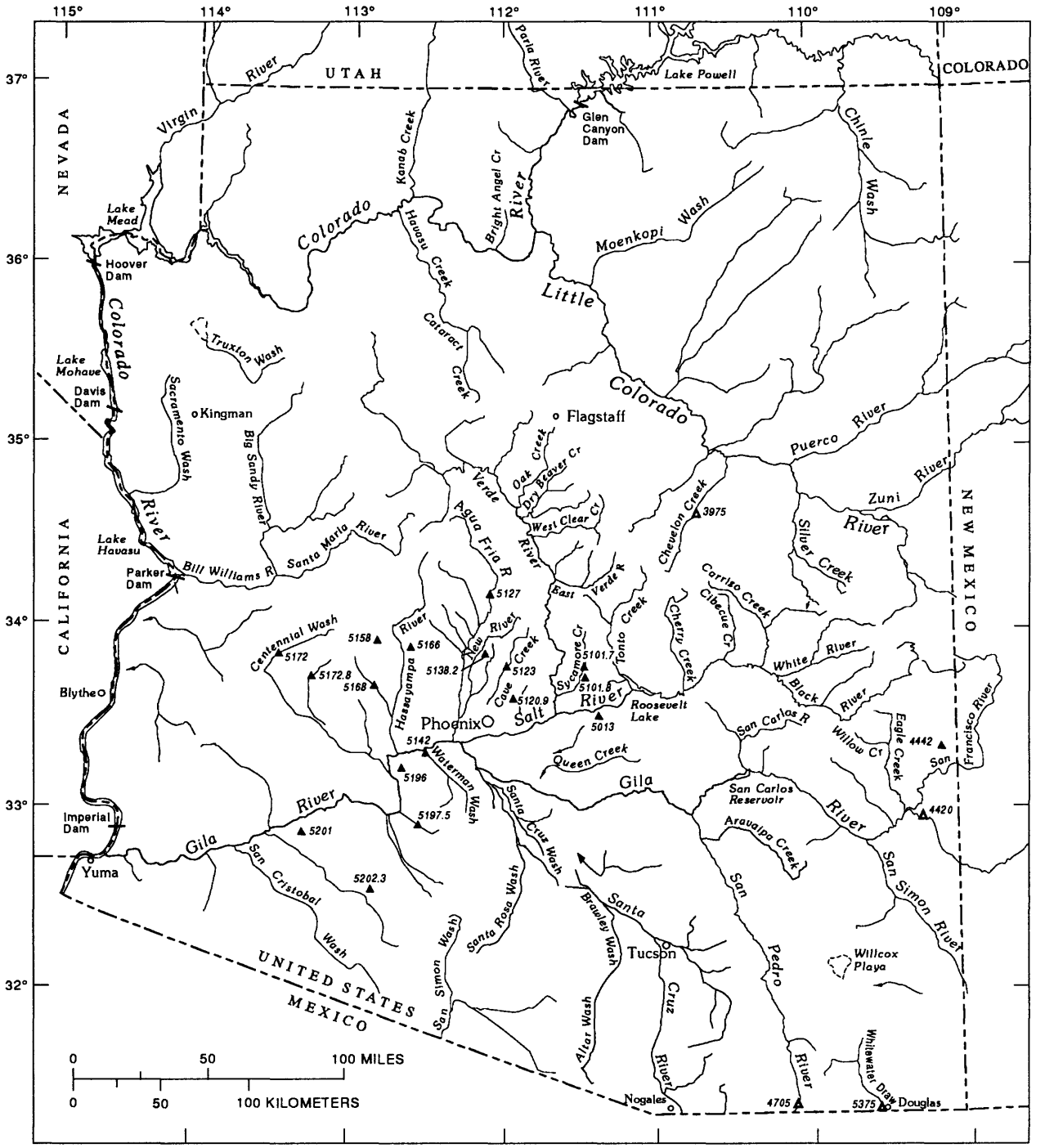


Base from U.S. Geological Survey
State base maps, 1:500,000,
Arizona, 1974; Nevada, 1965;
New Mexico, 1965; and Utah, 1959

EXPLANATION

▲4665 STREAMFLOW-GAGING STATION AND ABBREVIATED NUMBER—Complete station number is 09466500

Figure 4. Streamflow-gaging stations, March 1995.



Base from U.S. Geological Survey
State base maps, 1:500,000,
Arizona, 1974; Nevada, 1965;
New Mexico, 1965; and Utah, 1959

EXPLANATION

PARTIAL-RECORD GAGING STATION AND ABBREVIATED NUMBER—Complete station number is 09513600

▲5172 STATION EQUIPPED WITH CREST-STAGE GAGE ONLY

▲3975 STATION EQUIPPED WITH CREST-STAGE GAGE ONLY AND FLOOD-HYDROGRAPH RECORDER

Figure 5. Partial-record streamflow-gaging stations, March 1995.

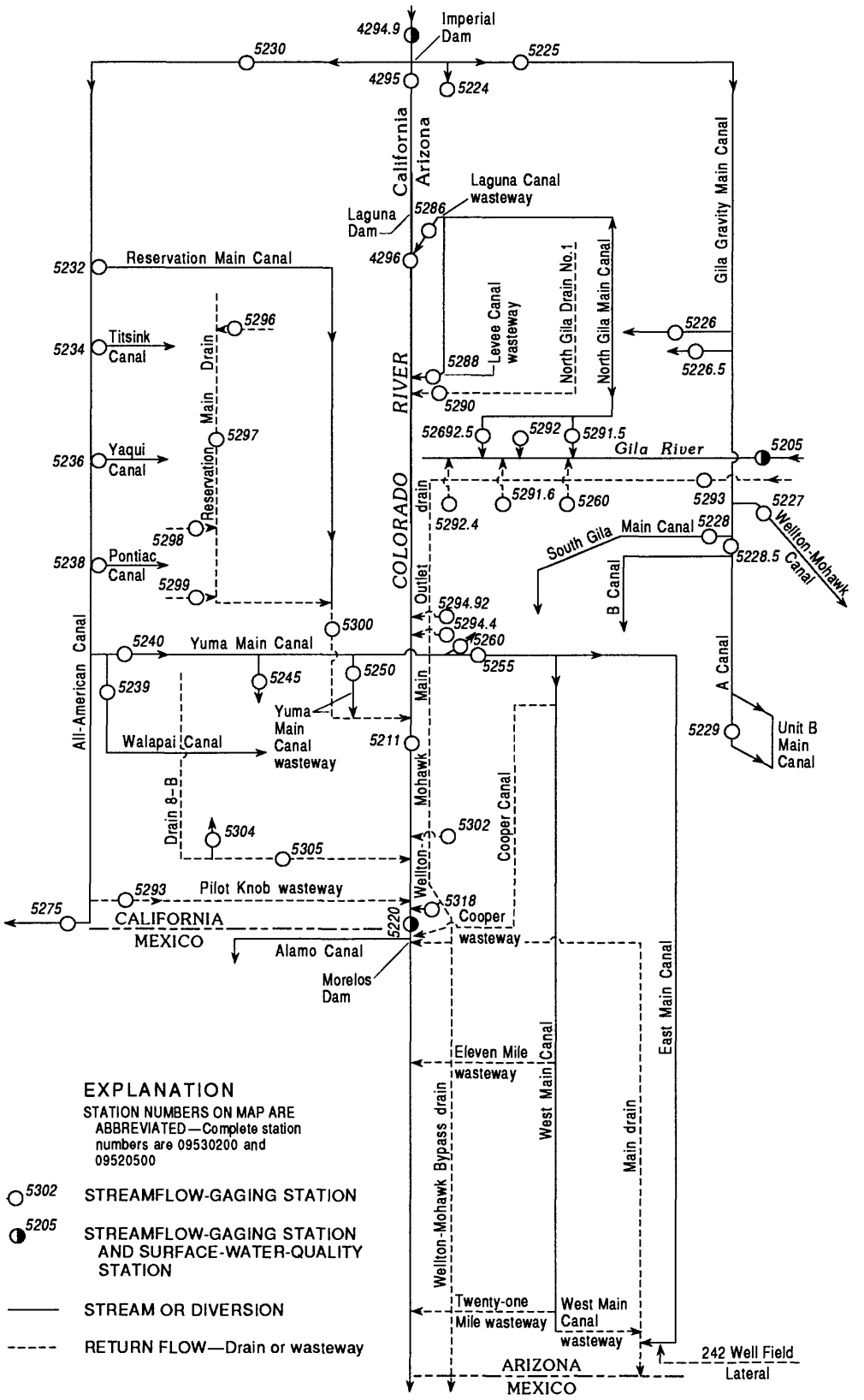


Figure 6. Streamflow-gaging stations and surface-water-quality stations on streams, diversions, and return flows between Imperial Dam and the southerly international boundary.

Runoff patterns in Arizona vary greatly. In desert areas of the Plateau uplands water province and the Basin and Range lowlands water province, average annual runoff is less than 0.1 inch. In the mountainous parts of these provinces and in most of the Central highlands water province, annual runoff is as much as 5 inches. Runoff from perennial streams in the Central highlands is collected in storage reservoirs that provide water for use in the Basin and Range lowlands. Some runoff infiltrates and recharges the ground-water reservoirs. The quantity of monthly runoff for water year 1994 compared with median monthly runoff for water years 1951–80 for three representative gaging stations is shown in figure 7.

Except for the Colorado River, few streams in the Plateau uplands water province are perennial. In the Central highlands water province, the principal stream is the Gila River, which has its headwaters in New Mexico. The Salt, Verde, and Aqua Fria Rivers originate in the Central highlands and are important tributaries to the Gila River. In the deserts of the Basin and Range lowlands water province, few streams are perennial. Major agricultural areas and the homes of seven of every eight Arizonans are in this province; the economy depends on ground water and water from surface storage reservoirs. Three reservoirs in the Basin and Range lowlands are provided with runoff from perennial streams in the Central highlands.

Ground Water

The Basin and Range lowlands province is the most highly developed of the three water provinces. In 1990 about 3.2 million acre-feet of ground water was withdrawn in the province, which was more than 94 percent of the total ground-water withdrawal in the State. In general, most water levels declined significantly during the 1950's through the 1970's when ground-water withdrawal was the greatest. Since the mid-1970's, however, ground-water withdrawal has decreased and the rate of water-level declines has been reduced, and in some areas, water levels are rising. The Central highlands province is the transition zone between the other two provinces and is the smallest. Only a few thousand acres of land is cultivated and the quantity of ground water withdrawn has not resulted in notable water-level declines. In 1990, about 87,000 acre-feet of water was withdrawn in the province. Annual ground-water withdrawals in this province are generally increasing and reached an all time high of 92,000 acre-ft in 1989. In the Plateau uplands province, ground-water development is small compared with that in the Basin and Range lowlands province. Ground water is used mainly by scattered farms and homesites, industrial and utility sites, and a few population centers. In 1990, about 106,000 acre-feet of water was withdrawn. Annual ground-water withdrawals in this province are generally increasing and reached an all time high of 112,000 acre-ft in 1989.

Quality of Water

Many rivers in Arizona provide water suitable for most uses, although human activities have adversely affected the quality of surface water in parts of the State. In 1994, surface-water-quality data were collected at 45 sites (fig. 8). Hydrologic modifications in the form of dams, reservoirs, diversion canals, vegetation removal, sand and gravel mining, and irrigation return flows have had a significant negative effect on native fish and wildlife in Arizona and

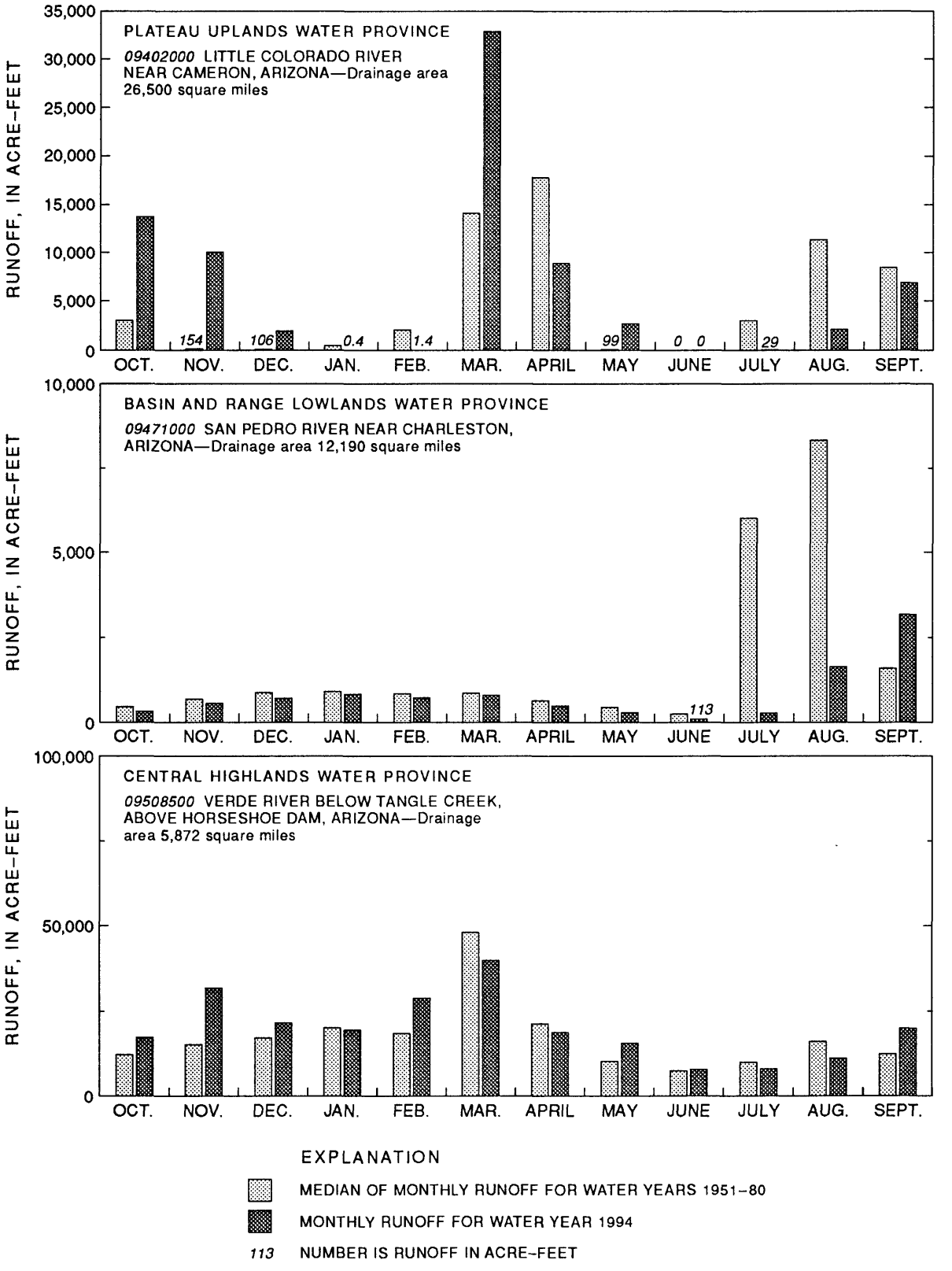
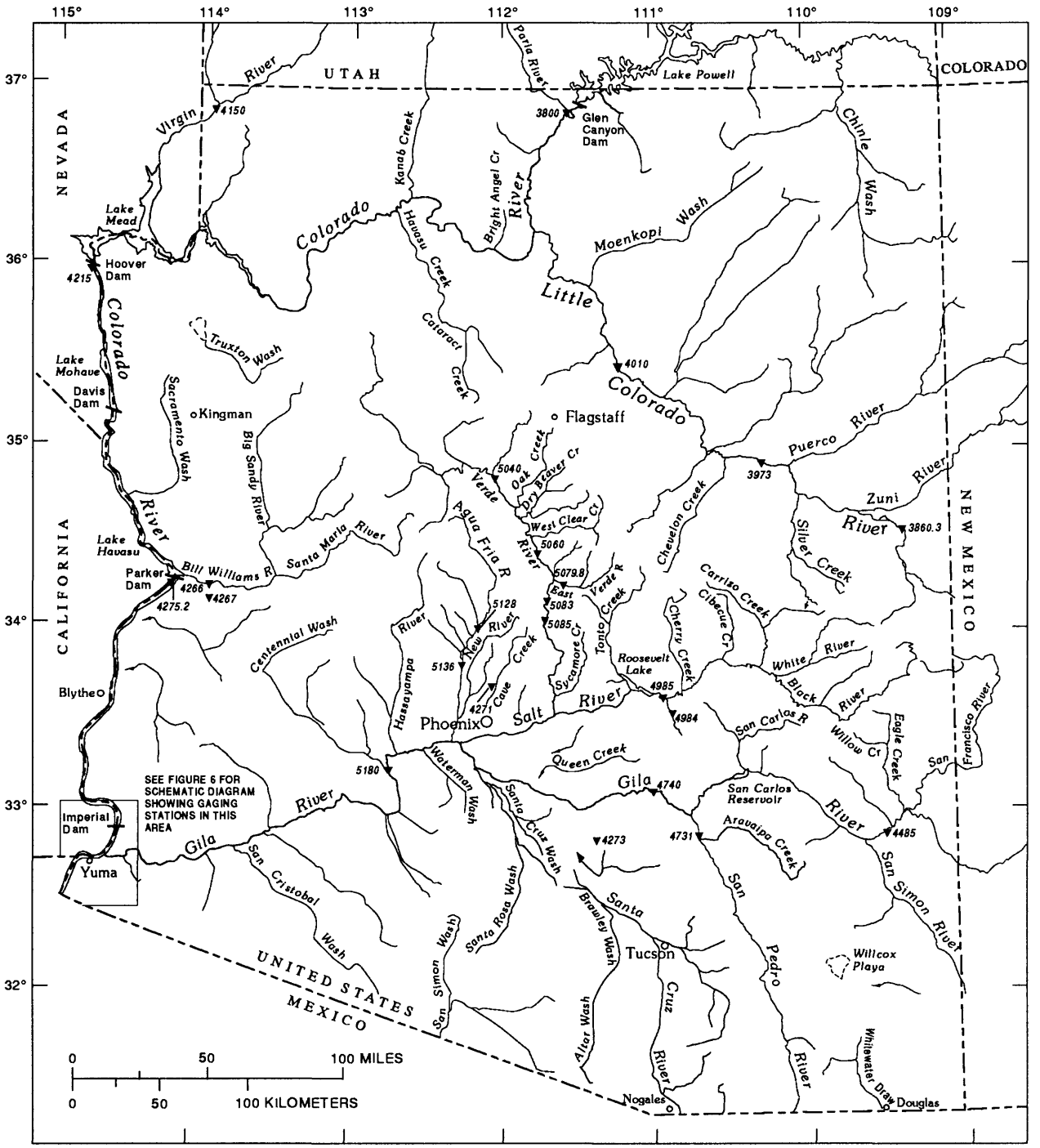


Figure 7. Runoff during water year 1994 compared with median runoff for water years 1951–80 for three representative streamflow-gaging stations.



Base from U.S. Geological Survey
State base maps, 1:500,000,
Arizona, 1974; Nevada, 1965;
New Mexico, 1965; and Utah, 1959

EXPLANATION

5136▼ WATER-QUALITY STATION AND ABBREVIATED NUMBER—Complete station number is 09513600

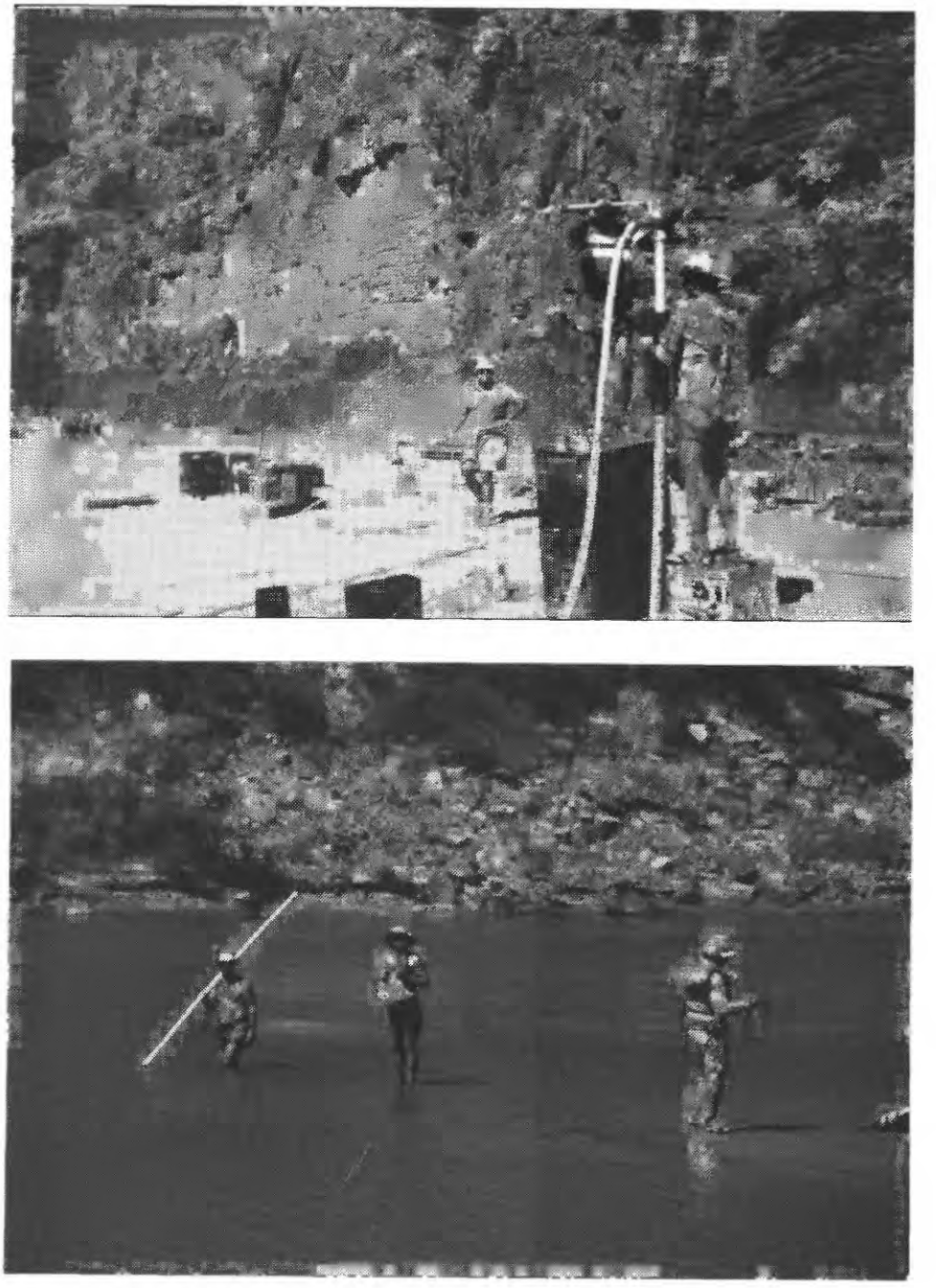
Figure 8. Surface-water-quality stations, March 1995.

directly impair water quality. Livestock grazing, mining activities, intense recreational use, and urbanization have also negatively affected stream quality.

Quality of the ground water is a major concern because ground water is the principal source for public supply. Most of the ground water is of suitable quality for human consumption and most other uses, although ground-water-quality problems exist locally at several locations throughout the State. Ground-water-quality problems attributed to anthropogenic and naturally occurring contamination can be found throughout Arizona. In some areas, changes in ground-water quality are caused by (1) recirculation of salts in irrigation water, (2) leachates from mining operations, (3) disposal of toxic wastes, (4) leaking underground storage tanks, and (5) leachates from landfills.

Water Use

Water-use patterns in Arizona are dominated primarily by agriculture and secondarily by rapidly growing urban population centers in Maricopa and Pima Counties. Almost all field and orchard crops are irrigated because the climate is semiarid and precipitation is too little and erratic to be useful for growing crops. Land irrigated by surface water is concentrated in the valleys and basins near the Colorado, Gila, Salt, and Verde (Yavapai County) Rivers. Land irrigated by ground water is mainly in the alluvial basins in the southern and the western parts of the State.



Monitoring beach erosion and sediment movement,
Colorado River in the Grand Canyon.

PROJECTS FUNDED IN FISCAL YEARS 1995–96

Monitoring stream-flow in Iron Springs basin.

Effects of flooding during February 1993, Havasu Creek.

Surface-Water Stations *(AZ001)*

Location: Statewide (see figure 4)

Project Chief: Christopher F. Smith

Period of Project: Continuous since 1912

Cooperating Agencies: Arizona Department of Environmental Quality, Arizona Department of Water Resources, City of Tucson, Flood Control District of Maricopa County, Gila Valley Irrigation District, Maricopa Water District, Metropolitan Water District of Southern California, Pima County Flood Control District, Salt River Valley Water Users' Association, Show Low Irrigation Company, Bureau of Land Management, Bureau of Reclamation, Fish and Wildlife Service, National Park Service, Corps of Engineers, Forest Service, International Boundary and Water Commission, Federal Power Commission, and Arizona Public Service Co.

Problem: Surface-water runoff is highly variable, both areally and seasonally, throughout the State. Information is needed for purposes of hydrologic surveillance, planning, design, hazard warning, and management. Monitoring of runoff is essential to water-related fields such as water supply, hydroelectric power, flood control, irrigation, bridge and culvert design, wildlife management, pollution abatement, flood-plain management, and water-resources development. An appropriate data base is necessary to provide this information.

Objectives: Maintain a network of surface-water stations to collect streamflow data needed for (1) assessment of surface-water resources; (2) operating reservoirs for power, flood control, and irrigation; (3) flow forecasting; (4) monitoring of flow for instream-use requirements; (5) water-quality estimates; (6) waste disposal and pollution control; (7) compact and legal requirements; and (8) defining statistical streamflow characteristics needed for research, planning, and design of dams, bridges, culverts, canals, flood-management projects, and ground-water-recharge facilities.

Approach: Standard U.S. Geological Survey methods are used to measure and record stages and discharges of streams and stages and contents of lakes and reservoirs. Frequency of data collection is determined by the principal purpose of each site.

Progress and Significant Results, FY1994: Surface-water data were collected and compiled for publication for 229 active sites of which 174 are continuous streamflow stations.

Plans for Fiscal Year 1995: Statewide data collection and review will continue for the 229 active sites.

Reports:

Boner, F.C., Konieczki, A.D., and Davis, R.G., 1991, Water resources data, Arizona, water year 1990: U.S. Geological Survey Water Data Report AZ–90–1, 381 p.

Boner, F.C., Davis, R.G., and Duet, N.R., 1992, Water resources data for Arizona, water year 1991: U.S. Geological Survey Water Data Report AZ–91–1, 411 p.

Smith, C.F., Boner, F.C., Davis, R.G., Duet, N.R., and Rigas, P.D., 1993, Water resources data for Arizona, water year 1992: U.S. Geological Survey Water Data Report AZ–92–1, 360 p.

Smith, C.F., Rigas, P.D., Ham, L.K., Duet, N.R., and Anning, D.W., 1993, Water resources data for Arizona, water year 1993: U.S. Geological Survey Water Data Report AZ-93–1, 378 p

Spicer, L.M., and Van De Vanter, E.K., compilers, 1993, Activities of the Water Resources Division in Arizona, 1986–91: U.S. Geological Survey Open-File Report 93–165, 144 p.

Ground-Water Stations *(AZ002)*

Location: Statewide

Project Chief: Norbert R. Duet, Jr.

Period of Project: Continuous since 1939

Cooperating Agency: Arizona Department of Water Resources

Problem: Long-term water-level records are needed to evaluate the effects of climatic variations on the recharge to and discharge from the ground-water systems, provide a data base from which to measure the effects of development, assist in the prediction of future supplies, and provide data for management of the resource.

Objectives: (1) Collect ground-water-level data and provide a long-term data base that can be used to monitor the general response of the hydrologic system to natural and man-made stresses. (2) Provide a data base against which the short-term records acquired in areal studies can be analyzed. The analysis must provide an assessment of the ground-water resource, allow prediction of future conditions, and provide the data base necessary for management of the resource.

Approach: The USGS and the Arizona Department of Water Resources (ADWR) jointly measure and maintain a Statewide observation-well network. In 1990, ADWR expanded their role in the operation of the observation-well network. The data are exchanged between agencies. Each year, ADWR conducts investigations in several ground-water areas. The studies include well inventories, water-level measurements, and water-quality samples. The results of the studies are published in the State's Hydrologic Map Series Reports (HMS), which typically show depth to water, change in water levels, altitude of the water level, and quality of water.

Progress and Significant Results, Fiscal Year 1994: Between 1991 and 1995, ADWR has maintained the leading role in collection of ground-water data. ADWR presently has a monitoring network of approximately 1,200 ground-water data-collection sites. ADWR maintains the responsibility for ground-water basin studies and has published four map reports (HMS) between 1992 and 1994. Ground-water levels for selected sites were published in the USGS "Water Resources Data Reports for 1990, 1991, 1992, and 1993." The "Annual Summary of Ground-Water Conditions" also was published for 1987–90 (Anning and Duet, 1994).

Plans for Fiscal Year 1995: Minimal data collection, review, and entry into GWSI will continue.

Reports:

Anning, D.W., and Duet, N.R., 1994, Summary of ground-water conditions in Arizona, 1987-1990: U.S. Geological Survey Open-File Report 94–476, 2 sheets.

Konieczki, A.D., and Wilson, R.P., 1992, Annual summary of ground-water conditions in Arizona, spring 1986 to spring 1987: U.S. Geological Survey Open-File Report 92–54, 2 sheets.

MacNish, R.D., 1992, Scientific challenges in managing the Colorado River, *in* Jones, M.E., and Laenen, Antonius, eds., Interdisciplinary Approaches in Hydrology and Hydrogeology: American Institute of Hydrology, Annual Meeting, October 1992, p. 323

MacNish, R.D., Smith, C.F., and Goddard, K.E., 1993, Floods in Arizona, January 1993: U.S. Geological Survey Open-File Report 93–54, Water Fact Sheet, 2 p.

Phillips, J.V., and Hjalmarson, H.W., 1994, Floodflow effects on riparian vegetation in Arizona, *in* Cotroneo, G.V., and Rumer, R.R., eds., Hydraulic Engineering'94, v. 1, Proceedings of the 1994 Conference: American Society of Civil Engineers, p. 707–710.

Wilson, R.P., 1991, Summary of ground-water conditions in Arizona 1985-86: U.S. Geological Survey Water-Resources Investigations Report 90–4179, 2 sheets.

Ground-water level recording sites.

Quality of Water Stations *(AZ003)*

Location: Statewide (see figure 8)

Project Chief: Chris Smith

Period of Project: Continuous since 1969

Cooperating Agencies: Arizona Department of Environmental Quality, Bureau of Indian Affairs, Bureau of Reclamation, Army Corps of Engineers, Central Arizona Water Conservation District, Salt River Valley Water User's Association.

Problem: Water-resource planning and water-quality assessment require a nationwide base level of standardized information. For intelligent planning and realistic assessment of the water resource, the chemical, biological, and physical quality of the surface water of Arizona must be defined and monitored.

Objectives: Provide nationally consistent water-quality data needed by government agencies and other groups involved in natural or regional water-quality planning and management. This includes data necessary for Federal management of interstate and international waters.

Approach: A network of surface-water/water-quality stations is operated to provide average chemical concentrations, loads, and time trends as required by planning and management agencies.

Progress and Significant Results, Fiscal Year 1994: The sampling and analytical program was continued throughout the year. Data from this program are entered into the National Water Information System (NWIS), which update the National Water Data Storage and Retrieval System (WATSTORE) on a monthly basis. Data from this project are included in the annual data report.

Plans for Fiscal Year 1995: Continue the water-quality monitoring program with the following changes: One site will be added, nine sites will be discontinued, and the sampling frequency for four sites will be decreased from monthly to bimonthly. Program changes are due to decreased matching funds and modified cooperator priorities.

Sediment Stations *(AZ004)*

Location: Statewide

Project Chief: Gregory G. Fisk

Period of Project: Continuous since 1925

Cooperating Agencies: Bureau of Reclamation, Corps of Engineers, Flood Control District of Maricopa County

Problem: Water-resources planning and water-quality assessment require a nationwide data base of standardized information. Erosion, transport, and deposition of sediment can have major effects on streams, lakes, and reservoirs, and knowledge of sediment transport is essential for appropriate planning and assessment. To obtain the necessary information, bed material and suspended-sediment transport must be monitored on a regular basis on a wide variety of streams throughout the country.

Objective: Provide data on bed material and suspended-sediment transport in streams in the arid Southwest to a national data base for use in broad Federal and State planning and action programs and for Federal management of interstate and coastal waters.

Approach: Bed-material and suspended-sediment samples are collected at regular intervals at a network of stations in Arizona, and the data are entered into the national data base. Bed-material samples are collected from one to four times per year. Suspended-sediment samples are collected from 6 to 12 times per year during regular site visits or on a storm basis by automatic sampler.

Progress and Significant Results, Fiscal Year 1994: Suspended-sediment and bed-material samples were collected during regular site visits at gaging stations 09473100, San Pedro River below Aravaipa Creek near Mammoth, and 09474000, Gila River at Kelvin. Suspended-sediment samples were collected by automatic sampler at gaging stations: 09397300, Little Colorado River near Joseph City; 09402000, Little Colorado River near Cameron; 09401000, Little Colorado River at Grand Falls.

Plans for Fiscal Year 1995: Collection of data will continue at five of the six sites listed above. Sampling for the Little Colorado River at Grand Falls was discontinued, September 30, 1994. Instantaneous suspended-sediment concentration and bed-material grain-size distribution for the San Pedro and Gila River sites will be published for water year 1994. Instantaneous

suspended-sediment concentrations for the Leroux Wash site will be published for water years 1986–93. Daily suspended-sediment discharge for days on which the instantaneous discharge exceeded 500 cubic feet per second at the Little Colorado River near Joseph City site will be published for water years 1989–95. Daily suspended-sediment discharge for the gaging station on the Little Colorado River at Grand Falls will be published for water years 1989–94 for days on which the instantaneous discharge exceeds 200 cubic feet per second. Daily suspended-sediment discharge and suspended-sand discharge will be published for the gaging stations on Little Colorado River near Cameron when the mean daily discharge exceeds 20 cubic feet per second and Paria River at Lees Ferry when the discharge exceeds 30 cubic feet per second for 1990 to 1995 water years.

Water Use *(AZ007)*

Location: Statewide

Project Chief: David N. Anning

Period of Project: Continuous since June 1979

Cooperating Agency: Arizona Department of Water Resources

Problem: Water-use data are presently collected by several local, State, and Federal agencies. Water use refers to the quantity of water withdrawn and used for agricultural, industrial, power-generation, municipal, or domestic purposes and returned to the ground-water or surface-water system. A comprehensive water-use data base was needed to provide (1) data for planners or governmental agencies that need generalized information relating water use to irrigated acreage, ore production, municipal use, and other uses; (2) data with areal and temporal detail that can be used to model and evaluate management alternatives; and (3) easy accessibility.

Objectives: Provide information on water-use rates and consumptive use by area for specific time periods so decisions regarding changes in delivery systems and associated economic studies can be realistically made. Provide a data base of ground-water withdrawals that can be used to evaluate management alternatives through modeling techniques. Provide a data base that is easily accessible by authorized agencies and which, at the same time, will honor and protect the privacy of individual water users. The data base will be expandable to accommodate new development and will permit the removal of out-of-date or abandoned points of withdrawal.

Approach: Data on ground-water withdrawals and surface-water diversions are obtained directly from companies or other government agencies wherever possible. Where flow meters are not in use, crop acreages and climate data will be obtained to compute withdrawal. A shift in emphasis was made in 1984 when flow meters, required as a result of the new State ground-water law, were put in use in the State-designated Active Management Areas.

Progress and Significant Results, Fiscal Year 1994: Estimates of ground-water withdrawals by ground-water areas for 1987–90 were completed and will be published in "Summary of ground-water conditions in Arizona, 1987–90." During the 1980's, ground-water withdrawals decreased in the Basin and Range Lowlands water province and increased in the Central Highlands and Plateau Uplands water provinces. Ground-water withdrawals were estimated using satellite

images and empirical crop irrigation requirement rates. Crops in Cochise, Graham, and Greenlee Counties were mapped to ground-truth Landsat TM satellite images.

Plans for Fiscal Year 1995: Continue to obtain data on ground-water withdrawals and surface-water diversions directly from users of large quantities of water whenever possible. The annual data will be compiled and published. Continue collecting metered surface-water and ground-water withdrawals for 1991–94 wherever possible. Compile these data using the ground-water basin boundaries defined by the Arizona Department of Water Resources. Estimate nonmetered withdrawals for irrigation using Landsat TM and NOAA AVHRR satellite images, county crop acreages, and empirical crop irrigation requirements. Irrigation ground-water withdrawals will be estimated as being equal to the residual of irrigation water demand minus irrigation surface-water diversions. Compare results from different estimation techniques to metered data, and utilize the most feasible method for estimating nonmetered irrigation ground-water withdrawals for 1991–94.

Reports:

Wilson, R.P., 1991, Summary of ground-water conditions in Arizona 1985-86: U.S. Geological Survey Water-Resources Investigations Report 90–4179, 2 sheets.

Special Site Studies for Other Federal Agencies *(AZ023)*

Location: Statewide

Project Chief: Nick B. Melcher

Period of Project: Continuous since 1971

Cooperating Agencies: Other Federal agencies

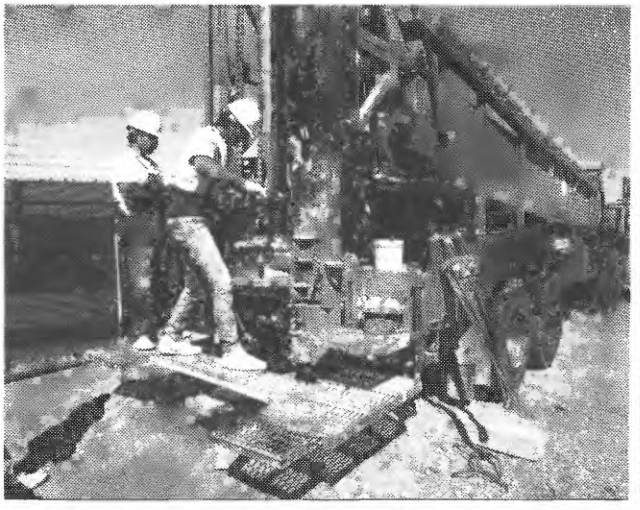
Problem: Other Federal agencies occasionally require the assistance of the USGS for special small-scale studies to assist them in their work.

Objectives: To provide technical assistance to other Federal agencies for small-scale assignments of a consulting nature.

Approach: Provide technical assistance as requested.

Progress and Significant Results, Fiscal Years 1994: Consulting services and technical assistance were provided as requested by other Federal agencies.

Plans for Fiscal Year 1995: Continue work for other Federal agencies as requested.



Drilling ground-water monitoring wells, Davis-Monthan Air Force Base.

Monitoring Hydrologic Effects of Ground-Water Withdrawals and Strip Mining at Black Mesa *(AZ028 and AZ080)*

Location: Northeastern Arizona

Project Chief: G.R. Littin and others

Period of Project: Continuous since 1971

Cooperating Agencies: Arizona Department of Water Resources and Bureau of Indian Affairs

Problem: Strip mining of coal on Black Mesa has caused concern about the effects of ground-water withdrawals as they relate to changing the potentiometric water surface of the N aquifer (Navajo Sandstone).

Objectives: Determine the magnitude of any water-level changes in the N aquifer near Black Mesa and differentiate changes caused by pumping by Peabody Coal Company and by nearby communities for public supply.

Approach: Observation wells will be used in addition to Peabody Coal Company wells to monitor water-level changes in the N aquifer. Flow meters will measure pumpage from all public-supply wells and Peabody wells to determine the total quantity withdrawn from the system.

Progress and Significant Results, Fiscal Year 1994: Continued data collection including water levels and water quality from selected wells; water quality and discharge from selected springs; annual pumpage from coal-mine well field and Indian communities; and continuous discharge data on one stream. Water levels declined in about 50 percent of those wells penetrating the confined part of the N aquifer. Water levels declined in about 50 percent of those wells penetrating the unconfined parts. Water quality was consistent with previously tested samples taken from the same wells in years past. Ground-water pumpage increased slightly since 1993. The Black Mesa model (Brown and Eychaner, 1988), was run. Results indicated a need for sensitivity analysis in a few areas and possibly a complete model recalibration.

Plans for Fiscal Year 1995: Continue the same data-collection network and evaluate monitoring data; conduct seepage investigation and streamflow-gaging site reconnaissance along Laguna Creek; prepare the annual progress report covering the 1994 calendar year.

Reports:

Littin, G.R., 1992, Results of ground-water, surface-water, and water-quality monitoring, Black Mesa area, northeastern Arizona—1990–91: U.S. Geological Survey Water-Resources Investigations Report 92–4045, 32 p.

Littin, G.R., 1993, Results of ground-water, surface-water, and water-quality monitoring, Black Mesa area, northeastern Arizona, 1991–92: U.S. Geological Survey Water-Resources Investigations Report 93–4111, 23 p.

Sottilare, J.P., 1992, Results of ground-water, surface-water, and water-quality monitoring program, Black Mesa area, northeastern Arizona—1989–90: U.S. Geological Survey Water-Resources Investigations Report 92–4008, 38 p.

Movement of Contaminants in Ground Water, Lower Miami Wash and Pinal Creek Basins, Arizona *(AZ082)*

Location: East-central Arizona

Project Chief: James G. Brown and Judson W. Harvey

Period of Project: April 1984 to October 1994

Cooperating Agencies: U.S. Geological Survey Toxic Substances Hydrology Program

Problem: Ground water in the Pinal Creek basin is contaminated with acidic-waste solutions from copper-mining and extraction activities. Trace metals have been mobilized in large concentrations in the alluvial aquifer, and emergence of trace metals with ground-water discharge to Pinal Creek may eventually threaten water quality at Lake Roosevelt, a major water supply for the city of Phoenix. Research at Pinal Creek has significantly advanced understanding of the role of mineral-solid reactions in controlling transport of trace metals in contaminated ground water; however, important questions remain unresolved and remain to be studied in the Pinal Creek basin.

Objectives: Research in the Pinal Creek Basin has the overall objective of increasing scientific understanding of the controls on contaminant transport of metals in ground water and streamflow. This effort includes developing new methods and models to investigate contaminant transport and publishing outstanding findings. Research has been and continues to be a cooperative effort among personnel of the Arizona District, the National Research Program in Reston and Menlo Park, and the University of Arizona. The methods and models developed at Pinal Creek should be applicable to some of the thousands of sites nationwide that have been affected by acidic contamination from abandoned and active mines.

Approach: The reactions that controlled the observed chemical changes in the plume are being identified through sampling of ground water, unsaturated-zone gases, and aquifer materials; and geochemical transport modeling. Chlorofluorocarbon age dating is being used to refine ground-water flow and transport models. Interactions between contaminated ground water and surface water are being characterized through the use of stream-tracer experiments, detailed sampling, and computer modeling of stream/shallow ground-water transport interactions.

Progress and Significant Results, Fiscal Year 1994: A coordinated effort by District and NRP researchers and University of Arizona scientists resulted in the successful completion of a two surface-water tracer experiments. Preliminary results indicate significant subreach variability in gas-exchange coefficients at Pinal Creek. Water-Resources Investigations Report entitled

"Hydrogeology and hydrologic system of Pinal Creek basin, Gila County, Arizona", by Chris C. Neaville and James G. Brown was published.

Plans for Fiscal Year 1995: Continue analysis of observed chemical changes in the aquifer for 1994–95. Continue transport analysis of manganese in the coupled stream-aquifer system. Assist NRP researchers from Reston with unsaturated-zone studies, focusing on gas fluxes. In cooperation with NRP researchers from Menlo Park, conduct field study on effect of stream subsurface-water exchange on metals transport in perennial streamflow. Complete revision and obtain approval to publish WSP summarizing research at the site for 1984–94.

Reports:

Brown J.G., 1991, Particle-tracking analysis of flow in the stream-aquifer system in Pinal Creek basin, Arizona, *in* Mallard, G.E., and Aronson, D.A., eds., U.S. Geological Survey Toxic Substances Hydrology Program—Proceedings of the Technical Meeting, Monterey, California, March 11–15, 1991: U.S. Geological Survey Water-Resources Investigations Report 91–4034, p. 448–453.

Brown, J.G., Stollenwerk, K.G., and Glynn, P.D., 1993, Geochemical and hydrologic characterization of acidic mine contamination in Pinal Creek basin, Arizona: U.S. Department of the Interior Hazardous Materials Management Conference, Denver, Colorado, May 1993, Resource Guide.

Eychaner, J.H., 1991, The Globe, Arizona, research site—Contaminants related to copper mining in a hydrologically integrated environment, *in* Mallard, G.E., and Aronson, D.A., eds., U.S. Geological Survey Toxic Substances Hydrology Program—Proceedings of the Technical Meeting, Monterey, California, March 11–15, 1991: U.S. Geological Survey Water-Resources Investigations Report 91–4034, p. 439–447.

Eychaner, J.H., 1991, Solute transport in perennial streamflow at Pinal Creek, Arizona, *in* Mallard, G.E., and Aronson, D.A., eds., U.S. Geological Survey Toxic Substances Hydrology Program—Proceedings of the Technical Meeting, Monterey, California, March 11–15, 1991: U.S. Geological Survey Water-Resources Investigations Report 91–4034, p. 481–485.

Faires, L.M., and Eychaner, J.H., 1991, Trace-element trends at Pinal Creek, Arizona, *in* Mallard, G.E., and Aronson, D.A., eds., U.S. Geological Survey Toxic Substances Hydrology Program—Proceedings of the Technical Meeting, Monterey, California, March 11–15, 1991: U.S. Geological Survey Water-Resources Investigations Report 91–4034, p. 461–465.

Gellenbeck, D.J., and Hunter, Y. R., 1994, Hydrologic data from the study of acidic contamination in the Miami Wash-Pinal Creek area, Arizona, water years 1992–93: U.S. Geological Survey Open-File Report 94–508, 103 p.

Longsworth, S.A., 1991, Measurement of stream reaeration at Pinal Creek, Arizona, *in* Mallard, G.E., and Aronson, D.A., eds., U.S. Geological Survey Toxic Substances Hydrology Program—Proceedings of the Technical Meeting, Monterey, California, March 11–15, 1991: U.S. Geological Survey Water-Resources Investigations Report 91–4034, p. 491–497.

Longsworth, S.A., and Taylor, A.M., 1992, Hydrologic data from the study of acidic contamination in the Miami Wash-Pinal Creek area, Arizona, water years 1990–91: U.S. Geological Survey Open-File Report 92–468, 59 p.

Neaville, C.C., and Brown, J.G., 1994, Hydrogeology and hydrologic system of Pinal Creek basin, Gila County, Arizona: U.S. Geological Survey Water-Resources Investigations Report 93–4212, 33 p.

Wallin, R.W., Bassett, R.L., and Eychaner, J.H., 1991, Ground-water transport of polycyclic aromatic hydrocarbons in association with humic substances in the Pinal Creek basin, Globe, Arizona, *in* Mallard, G.E., and Aronson, D.A., eds., U.S. Geological Survey Toxic Substances Hydrology Program—Proceedings of the Technical Meeting, Monterey, California, March 11–15, 1991: U.S. Geological Survey Water-Resources Investigations Report 91–4034, p. 511–515.

Working with mobile-laboratory analysis equipment.

Collecting water samples.

National Water Information System (NWIS) Program—PRIME-Based NWIS Ground-Water Site Inventory Subsystem Maintenance *(AZ114)*

Location: Administrative

Project Chief: Colleen A. Babcock

Period of Project: Continuous since January 1989

Cooperating Agency: Federal Program

Problem: Hydrologic data for the WRD are currently stored in several data bases. These data bases have been designed and developed over the past 25 to 30 years. The current data bases are either hierarchial or sequential in design. In more recent years when water issues are evaluated with a more multi-discipline approach, having to access several different archaic data systems hampers the effective use of the hydrologic data. Newer technology provides for better integration of data through the use of a relational data model. The new National Water Information System (NWIS) must be designed, developed, and implement, and the existing NWIS Ground-Water Site Inventory (GWSI) subsystem on the Prime minicomputers must be maintained.

Objectives: Provide data-base management for the GWSI subsystem and contribute to the planning and design effort for the new NWIS. As Data Base Manager, the project chief will direct the maintenance of computer software (programs) and provide user assistance and training related to the analysis, storage, and retrieval of ground-water data. The project chief will serve as a resource person for the design, development, and implementation of the new NWIS.

Approach: This project will provide funds for the project chiefs in District, State, and Subdistrict offices to provide the following software design and maintenance activities: (1) Assure computer software compatibility with new revisions of the PRIME minicomputer's operating system PRIMOS, test all software functions under new revisions of PRIMOS, and make necessary modifications to software and report operating-system problems to the distributed information systems (DIS) staff. (2) Identify and repair reported malfunctions in the computer software and prioritize items needing attention based on importance; identify solutions to problems using various software debugging techniques, make modifications to software code, and test revised software. (3) Prepare revisions of the computer software as a part of NWIS releases. (4) Provide user support and training for computer processing techniques in a distributed computer environment. (5) Coordinate activities with other NWIS data managers.

Progress and Significant Results, Fiscal Year 1994: Provided technical support in the design and development of NWIS-II. Provided user assistance as needed.

Plans for Fiscal Year 1995: Analysis of the Ingres software product, NWIS-II software, and the Data General hardware will be done this year and recommendations for tuning the components for

best performance will be made. Testing and implementation of the Ingres Replicator product for support of the reference information in the database will be done.

Reports:

Schlesinger, M.J., 1994, Data-base logging and journaling systems [abs.], *in* Balthrop, B.H., and Baker, E.G., eds., U.S. Geological Survey National Computer Technology Meeting—Program and abstracts, New Orleans, Louisiana, April 10–15, 1994: U.S. Geological Survey Open-File Report 94–52, p. 47

Lake Powell Water Quality *(AZ118)*

Location: Northern Arizona and southern Utah

Project Chief: Robert J. Hart

Period of Project: June 1990 to September 1995

Cooperating Agency: Bureau of Reclamation

Problem: The location of the penstocks of Glen Canyon Dam in the water column of the dam pool controls the quality of water being released to the downstream environment of the Colorado River. Because of their location, the penstocks generally take in cold water from the hypolimnion, which is released downstream. This cold water may not be conducive to native fish and other aquatic life.

Objectives: (1) Determine the general water-quality characteristics of the dam pool. (2) Determine temporal and spatial variations in water quality. (3) Determine chemical and thermal stratification and distribution in Lake Powell. (4) Determine factors that affect nutrient levels in Lake Powell. (5) Determine the standing crop of phytoplankton and zooplankton.

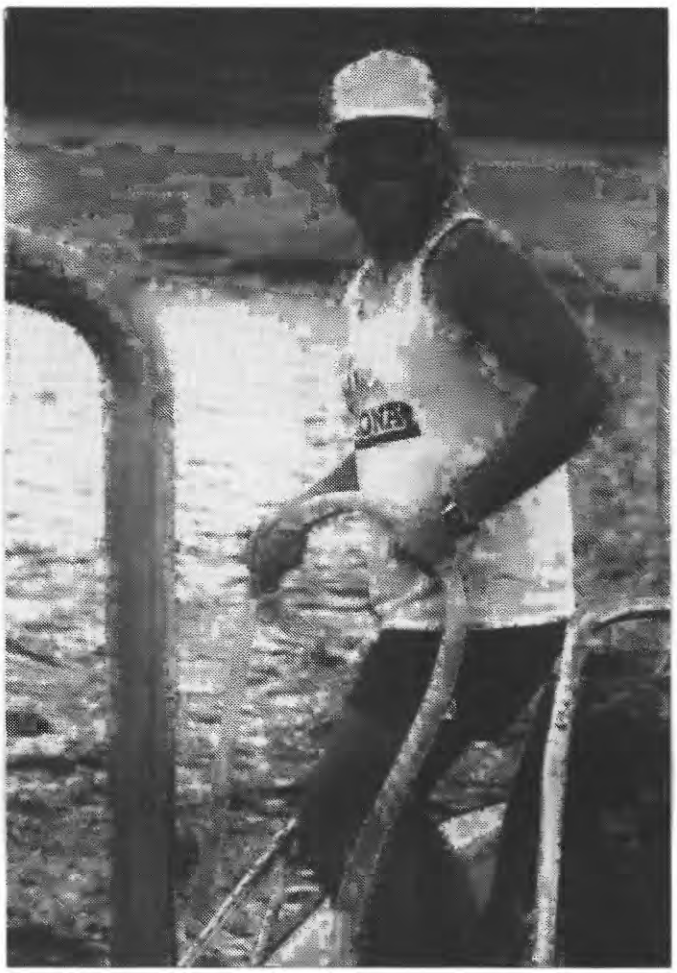
Approach: The study included point sampling through the water column in the dam pool at five locations near the dam. Sampling was done in a 24-hour period at a frequency of every 6 hours. Water-column measurement included dissolved oxygen, pH, specific conductance, light intensity, and water temperature. At least three depths in each vertical water column were sampled. Water samples will be collected directly from dam outlet structures (draft tubes) at the same frequency and time as lake samples. Lakewide measurements and samples were collected at selected sites to determine the advective flow and the distribution of chemical constituents. Zooplankton were also collected at selected sites lakewide.

Progress and Significant Results, Fiscal Year 1994: Two data-collection field trips were made during which water and lakebed samples were taken. Analysis of these samples were done for nutrients, metals, DOC, and major ions. Zooplankton tows were made and identification of species was made. Documentation of advective flow processes was made. Site specific research was made in the headwaters of Lake Powell and in Navajo Canyon (a tributary to Lake Powell). Lakebed sediments were collected and analyzed for various chemical constituents. Advective circulation was measured and lake stratification and extent were documented.

Plans for Fiscal Year 1995: Complete report on the forebay area and submit it for Headquarters' approval. Continue site-specific research on Lake Powell with National Research Program scientists.

Reports:

Hart, R.J., 1992, Comparison of water-quality characteristics of Lake Powell and the Colorado River, in Lake Reservoir, and Watershed Management in a Changing Environment: North American Lake Management Society Abstracts of Presentations 11th International Symposium, November 11–16, 1991, Denver, Colorado, p. 70.



Sampling lake water, Lake Powell.

Grand Canyon Sediment Transport *(AZ121)*

Location: Northern Arizona

Project Chief: Julia B. Graf

Period of Project: Continuous since June 1990

Cooperating Agency: Bureau of Reclamation

Problem: State and Federal agencies charged with management of the Colorado River in Glen and Grand Canyons must be able to assess the effects of alternative flow releases to get maximum benefit from the control of flow with minimum adverse effects to the riparian environment. The characteristics of hydraulic controls and flow in the river downstream from the dam must be understood physically and modeled mathematically before the effects of dam operation on the downstream environment can be assessed accurately.

Objective: Develop models capable of predicting stage, discharge, sand transport, and channel-bed evolution so that the effects of various dam-operation scenarios on the riparian zone in Grand Canyon can be determined.

Approach: Temporary stage gages were installed in 1991 about every 5 miles along the channel to provide data on amplitude and shape of the free-surface wave for development of flow models. The ability of the model to correctly predict the transport of the fluid mass will be checked with dye-tracer studies at as many as four flow conditions. Bed-geometry and bed-material characteristics will be measured in selected reaches, and methods for characterizing geometry in other reaches developed. Intensive sediment collection will be done at selected sites to investigate the feasibility of using a local model to improve sand-rating curves. This project is a part of a larger effort that has included projects Grand Canyon Hydrologic Data and Data-Base Management (AZ117), Lake Powell Water Quality (AZ118), Grand Canyon Water Quality (AZ119), and Grand Canyon Beach Evolution (AZ120). The description of this project includes the work of J. Dungan Smith and Stephen Wiele of the Water Resources Division, National Research Program, in addition to Arizona District personnel.

Progress and Significant Results, Fiscal Year 1994: Data from bathymetric surveys were combined with topographic data above the water line to make topographic maps of the channel below the Little Colorado River confluence and to prepare grids for development of multidimensional bed-evolution models. Models were used to estimate sand deposition in the

channel from a Little Colorado River flood of January 1993 and a report of results was prepared. Channel sand storage below the two largest tributaries, the Paria and Little Colorado Rivers, was measured three times during the year at a set of monumented cross sections, and a report of changes measured from the installation of the network in the summer of 1992 through February 1994 was prepared. Data on river-stage fluctuations related to water-level fluctuations in sand bars and to slumping of bars for the 1991 research flows and interim flow was processed and a data report was prepared. River stage was monitored at a network of about 42 stage gages, and 7 streamflow-gaging stations were operated during the year. Sediment samples were collected and sediment loads during runoff were estimated at streamflow-gaging stations on the Paria and Little Colorado Rivers.

Sand-storage monitoring showed that sand brought to the river by tributaries and deposited in the channel is transported downstream even under the relatively low daily peak discharges allowed under restricted operating rules in effect during the period. Sand initially deposited along the channel margins is eroded more slowly than sand in the channel, but less sand was stored at most measured cross sections in February 1994 than when sections were first measured in the summer of 1992. This contradicts the previously held hypothesis that sand would accumulate in the channel during restricted releases and be available for rebuilding of sand bars by higher flows. Channel geometry is extremely variable and strongly affects the location and amount of sand storage. Multidimensional flow, sediment transport, and bed-evolution models are required to estimate volume of sand deposition by tributary floods and redistribution of that sand by subsequent dam releases. Models applied to the January 1993 Little Colorado River flood estimate sand storage at monumented cross sections within about 5 percent of measured storage.

River-stage fluctuations appear to be related to slumping events on sand bars, but the relation is complex. Additional analyses of data and related information are required to determine the cause of observed slumping.

Plans for Fiscal Year 1995: Monumented cross sections will be resurveyed at least three times. Maps of the reach below the Little Colorado River will be finalized, and maps of a short reach below the Paria River will be begun. Model grid generation and model application will be extended to other periods for the reach below the Little Colorado River. The stage-gage and streamflow-gaging station network will be maintained as in 1994. Data on water-level fluctuations and tilt on sand bars will be analyzed and a report will be prepared. Reports of data from the stage and streamflow gages will be prepared for review.

Reports:

Graf, J.B., 1991, Longitudinal dispersion during steady and unsteady flow, Colorado River in the Grand Canyon, Arizona: American Geophysical Union, 1991 Fall Meeting Program and Abstracts, December 9–13, 1991, Abstract No. H51F–7.

Graf, J.B., Jansen, S.M.D., Smith, J.D., and Wiele, S.M., 1993, Characterization of channel geometry of an incised bedrock river for sediment-transport modeling [abs.]: American Geophysical Union supplement to EOS, October 26, 1993, 1993 Fall Meeting, December 6–10, 1993, San Francisco, California, p. 296.

Water-Quality Characterization of Urban Runoff, Maricopa County, Arizona *(AZ127)*

Location: Maricopa County, Arizona

Project Chief: Ken Fossum

Period of Project: October 1993 to September 1999

Cooperating Agency: Flood Control District of Maricopa County

Problem: Section 402(p) of the Water Quality Act of 1987 requires municipalities with a population of 100,000 or greater to obtain National Pollution Discharge Elimination System (NPDES) permits to control the quality of stormwater discharged into streams. To comply with conditions of the permit, the chemistry and toxicity of urban stormwater and streams that receive urban runoff must be monitored for the permit term. Chemistry and toxicity data for urban stormwater and streams receiving urban runoff in the Phoenix metropolitan area are needed by the Environmental Branch of the Flood Control District of Maricopa County for their NPDES program. Data on stormwater chemistry and toxicity are needed to implement management strategies that are intended to reduce pollutant loads and stormwater toxicity and to determine if the quality of streams that receive urban runoff is degraded.

Objectives: (1) Determine which factors contribute to the variability in stormwater chemistry and toxicity at basins with heavy-industrial, light-industrial, residential, and commercial land use. (2) Characterize the chemistry and toxicity of Salt River streamflow at various discharge rates and determine if urban runoff from Indian Bend Wash is influencing the quality of Salt River streamflow.

Approach: Stormwater and streamflow samples will be collected at four urban drainage basins and at four existing streamflow-gaging stations on the Salt River and Indian Bend Wash. Flow-weight composite samples of urban stormwater will be collected at the four drainage basins using automatic samplers. Streamflow samples from the Salt River and Indian Bend Wash will be manually collected using the equal-width-increment method. Chemical analyses will be conducted on samples to measure concentrations of constituents discharged from the drainage basins. Toxicity analyses will be conducted using photoluminescent bacteria to measure adverse effects of stormwater on aquatic organisms. Toxicity analyses will be conducted on whole water and filtered samples to determine if constituents in the dissolved and (or) solid phases cause a toxic response. Statistical methods will be used to evaluate factors that contribute to the variability in the chemistry and toxicity of stormwater and streamflow.

Progress and Significant Results, Fiscal Year 1994: A new gaging station was instrumented at a residential basin in Glendale, which replaced the residential basin in Youngtown. Both the winter and summer FY 1994 seasons were very dry, so the FY 1994 sample quota for urban-drainage basins was short by 7 samples, and the sample quota for streams was short by 11.

Plans for Fiscal Year 1995: Continue collecting data at urban and streamflow-gaging stations, try to make up for the FY 1994 sample deficit, and maintain ADAP's and QWDATA databases. Have outline for FY 1996 data approved.

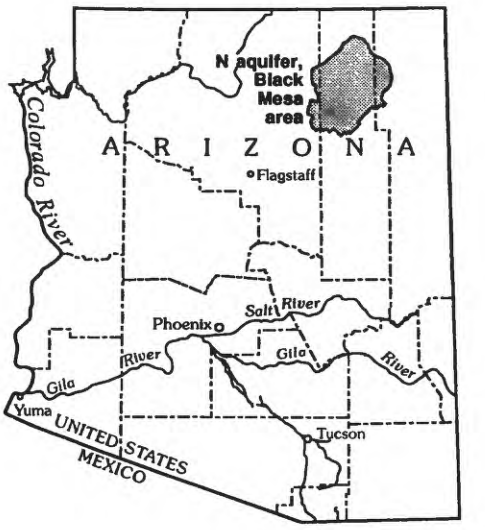
Reports:

Lopes, T.J., Phillips, J.V., and Fossum, K.D., 1993, Selected physical, chemical, and microbial characteristics of storm water, Maricopa County, Arizona, *in* Engur, Bahar, compiler, Arizona Water 2000: Phoenix, Arizona, Commission on the Arizona Environment, Proceedings of the Commission on the Arizona Environment and Arizona Hydrological Society, September 10–11, 1992, Poco Diablo Resort, Sedona, Arizona, p. 315–329.

Stormwater sampling at a residential drainage basin, Youngtown, Arizona.

Chemical Characteristics of Water in the N Aquifer in the Black Mesa Area, Arizona
(AZ134)

Location: Northeastern Arizona



Project Chief: Thomas J. Lopes

Period of Project: May 1992–September 1996

Cooperating Agency: Arizona Department of Water Resources

Problem: A description of the water chemistry in the N aquifer (Navajo Sandstone, Kayenta Formation, and Wingate Sandstone) and the geochemical processes that control it is needed for the Black Mesa area in the Navajo and Hopi Indian Reservations, Arizona. This aquifer is the most heavily used in the reservations for both municipal and industrial purposes and is the only aquifer capable of supplying potable water in sufficient quantities for communities and institutions in much of the Black Mesa area. Concern exists that increasing withdrawals from the N aquifer for municipal use combined with the continued withdrawal of water to slurry coal will cause excessive water-level declines or will cause infiltration of poor-quality water from the overlying D aquifer. Although many previous studies have been made of the geohydrology of the N aquifer, no study has been done on the geochemistry of the N aquifer. Analyses of ground-water ages and of geochemical controls will provide important information about the ground-water movement and the response of the aquifer to pumping and will improve the conceptual model of the flow system of the N aquifer.

Objectives: The primary purposes of this study are to describe the water chemistry, develop a geochemical model of the N aquifer, and develop a conceptual model of the flow system based on water chemistry and ground-water ages.

Approach: Available hydrologic, geologic, and water-chemistry data for the N aquifer will be compiled, evaluated, and entered into a relational data base. Standard graphical and geochemical procedures will be used. Samples will be collected from 30 to 40 wells and springs and analyzed for selected standard ions, nutrients, and C-14 and ratios of O-18 to O-16, S-34 to S-32, and deuterium to protium. Samples will also be analyzed for C-13 and tritium in support of the C-14 determination. Rock samples from the N aquifer will be collected for mineralogical and isotope analyses. The chemical and isotope analyses of water and minerals will be used to create geochemical models to define the principal reactions along the flow paths. By defining these reactions, a conceptual model of the geochemistry and the flow system of the N aquifer will be developed.

Progress and Significant Results, Fiscal Year 1994: Samples were collected for chemical and isotope analysis from wells selected for their areal distribution and well construction that indicated that the sample came entirely from the N aquifer or the D aquifer. All analyses were completed and the results tabulated. Radiocarbon ages of the water were calculated and plotted on a map. A report describing the results to date was written.

Plans for Fiscal Year 1995: The report will be reviewed and published as a Water-Resources Investigations Report.

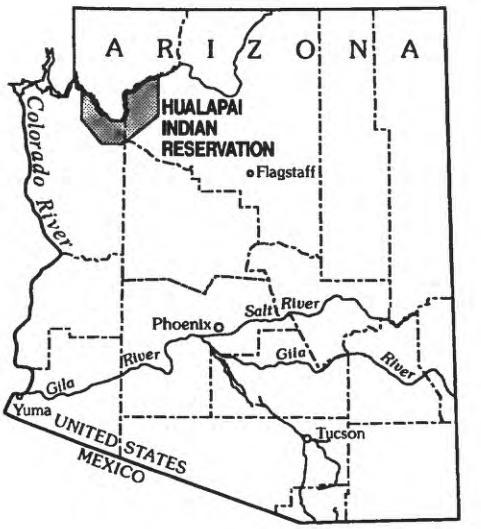
Assessment of the Water Resources Potential for the Hualapai Indian Reservation, Northwestern Arizona *(AZ135)*

Location: Northwestern Arizona

Project Chief: Donald J. Bills

Period of Project: Fiscal Year 1992 through 1995

Cooperating Agency: Hualapai Indian Tribe



Problem: Drought conditions, recent growth, and planned development have placed increasing demands on the water resources of the Hualapai Indian Reservation. As a result, the Hualapai Tribe has asked the Arizona District of the U.S. Geological Survey (USGS) to prepare a proposal to evaluate the water resources of their reservation and help them develop assessment and monitoring capabilities. The reservation experiences drought conditions that can have severe effects on the Tribe's wildlife and livestock herds. Several springs on the reservation have the capability of providing sufficient and suitable water for consumption by wildlife and cattle during emergency drought conditions.

Objectives: (1) To determine the quantity and quality of water available from the Muav Limestone and other significant spring sources for the entire reservation, which could be developed for use by wildlife and livestock during emergency drought conditions. (2) To evaluate currently defined and potential water resources and suggest alternatives for water-resources development on the basis of quantity, quality, water use, and economics. (3) To assist the Hualapai Tribe in developing a water-resource monitoring and management plan on the basis of the Reservation Integrated Resource Management System/Geographical-Information System (RIRMS-GIS).

Approach: Conduct a well and spring inventory to determine the occurrence, quantity and quality of water currently being discharged from water-bearing zones in the Muav limestone and other geologic units. Develop an estimate of recharge and runoff for the reservation using rainfall-runoff techniques on small and geologically unique basins. Different techniques will be evaluated that could be applied to determining this relationship. By utilizing information obtained in objective 1, locations can be defined for future production wells for public (high-yield) or livestock (moderate to low-yield) supply. Basins and drainages suitable for the development of stock tanks or reservoirs also could be suggested. The USGS would provide assistance and training to the Tribe in the collection, compilation, and analysis of the reservation's water resources and water-resources coverages that could be integrated into the tribes RIRMS-GIS.

Progress and Significant Results, Fiscal Years 1993–94: In 1993, samples for water-quality analysis were made from over 30 springs. Streamflow-gaging stations were installed and operated on Truxton Wash and Diamond Creek. GIS data coverages were established and preliminary data were entered into the DG workstation. Assessment of springs was initiated. Surface-geology coverage was initiated for entry into the GIS. Stock-tank reservoirs were selected for monitoring of recharge and runoff. In 1994, surface-water, ground-water, and water-quality data were collected and GIS coverages were developed for surface geology, structural geology, and water resources. Operation and maintenance of streamflow-gaging stations at Diamond Creek and Truxton Wash were continued. One flow event occurred on Diamond Creek that will require an indirect measurement. Spring surveys were continued, repeating about 25 sites and adding 5 new sites; discharge and field parameters and radiochemical and isotope samples were collected to be analyzed if funds permit. Preparation of the FY94 progress report this year to include: summary of data collected, preliminary, provisional estimate of flow from the reservation, preliminary budget and workplan for FY95, and recommendations, if any, for program changes and (or) additional work in FY95. Significant Findings: Significant spatial and temporal variability in spring flow, runoff estimates for the reservation vary over three orders of magnitude, some water chemistries in excess of MCL's, and spatial variability in isotopic and radiochemical results.

Plans for Fiscal Year 1995: Present a draft of the FY94 progress report to the Tribe by late October or early November, meet with the Tribe to discuss the report, and negotiate funding for the project for FY95. Present revised proposal to the Tribe to extend the project and address changing Tribal objective. Finalize plans for and install 2-3 rainfall-recharge-runoff sites requested by Tribe (pending availability of funds). Continue spring surveys (at least twice per year) including as many new sites as time and funds allow. Complete commitment to EPA 106 grant (report due to EPA June 1995), and begin well inventory for the reservation and surrounding area.

Toxicity and Chemistry of Urban Stormwater and Bed Material, Maricopa County, Arizona *(AZ136)*

Location: Central Arizona

Project Chief: Thomas J. Lopes

Period of Project: August 1992 to September 1994

Cooperating Agency: Arizona Department of Environmental Quality

Problem: The toxicity of stormwater and bed material of streams receiving urban runoff is an important property for assessing the quality of waters discharged from urban areas. In arid regions, toxic substances build up on urbanized surfaces and are partially washed off during high-intensity, short-duration storms. These conditions could produce surges of toxic runoff that is discharged into ephemeral streams. Toxicity of stormwater can result from many phases including dissolved metals, organics, suspended solids, and oil and grease. Few data exist on the toxicity of stormwater in arid regions for developing water-quality standards and for developing management strategies that will mitigate the toxic effects of stormwater. Data of this type are needed by the Arizona Department of Environmental Quality in regulating the quality of streams in Arizona.

Objectives: (1) To characterize the acute toxicity and chemistry of stormwater from residential, industrial, commercial, and undeveloped land uses. (2) To identify which phases (trace metals, organics, suspended solids, and oil and grease) of stormwater are toxic. (3) To characterize the acute toxicity and chemistry of bed material in streams receiving urban runoff.

Approach: First flush and flow-weighted composite samples of stormwater from five basins with residential, industrial, commercial, and undeveloped land uses and bed material from these basins and ephemeral streams that receive stormwater will be analyzed for acute toxicity to characterize the toxic properties of urban stormwater and bed material. Stormwater samples that produce toxic responses within 24 hours will have toxicity identification evaluations conducted to identify the phases in the water that are toxic. Water samples will be analyzed for dissolved trace metals, total organic carbon, suspended solid, and oil and grease to quantify the most likely toxic phases. Organophosphorus pesticides will be analyzed from flow-weighted whole-water samples of stormwater. Bed-material samples will be analyzed for organophosphorus and organochlorine pesticides, total recoverable metals and nutrients, fraction organic carbon, and oil and grease to characterize the chemistry of bed material.

Progress and Significant Results, Fiscal Years 1993–94: In 1993, all sediment samples were collected. All stormwater samples for commercial, residential, and light-industrial basins were collected. Only one sample for the heavy-industrial basin was collected due to lack of runoff. In 1994, sampling was completed for the study, but only four samples were collected from the two large drainages because of dry conditions. Data analysis was completed and a draft of the report was sent to Tom Byl, PhD. Tn District, and to the cooperator for colleague review.

Plans for Fiscal Year 1995: Finish review process and published report.

Reports:

Lopes, T.J., and Amalfi, F.A., 1993, Toxicity of urban stormwater and bed material, Maricopa County, Arizona [abs.]: North American Lake Management Society Proceedings, Seattle, November 29–December 4, 1993

Transient Leakage *(AZ138)*

Location:

Project Chief: Stanley A. Leake

Period of Project: October 1992–September 1997

Cooperating Agency: USGS RASA Program

Problem: Transient leakage in a ground-water flow model is the capability of calculating flow to or from a confining bed and storage changes in the confining bed without representing the confining bed as one or more model layers. The need for transient-leakage capabilities in the Modular Finite-Difference Ground-Water Flow Model (MODFLOW) was recognized when the program was under development more than 10 years ago. Subsequently, a transient-leakage package was developed using a method published in scientific literature in 1981. The method, however, did not produced acceptable results for all reasonable values of confining-bed properties and the Transient-Leakage Package was not released with the original release of MODFLOW. About 5 years later, the RASA Subsidence-Modeling project in the Arizona District modified the Transient-Leakage package to use a new method developed for the U.S. Geological Survey Modular Finite-Element Model. The Transient-Leakage package using this new methodology works well, however, a published documentation report is needed before the package can be distributed for general use. The methods developed for the Transient-Leakage package also could be used to construct aquifer-influence functions for MODFLOW. These functions would allow the approximation of aquifer response beyond the boundaries of a model grid.

Objectives: The immediate objective is to formally document the Transient-Leakage Package for MODFLOW. If funding is available in future years, the transient-leakage effort will be extended to developing aquifer-influence functions.

Approach: The remaining work items for the Transient-Leakage Package are (1) modify the program to calculate downward flow from a confining bed when the head in the underlying aquifer falls below the bottom of the bed, and (2) fully document the program in a Techniques of Water-Resources Investigations (TWRI) report with preliminary release as an open-file report. A report was written for the original transient leakage package but was never published. Item 2 will consist of modifying this existing report to include the method and test problems developed for the current version of the package.

Progress and Significant Results, Fiscal Years 1993–94: In 1993, the report on the Transient-Leakage Package for MODFLOW was written and sent to colleague reviewers. Alternative formulations were tested for computing volumetric storage change in confining units. In 1994, the transient-leakage package for MODFLOW was documented. The report was

approved for release in the TWRI series and was printed in preliminary form as Open-File Report 94–59. The report and program were distributed inside and outside the U.S. Geological Survey.

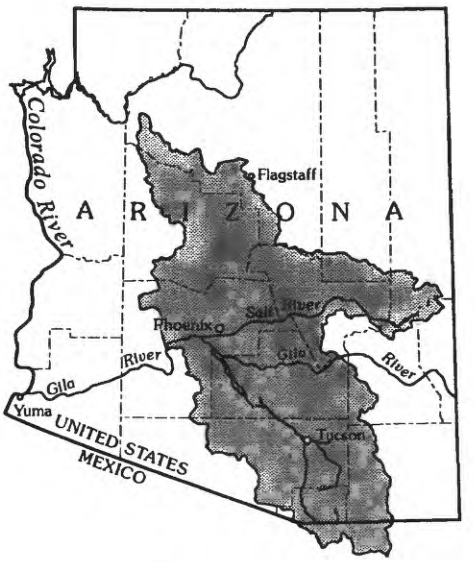
Plans for Fiscal Year 1995: Work on documenting advanced methods for simulating aquifer-system compaction will begin. The work will be completed in future fiscal years.

Reports:

Leake, S.A., 1993, New computer program for simulating storage changes and transient leakage in confining units using MODFLOW [abs.]: American Geophysical Union supplement to EOS, October 26, 1993, 1993 Fall Meeting, December 6–10, 1993, San Francisco, California, p. 306.

Leake, S.A., Leahy, P.P., and Navoy, A.S., 1994, Documentation of a computer program to simulate transient leakage from confining units using the modular finite-difference ground-water flow model: U.S. Geological Survey Open-File Report 94–59, 70 p.

Central Arizona Basins National Water-Quality Assessment Program *(AZ142)*



Location: Central and southern Arizona, northern Mexico

Project Chief: Gail E. Cordy

Period of Project: October 1993–On going

Cooperating Agency: U.S. Geological Survey
National Water-Quality Assessment Program

Problem: In order to make decisions about water-quality issues for the Nation, consistent information representing multiple areal scales over a long period of time are needed. This information is not currently available, and as a result Congress initiated funding for the development of the National Water Quality Assessment Program.

Objectives: (1) To provide a consistent description of current water-quality conditions in the study area; (2) to define long-term trends in water quality; and (3) to identify, describe, and explain, if possible, the major natural and human factors that affect observed water-quality conditions and trends.

Approach: Compile available water-quality information; sample and analyze surface and ground water for a wide array of physical, chemical and biological properties; and interpret and report the results.

Progress and Significant Results, Fiscal Year 1994: In FY94, the NAWQA Fact Sheet was published and distributed. The first Liaison Committee meeting was held with more than 60 representatives from a variety of local, state, and Federal agencies as well as private groups such as the Nature Conservancy. Because the study unit extends into Mexico, representatives from across the border are being sought to serve on the Committee. A representative from a natural resources agency of Sonora, Mexico, attended the first meeting. Representatives of the International Border and Water Commission have been invited to the second meeting to be held November 30, 1994. Other progress in FY94 included identification of eight major water-quality issues of concern in the study unit; acquisition and compilation of initial geographic information systems (GIS) databases for land use, land cover, geology, and digital elevation; preparation of a topical outline and initial work on the "Environmental Setting" report; and submission of detailed request for STORET data for the study unit.

Plans for Fiscal Year 1995: Plans for FY95 will focus on the retrospective analysis of water-quality data. Pesticides, volatile organic compounds, nutrients, and aquatic biology will be the focus of the effort. Electronic data bases from other State and local agencies will be compiled and interpreted in conjunction with USGS and STORET data. In addition, field reconnaissance will be done to determine the most suitable locations for basic fixed sites and intensive fixed sites for surface-water and biological sampling and to determine appropriate wells for the ground-water-quality inventory planned for FY96. Much of the design for the 3-year high-intensity data-collection phase will be completed in 1995. Liaison committee meetings will continue to be held twice yearly. Full staffing will be achieved by late 1995.

Reports:

Cordy, G.E., 1994, National Water-Quality Assessment Program—Central Arizona basins: U.S. Geological Survey Fact Sheet 94–016, 2 p.

_____1994, NAWQA—The U.S. Geological Survey's water-quality assessment program in Arizona [abs], *in* Approaching the Millennium—Evolving Perspectives in Water Resources: Arizona Hydrological Society, Proceedings of the Seventh Annual Symposium, Scottsdale, Arizona, September 22–23, 1994, p. 255–258.

Chemistry and Toxicity of Urban Sediments, Maricopa County, Arizona *(AZ143)*

Location: Maricopa County

Project Chief: John T. Parker

Period of Project: October 1993–September 1995

Cooperating Agency: Flood Control District of Maricopa County

Problem: Monitoring stormwater is not adequate to determine if land-use activities significantly influence chemistry and toxicity of urban runoff. Most constituent concentrations depend on suspended-solids concentrations in stormwater. Characterizing sediment chemistry and toxicity from drainage basins with homogenous land use would be a direct method of assessing land-use effects on stormwater chemistry.

Objectives: (1) Characterize the chemistry and toxicity of sediments from detention basins that drain residential, commercial, and industrial land uses. (2) Determine if there is a statistical difference between sediments from the different land uses. (3) Determine if there are temporal changes in urban sediment quality.

Approach: Select 12 detention basins for each of 2 years of project—4 each of industrial, commercial and residential basins. One-half will be dirt and one-half grass-covered basins. Collect sediment samples for analysis of less than or equal to 125 micrometers sediments. Conduct acute toxicity tests on sediments and analyze for organochlorines, trace metals, nutrient and organic carbon. Resample two basins in spring, summer, and fall to determine temporal variation.

Progress and Significant Results, Fiscal Year 1994: Sampling for chemical and toxicity analyses was completed for 12 urban detention basins. Analyses showed high variability for toxicity but little relation to land use. Concentrations of inorganic chemical constituents of urban sediments were similar to background levels. Several basins had sediments with concentrations of organic compounds in excess of 100 parts per billion.

Plans for Fiscal Year 1995: Complete sampling by December 1, 1994. A data report is to be published by end of FY95. A journal article on contaminants of urban sediments is being prepared for submission in FY95.

n-Verification (AZ146)

Location: Maricopa County, Arizona, and the surrounding area

Project Chief: Jeff V. Phillips

Period of Project: March 1994-September 1997

Cooperating Agency: Flood Control District of Maricopa County.

Problem: Flood profiles are computed using water-surface-profile computer models that are based on open-channel hydraulic principles. All water-surface-profile computer model areas are based on three fundamental open-channel hydraulic equations—the Manning equation, continuity equation, and energy equation. The Manning equation requires an evaluation of channel characteristics and an estimate of the roughness coefficient (*n*). The ability to assess roughness coefficients has been called an art developed through experience. Because of the subjective nature of *n*-value selection, channel roughness-coefficient verifications are needed. In addition, significant changes in Manning's roughness coefficient can result from flood-stage flows either removing or laying-over riparian vegetation. Since computed conveyances are directly related to *n* values, major inaccuracies will cause considerable errors in related studies such as flood-plain delineation and bridge design.

Objectives: (1) To verify Manning's roughness coefficient on selected streams in Maricopa County and surrounding areas. (2) To develop a predictive method for determining the floodflow-related effects of changing riparian vegetation conditions on channel conveyances.

Approach: Roughness-coefficient verification measurements will be performed for selected channel reaches in Maricopa County. A minimum of three *n*-verification measurements will be made at selected sites to study the relation of Manning's *n* with hydraulic radius. In addition, riparian vegetation will be documented and studied at selected locations in central Arizona. A set of photographs will be taken at each site seasonally (each summer and winter) and after significant flow events. Riparian vegetation affected by flows will be evaluated by computing stream power at cross sections and studying the resultant effect on the vegetation. Stream power is a measure of energy transfer and has been used to predict flow regime for alluvial channels by relating stream power and median grain size. A similar relationship will be developed for stream power and height of riparian vegetation to predict degree of effect on the vegetation.

Progress and Significant Results, Fiscal Year 1994: A preliminary method to predict vegetation conditions resulting from peak floodflow was developed mainly on the basis of data obtained from

the 1993 floods in central Arizona. Initial results suggest that vegetation conditions following peak floodflows are a function of stream power and vegetation height. These data show that a significant increase in channel conveyance can occur when floodflows lay over or remove riparian vegetation. Current guidelines for estimating roughness coefficients do not adequately address these changes and significant computational errors can result. The preliminary method developed was presented at the U.S. Geological Survey Regional District Review in Salt Lake City, Utah, and also at the American Society of Civil Engineers 1994 National Conference on Hydraulic Engineering. Progress includes installation of crest-stage gages at *n*-verification study reaches for the purpose of obtaining accurate water-surface elevations of floodflow peaks. Also, vegetated reaches along the Colorado River in the Grand Canyon were located and photographed for potential monitoring during the pending test-flood release.

Plans for Fiscal Year 1995: The first of two journal papers has been completed and published. The topic of the second journal paper will be a substantive technique to predict vegetation conditions resulting from floodflows. The final report will be a water-supply paper and is scheduled to be completed by end of FY97. The final report will include the *n*-verification measurements, the substantive method for predicting vegetation conditions during floodflows, and examples for use of the method. Diagrams and color photographs will be an integral part of the final report.

Reports:

Phillips, J.V., and Hjalmarson, H.W., 1994, Floodflow effects on riparian vegetation in Arizona, *in* Cotroneo, G.V., and Rumer, R.R., eds., Hydraulic Engineering '94, v. 1, Proceedings of the 1994 Conference: American Society of Civil Engineers, p. 707–710.

Looking downstream from bridge at Gila River below Gillespie Dam prior to the January–February 1993 flood.

Looking downstream from bridge at Gila River below Gillespie Dam following the January–February 1993 flood.

Preliminary assessment of hydrologic conditions in the southern boundary area of the Tohono O'Odham Indian Reservation, Arizona *(AZ147)*

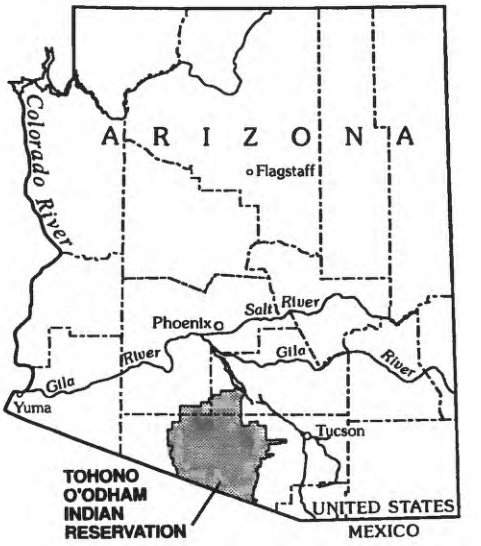
Location: Tohono O'Odham Indian Reservation, Arizona

Project Chief: Michael C. Carpenter

Period of Project: October 1993–September 1995

Cooperating Agency: Tohono O'Odham Nation

Problem: Information on the quantity and quality of water resources in the southern boundary area of the Tohono O'Odham Indian Reservation is needed for effective resource management.



Objectives: Compile existing ground-water and surface-water data and describe general water-resources conditions along the southern boundary area of the reservation. If sufficient data are available, conduct a post-audit of the Hollett ground-water flow model. Identify additional data needs for a more intensive study along the southern boundary area of the reservation.

Approach: Existing ground-water and surface-water data will be compiled and reviewed. The Hollett ground-water model will be converted from two dimensional to MODFLOW. Ground-water and surface-water conditions will be monitored and analyzed along with precipitation to determine hydrologic conditions in basins near the international boundary.

Progress and Significant Results, Fiscal Years 1994: Initial meetings with the cooperator have taken place. The Hollett ground-water flow model has been converted to MODFLOW.

Plans for Fiscal Year 1995: Compile and analyze all hydrologic data that are available for the study area including water-level, rainfall, pumpage, and streamflow data. Complete post-audit of Hollett model. Compile available hydrogeologic information and describe general ground-water conditions. Complete workplan and write report. Assist in program development with the Tohono O'Odham Water-Resources Department. Possible additional work to include drilling monitor wells and installing surface-water stations along the southern boundary. Additional work may also

include the installation of a vertical extensometer to measure land subsidence owing to ground-water withdrawal.

Collapse of land surface, Tohono O'Odham Reservation.

Well Inventory of the Lower Colorado River Flood Plain and Adjacent Areas in Arizona, California, Nevada, and Utah *(AZ148)*

Location: Lower Colorado River

Project Chief: Sandra J. Owen-Joyce

Period of Project: March 1994–September 1997

Cooperating Agency: Bureau of Reclamation

Problem: Accounting for the consumptive use of Colorado River water withdrawn from the river aquifer by wells requires that each well within the boundary of the river aquifer be located and inventoried in order to apply the method, which can be used to identify those wells that yield water that will be replaced by water from the river.

Objectives: Inventory wells on the flood plain of the lower Colorado River and complete the well inventory on the adjacent alluvial slopes and tributary valleys.

Approach: (1) Wells will be visited in the field and owners interviewed to collect current available data required to fill out well-inventory forms and to obtain additional ownership information and drillers' logs. (2) Well positions will be determined or updated within 10 meters by using Global-Positioning System satellite surveys. Well sites and measuring points will be photographed. (3) Water levels will be measured where required and access is possible. (4) U.S. Geological Survey (USGS) and Bureau of Reclamation (BOR) well-inventory forms will be coded for each well. (5) Appropriate data will be entered in USGS data base.

Progress and Significant Results, Fiscal Year 1994: Well-inventory data collection during FY94 was limited by the cooperator to federal wells in the Yuma area. About 1,150 wells were located by using Global-Positioning System satellite surveys by the USGS and BOR field teams. Many wells already in the GWSI data base, which were last inventoried in the 1960's, were revisited to check on their continued existence and status. All wells visited by USGS personnel have been inventoried and photographed. Data processing is in progress. Fact Sheet report is complete, USGS reviews are complete, and submittal for Director's approval is pending final approval to publish by cooperator.

Plans for Fiscal Year 1995: At request of cooperator, USGS is to begin well-inventory data collection on the Colorado River Indian Reservation. Work on the reservation requires

coordination with the Colorado River Indian Tribes and USGS field teams must include a tribal representative.

Using Global Positioning Satellite (GPS) equipment to accurately locate pumping wells.

Determining depth-to-water in a pumping well.

Water-Resources Remote-Sensing Data Base (AZ151)

Location: Various international areas

Project Chief: Wesley D. Meehan

Period of Project: Continuous since October 1994

Funding Agency: U.S. Army Corps of Engineers

Problem: In the past, U.S. military deployments have been in nonarid regions of the world where fresh surface-water supplies were readily available. Recently, U.S. military planners have recognized a need for water-support planning in the event of rapid deployment in unfamiliar parts of the world where adequate water resources are not easily accessible.

Objectives: To evaluate quantity, quality, and availability of surface-water, ground-water, and water-supply facility resources in arid regions of the world. Studies of the various areas will result in a better understanding of the water resources of the world and provide valuable information for defense needs. Products from the study will serve as input to an automated data base and overall hydrologic evaluation of assigned areas for future use in defense planning and operations.

Approach: Assignments of study areas are made by the U.S. Army Corps of Engineers, through the U.S. Geological Survey/Water Resources Division (USGS/WRD) Reston office. First, all available geohydrologic information is reviewed. Significant hydrologic and geologic data is incorporated into the Water-Resources Data-Base Program. The information is then used to evaluate surface-water, ground-water, and water-supply facility resources. Unpublished interpretative reports are generated that summarize all aspects of water availability within a specified region.

Plans for Fiscal Year 1995: The project will be initiated with the assignment of personnel and space allocations. Training will begin in May 1995, and project work will begin immediately after training.

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