WATER-RESOURCES ACTIVITIES IN UTAH BY THE U.S. GEOLOGICAL SURVEY, OCTOBER 1, 1992, TO SEPTEMBER 30, 1993

Compiled by Ellen E. Hardy and Stefanie L. Dragos

U.S. GEOLOGICAL SURVEY
Open-File Report 95-138

Salt Lake City, Utah
1995

U.S. DEPARTMENT OF THE INTERIOR

BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY

Gordon P. Eaton, Director

For additional information
write to:

District Chief
U.S. Geological Survey
Water Resources Division
1745 West 1700 South
Room 1016 Administration Building
Salt Lake City, Utah 84104

Copies of this report can be
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U.S. Geological Survey
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Denver, Colorado 80225

Message from the District Chief

The U.S. Geological Survey, Water Resources Division, is entering its 104th year of activities in Utah. The demand for quantitative, unbiased water-resources information continues to increase as Utah's demand for water increases. The mission of the U.S. Geological Survey, which includes assessing the quantity and quality of the Nation's water resources, is directed toward providing timely, relevant ground-water, surface-water, and water-quality data and interpretation to help the State of Utah meet these demands.

The Utah District's income for fiscal year (FY) 1993 was about $4.9 million, a reduction of about $400,000 from FY 1992. This reduction is the result of less work in support of other Federal agencies and a decline in the availability of Federal matching funds.

The most significant hydrologic event of the 1993 water year was the break in the long term (1987-92) drought conditions throughout Utah. Annual mean discharge for five of nine long-term, representative stream-flow-gaging stations during 1993 was greater than the median for water years 1944-91. New monthly minimums were recorded at several stations early in the water year as the drought persisted. The San Juan River at Bluff recorded the highest monthly mean flow for March in a period of record since 1914.

Despite a much greater-than-normal snowpack, ranging from 80 percent in the Bear River Basin to 400 percent in the Virgin River Basin, and widespread predictions of possible flooding, snowmelt flooding was limited because cool, spring weather conditions allowed a low, sustained runoff. High-water conditions persisted for many weeks at several stations. The only severe flooding occurred in the Virgin River Basin in southwestern Utah in January and February. Flooding damaged several gaging stations on the Virgin and Santa Clara Rivers, and a station on the Provo River near Hailstone was destroyed. The Hailstone gage was destroyed because of bank erosion after vegetation was cleared for the new Jordanelle Reservoir.

Some smaller floods resulted from isolated summer thunderstorms in the southern part of the State. Peaks of record were recorded at Castle Creek near Moab, Beaver Dam Wash near Enterprise, and East Fork Virgin River near Springdale.

The future promises the continued challenge of helping local, State, and Federal agencies meet their water-resources information needs in the most cost-effective, timely manner. I look forward to another active, productive year developing and strengthening partnerships to meet these needs.

H.L. Case III
District Chief
U.S. Geological Survey, Water Resources Division
Salt Lake City, Utah

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INTRODUCTION

This report contains summaries of the progress of water-resources studies in Utah by the U.S. Geological Survey (USGS), Water Resources Division, Utah District, from October 1, 1992, to September 30, 1993. The program in Utah during this period consisted of 21 projects; a discussion of each project is presented in the main body of this report.

The following sections outline the origin of the USGS, the basic mission of the Water Resources Division, the organizational structure of the Utah District, the distribution of District funding in terms of source of funds and type of activity funded, and the agencies with which the District cooperates. The last part of the introduction is a list of reports produced by the District from October 1992 to September 1993.

Origin of the U.S. Geological Survey

The 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 geologic 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 map-making 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 databases 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 publication 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."

Mission of the U.S. Geological Survey, 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 USGS, 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.

To accomplish its mission, the Water Resources Division, in cooperation with State and local governments and other Federal agencies:

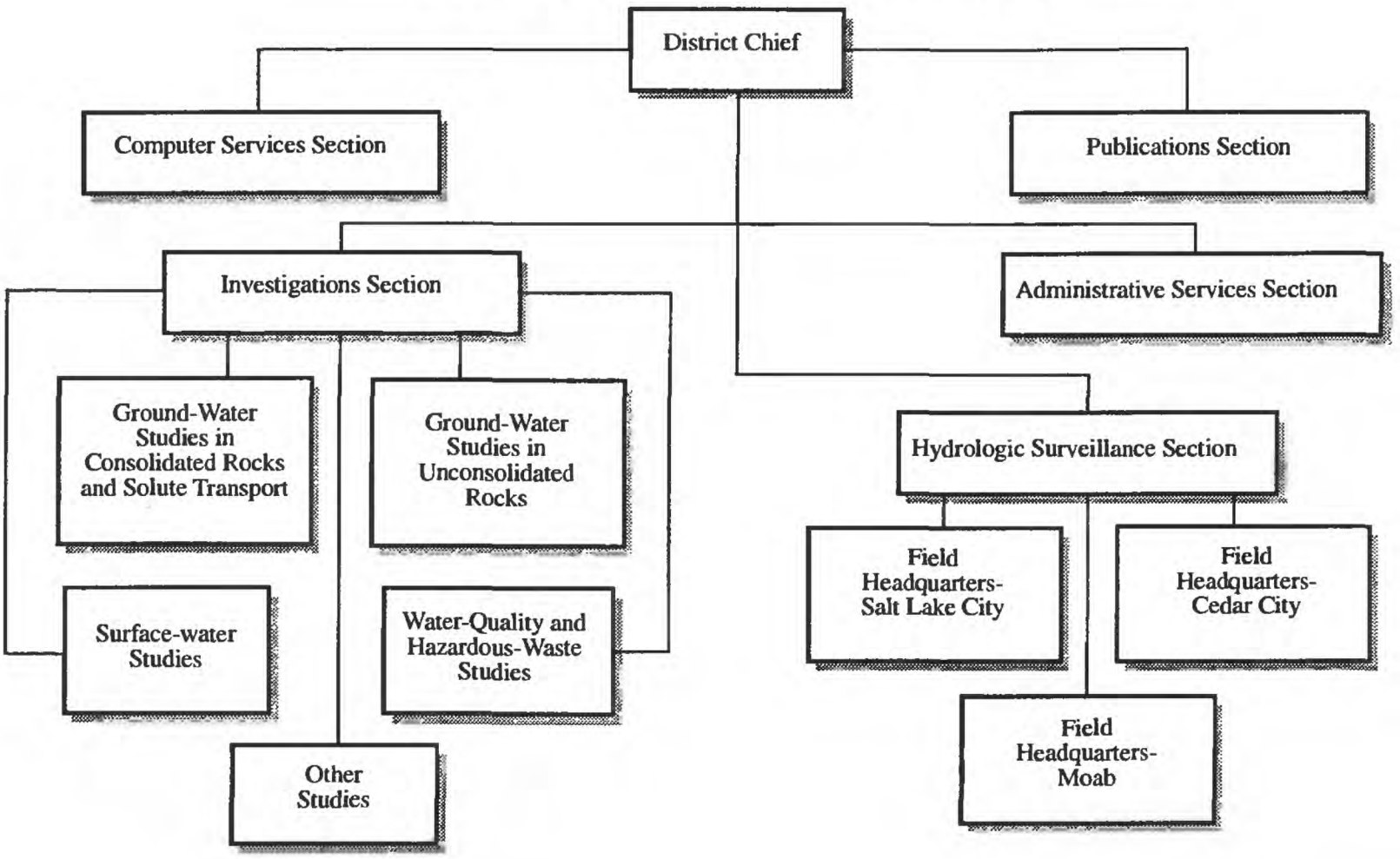
- Systematically collects data needed for the continuing determination and evaluation of the quantity, quality, and use of the Nation's water resources.
- Conducts analytical and interpretive water-resources appraisals to describe the occurrence, availability, and physical, chemical, and biological characteristics of surface and ground water and their interrelation.
- Conducts supportive basic and problem-oriented research in hydraulics, hydrology, and related fields of science and engineering to improve the basis for field investigations and measurement techniques and to understand hydrologic systems sufficiently well to predict quantitatively their response to stress, either natural or manmade.
- Disseminates water data and the results of investigations and research through reports, maps, computerized information services, and other forms of public releases.
- Coordinates the activities of all Federal agencies in the acquisition of certain water data.
- Provides scientific and technical assistance in hydrologic fields to State, local, and other Federal agencies, to licensees of the Federal Energy Regulatory Commission, and, on behalf of the U.S. Department of State, to international agencies.
- Acquires, develops, and disseminates information on water-related natural hazards such as droughts, floods, landslides, land subsidence, mudflows, and volcanoes.
- Administers the provisions of the Water Resources Research Act of 1984 that include the programs of the State Water Resources Research Institutes and the Research Grants and Contracts.
- Supports the provisions of the National Environmental Policy Act of 1969 and manages USGS conduct of natural-resources surveys in response to the Comprehensive Environmental Response, Compensation, and Liability Act (Superfund Act) of 1980.

Authority for carrying out this mission is derived from legislation of 1879, which created the USGS, and legislation of 1888 and 1894, which provided for gaging of streams and determining the Nation's water supply. Congressional appropriations have been made annually since 1894 for gaging streams and performing other functions relating to water resources. In 1964, the USGS's mission was broadened to include the role of lead agency in the coordination of the activities of all Federal agencies in the acquisition of certain water data. This responsibility was assigned to the Department of the Interior by the Office of Management and Budget Circular A-67.

Organization of the Utah District

The Utah District of the Water Resources Division is organized into five operating sections under the District Chief (see organization chart). Water-resources projects are done by the Investigations Section (primarily interpretive studies) and Hydrologic Surveillance Section (primarily collection of hydrologic data). Responsibility for each project is assigned to a project chief. Support for project work is supplied by the Publications Section, which processes and illustrates reports, and the Computer Services and Administrative Services Sections. The Utah District consists of the District Office in Salt Lake City and Field Headquarters in Salt Lake City, Moab, and Cedar City. The locations of these offices and their areas of responsibility are shown in figure 1.

Utah District Organization



OFFICE ADDRESSES OF THE UTAH DISTRICT

Inquiries regarding projects described in this section may be directed to the District Office or the office in which the work originated.

District Office
and Salt Lake City Field Headquarters
(801) 975-3350

U.S. Geological Survey
Water Resources Division
Room 1016 Administration Building
1745 West 1700 South
Salt Lake City, Utah 84104

Cedar City Field Headquarters
(801) 586-4543

U.S. Geological Survey
Water Resources Division
82 North 100 East
P.O. Box 1066
Cedar City, Utah 84720

Moab Field Headquarters
(801) 259-5495

U.S. Geological Survey
Water Resources Division
50 East Center Street
P.O. Box 490
Moab, Utah 84532

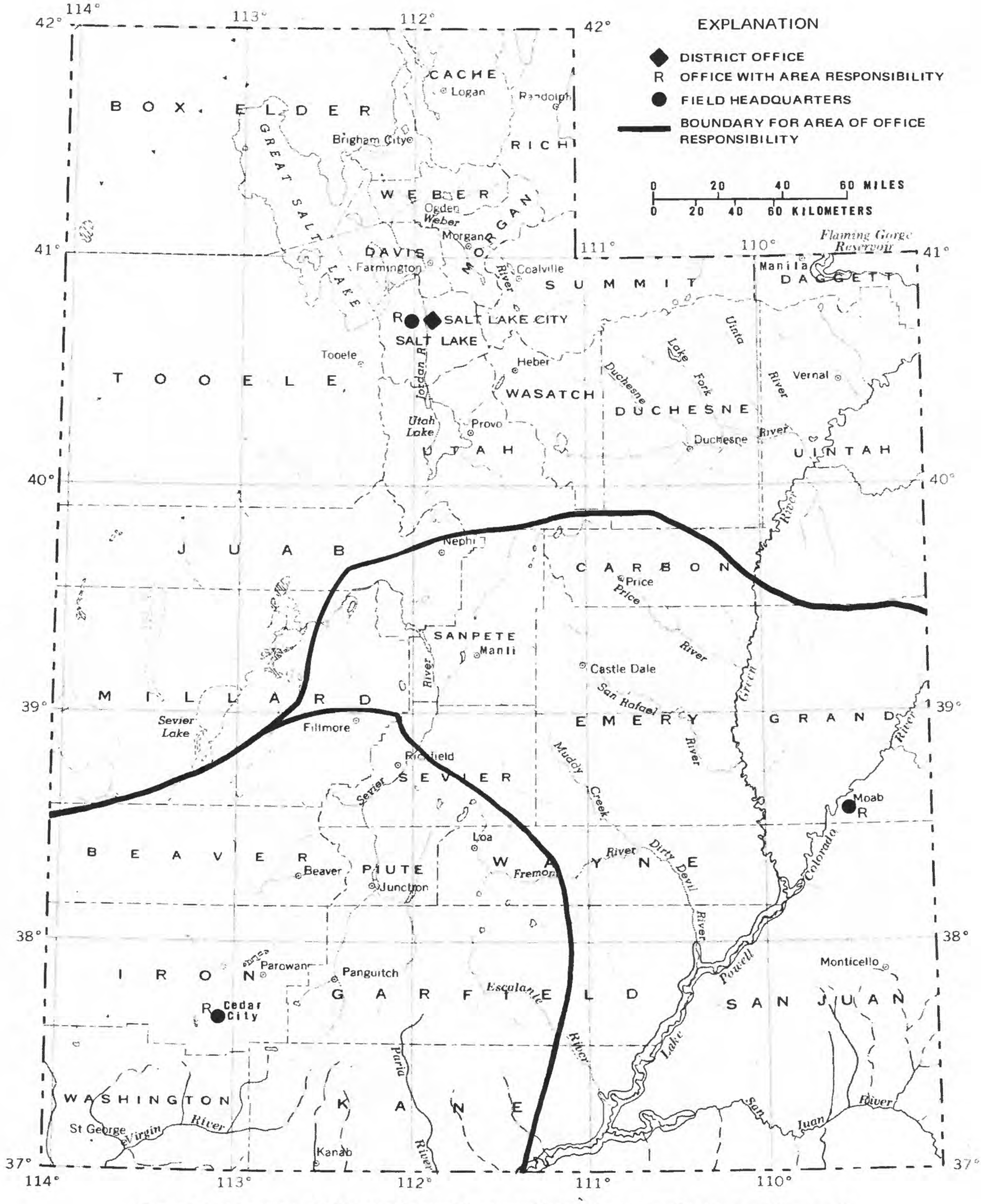
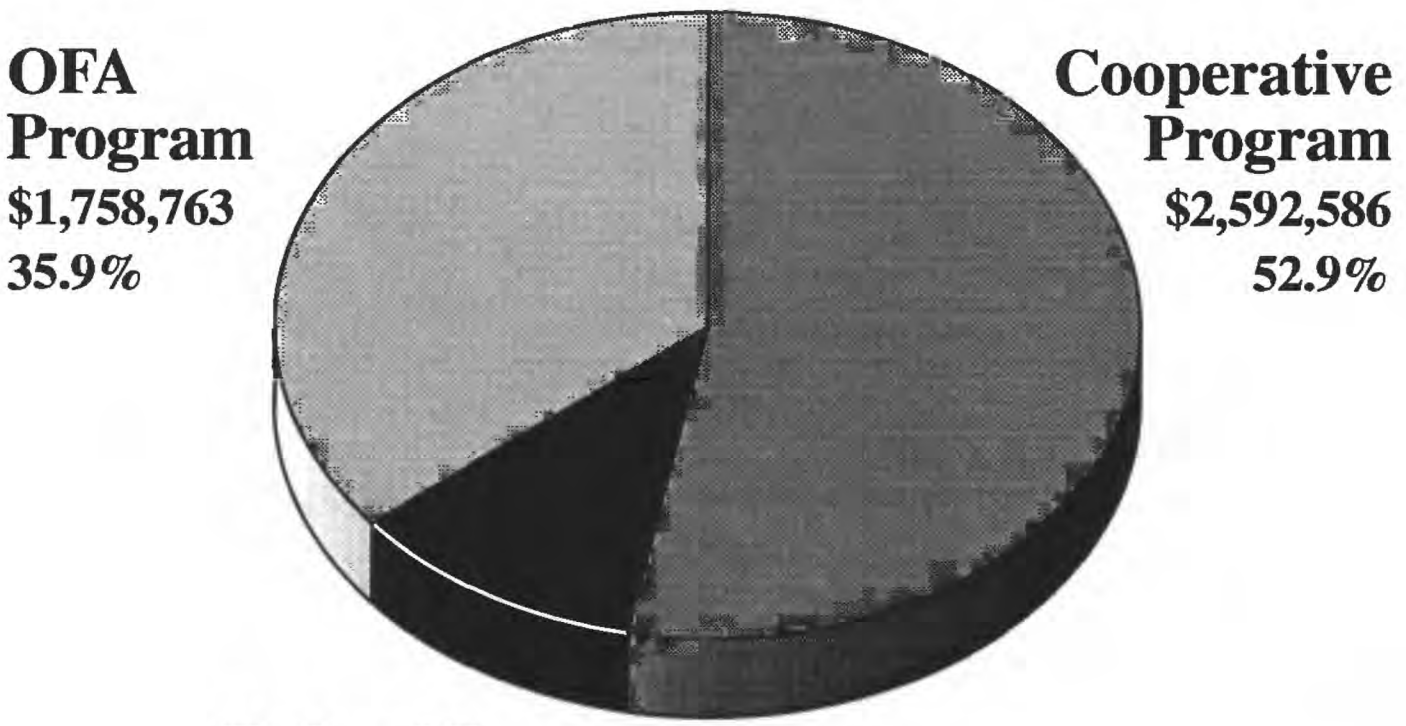


Figure 1.--Location of U.S. Geological Survey, Water Resources Division, offices and general areas of responsibility.

Program Funding and Cooperating Agencies

Funds to support water-resources work by the Utah District are from three sources. Cooperative-program funds and services are provided from State and local government agencies and generally are matched by Federal funds on a 50-50 basis. Funds transferred from other Federal agencies (OFA) are part of the OFA Program, and funds appropriated directly to the USGS by Congress are part of the Federal Program. In FY 1993, total financial support from these programs for the Utah District was about $4.9 million. The distribution of funds among the three sources is shown below:



In FY 1993, the Utah District pursued three broad categories of studies: (1) collection of hydrologic data, (2) areal appraisals and interpretive studies, and (3) research projects. About 42 percent of the program was for collection of hydrologic data, 54 percent was for interpretive studies and appraisals, and 4 percent was for research projects. These studies provide water managers and planners with information about the availability and quality of Utah's water resources. The distribution of funds among the three categories is as follows:

From October 1, 1992, to September 30, 1993, the cooperating agencies for District projects were:

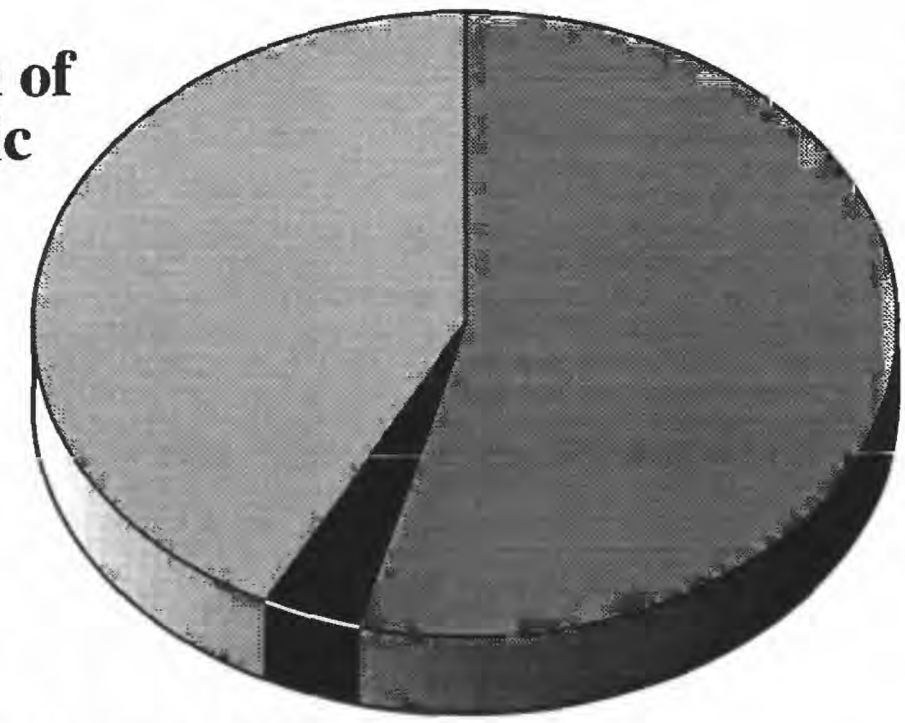
State Agencies

Arizona Department of Water Resources

Nevada Department of Conservation and Natural Resources
- Division of Water Resources

Utah Department of Environmental Quality
- Division of Water Quality

Utah Department of Natural Resources
- Division of Oil, Gas, and Mining
- Division of Water Resources
- Division of Water Rights
- Geological Survey



Local Agencies

Bear River Commission
Central Utah Water Conservancy District
East Juab County Water Conservancy District
Ogden River Water Users Association
Salt Lake County Division of Flood Control and Water Quality
Weber Basin Water Conservancy District
Weber River Water Users Association

Federal Agencies

U.S. Department of the Interior
- Bureau of Land Management
- Bureau of Reclamation
- National Park Service
- National Irrigation Water-Quality Program
- U.S. Fish and Wildlife Service

U.S. Environmental Protection Agency

U.S. Department of Agriculture
- Soil Conservation Service

U.S. Air Force

Reports Released or Published

Reports prepared by or in cooperation with the Utah District can be obtained at the following locations:

Utah District Office: Open-File Reports; Water-Resources Investigations Reports; Water-Data Reports; Utah Department of Natural Resources Technical Publications, and Cooperative Investigations Reports.

U.S. Geological Survey Earth Science Information Center: USGS Water-Supply Papers, Professional Papers, Circulars, and Hydrologic Investigations Atlases.

Utah Department of Natural Resources, Division of Water Rights: Technical Publications, Water Circulars, Water-Use Reports.

Utah Department of Natural Resources, Division of Water Resources: Cooperative Investigations Reports.

The following reports were published during October 1, 1992, to September 30, 1993:

Batty, D.M., Allen, D.V., and others, 1993, Ground-water conditions in Utah spring of 1993: Utah Department of Natural Resources Cooperative Investigations Report Number 33, 124 p.

Gates, J.S., and Hardy, E.E., 1993, Water-resources activities in Utah by the U.S. Geological Survey, October 1, 1991, to September 30, 1992: U.S. Geological Survey Open-File Report 93-467.

Freethey, G.W., 1993, Maps showing recharge areas and quality of ground water for the Navajo aquifer, western Washington County, Utah: U.S. Geological Survey Water-Resources Investigations Report 92-4160.

Herbert, L.R., and Thomas, B.K., 1992, Seepage study of the Bear River including Cutler Reservoir in Cache Valley, Utah and Idaho: Utah Department of Natural Resources Technical Publication No. 105.

ReMillard, M.K., and others, 1992, Water resources data, Utah, water year 1992: U.S. Geological Survey Water-Data Report UT-91-1, 375 p.

Spangler, L.E., Freethey, G.W., and Green, G.A., 1993, Physical extent, recharge areas, relative potential for recharge and contamination, and quality of water in the principal aquifers, western Kane County, Utah: U.S. Geological Survey Water-Resources Investigations Report 92-4070.

Stephens, D.W., Waddell, Bruce, Peltz, L.A., Miller, J.B., 1992, Detailed study of selenium and selected elements in water, bottom sediment, and biota associated with irrigation drainage in the middle Green River basin, Utah, 1988-90: U.S. Geological Survey Water-Resources Investigations Report 92-4084.

Stolp, B.J., Drumiler, Marilyn, and Brooks, L.E., 1993, Selected hydrologic data for southern Utah and Goshen Valleys, Utah, 1890-1992: U.S. Geological Survey Open-File Report 93-108.

Thiros, S.A., 1992, Selected hydrologic data for Salt Lake Valley, Utah, 1990-92, with emphasis on data from the shallow unconfined aquifer and confining layers: U.S. Geological Survey Open-File Report 92-640.

CURRENT PROJECTS BY NUMBER AND TITLE

Collection of Hydrologic Data

Surface-Water Data

Number: UT-00-001

Cooperating Agencies: Bureau of Reclamation; National Park Service; Utah Division of Water Rights; Utah Division of Water Resources; Utah Geological Survey; Bear River Commission; Weber Basin Water Conservancy District; Salt Lake County Division of Flood Control and Water Quality; Weber River Water Users Association; Ogden River Water Users Association; Central Utah Water Conservancy District; and local water agencies

Staff: L.R. Herbert, Hydrologic Technician, Project Chief (part time)
Other District personnel as assigned

Period of Project: Continuing

Problem: Information on surface water is needed for the planning, design, operation, and management of Utah's surface-water resources and for warning of hazards related to surface water. Such information is used in water-related fields such as water supply, hydroelectric power generation, irrigation, flood control, bridge and culvert design, wildlife management, pollution abatement, flood-plain management, and water-resources development. To provide this information, an appropriate database on discharge of streams and contents and stages of reservoirs and lakes is necessary.

Objectives: To obtain data on stream discharge and reservoir and lake contents and stages at selected sites throughout Utah.

Approach: Standard methods for the operation and maintenance of streamflow-gaging stations and for the computation, computer storage, and publication of the data are used.

Progress: Data collection and computation necessary for the publication of discharge records for 180 streamflow-gaging stations and contents and stage records for 20 reservoir- and 3 lake-stage stations continued during the year. In addition, streamflow data were collected at seven partial-record sites. Also, periodic measurements were made of flow of water through the breach in the causeway across Great Salt Lake. The locations of the stations and station numbers are shown in figure 2. Data collected at these stations, as well as larger-scale maps showing station locations, are presented in the series of reports entitled "Water resources data for Utah," USGS Water-Data Reports. The stations are classified as follows:

	Number of stations
Discharge	
Current use	149
Hydrologic data for planning and design	37
Benchmark for long-term trends	1
Contents of lakes and reservoirs	21
Stage of Great Salt Lake	2

Nine streamflow-gaging stations were discontinued as of September 30, 1993. These were:

09184000 Mill Creek near Moab
09235600 Pot Creek above diversions, near Vernal
09333500 Dirty Devil River above Poison Spring Wash
09378600 Montezuma Creek near Bluff
09378650 Recapture Creek below Johnson Creek
09405200 Deep Creek near Cedar City
09405250 East Fork Deep Creek
09405900 North Creek near Virgin
09408135 Virgin River above Quail Creek, near Hurricane

Streamflow-gaging stations established as of September 30, 1993, for use in FY 1994 were:

09406640 Leap Creek above Maple Hollow, near Pintura
09406900 Wet Sandy Creek near Pintura

Plans for Next Year: Continue operation of network. Prepare 1994 water-year records for publication. Continue monitoring flow through the breach in the Great Salt Lake causeway. Complete report on floods in the Great Basin during 1983-84. Complete report on surface-water reconnaissance of the Sevier River basin upstream from Sevier Bridge Reservoir.

Reports:

ReMillard, M.D., and others, 1993, Water resources data for Utah, water year 1992: U.S Geological Survey Water–Data Report UT-92-1.

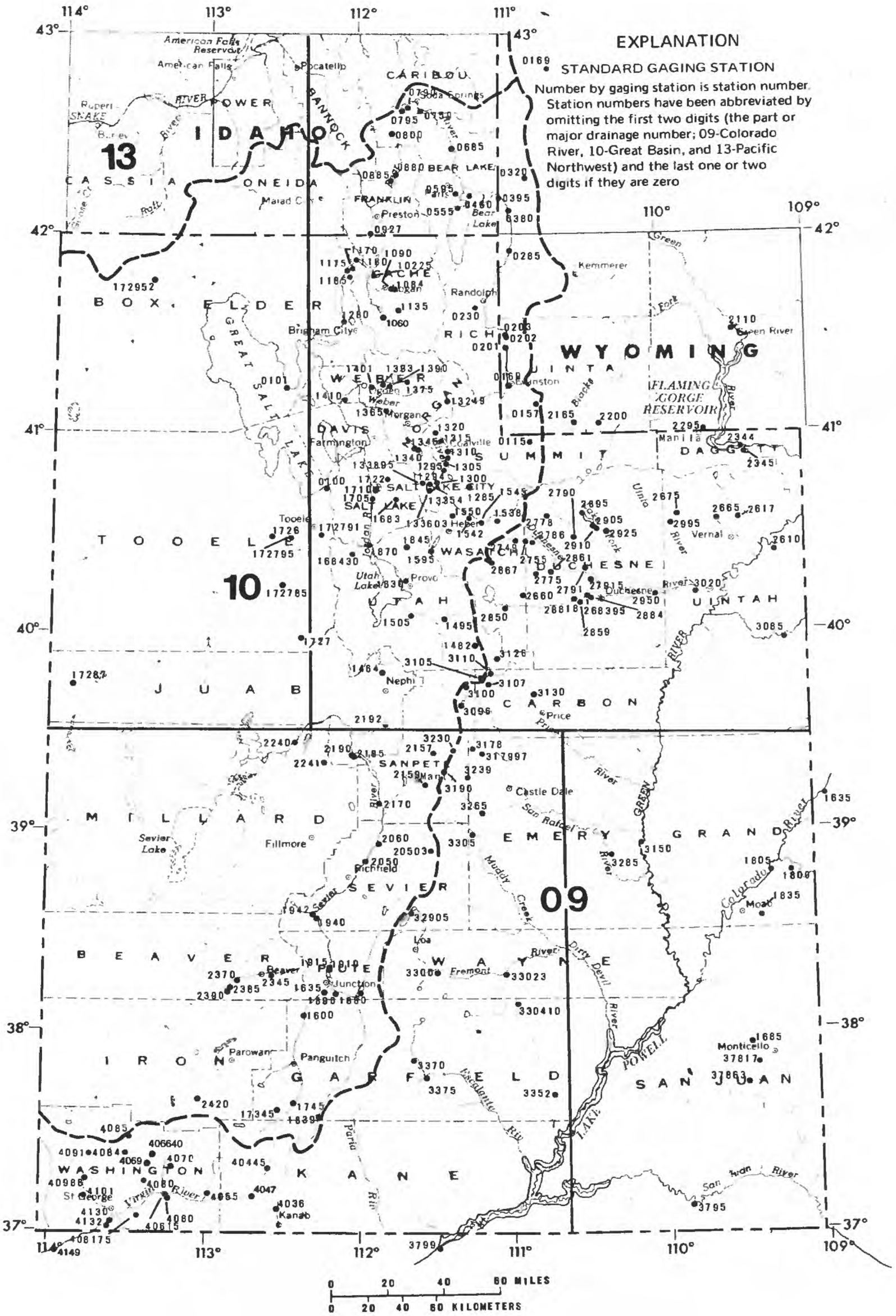


Figure 2. Location of gaging stations.

Ground-Water Data and Ground-Water Conditions in Utah

Number: UT-00-002

Cooperating Agencies: Utah Division of Water Rights; Utah Division of Water Resources

Staff: L.R. Herbert, Hydrologic Technician, Project Chief
D.M. Batty, Hydrologic Technician and editor of annual ground-water conditions report (part time)
Other District personnel as assigned

Period of Project: Continuing

Problem: Long-term records of water levels and ground-water withdrawals are needed to evaluate the effects of climatic variations, to determine the effects of withdrawals from aquifers on water levels, to assist in the prediction of future conditions of aquifers, and to provide data for management of ground-water resources.

Objectives: (1) To obtain long-term records of ground-water levels for determination of water-level changes for yearly or other periods, (2) to determine withdrawals from aquifers in the State, and (3) to make an annual evaluation of ground-water conditions in Utah and publish the information in a report.

Approach: Measure water levels annually (normally February to March) and operate continuous water-level recorders on selected wells (fig. 3). Visit selected discharging irrigation wells, measure discharge, determine the ratio of water produced to energy consumed, and use the ratio along with energy-consumption data to compute total annual pumpage. Visit selected flowing wells and measure discharge. Obtain estimates of ground water withdrawn from wells for public supply and industrial use from the Utah Division of Water Rights. Obtain additional selected estimates of industrial use of water from wells by interviewing users, or by rating pumps and using the ratio of water produced to energy consumed with energy-consumption records. Determine the number and diameter of new wells drilled annually from well drillers' reports filed with the Utah Division of Water Rights. Prepare an annual report on ground-water conditions in Utah that includes data, graphs, and maps showing water-level changes; withdrawals from wells; number of wells drilled in defined ground-water basins or areas; changes in ground-water quality; and a discussion of ground-water conditions in each basin or area with significant withdrawals. Store water-level data in computer files and publish selected data in the annual report of water-resources data for Utah.

Progress: Water levels were measured in about 990 wells in February and March. In addition, water levels in 4 of these wells were measured monthly and water levels in 18 wells were measured quarterly. Continuous water-level recorders were maintained on 27 of these wells. During the irrigation season, about 500 discharging irrigation wells were visited; discharge was measured at about one-half of the wells, and the ratio of water production to energy consumption was determined. Natural flow was measured for about 50 wells during the irrigation season. Number and diameters of wells drilled during the past year were compiled. The thirtieth in the series of annual reports on ground-water conditions in Utah was completed. The continuous water-level records were published in the annual Water Resources Data—Utah Water Year 1992 report.

Plans for Next Year: Continue collecting, recording, and publishing data on water levels, ground-water withdrawals, and wells drilled. The thirty-first in the series of annual ground-water reports will be compiled. Prepare final illustrations and text for the brochure on ground-water studies, and print the brochure.

Reports:

Batty, D.M., and others, 1993, Ground-water conditions in Utah, spring of 1993: Utah Division of Water Resources Cooperative Investigations Report 33.

ReMillard, M.D., and others, 1993, Water resources data for Utah, water year 1992: U.S. Geological Survey Water–Data Report UT-92-1.

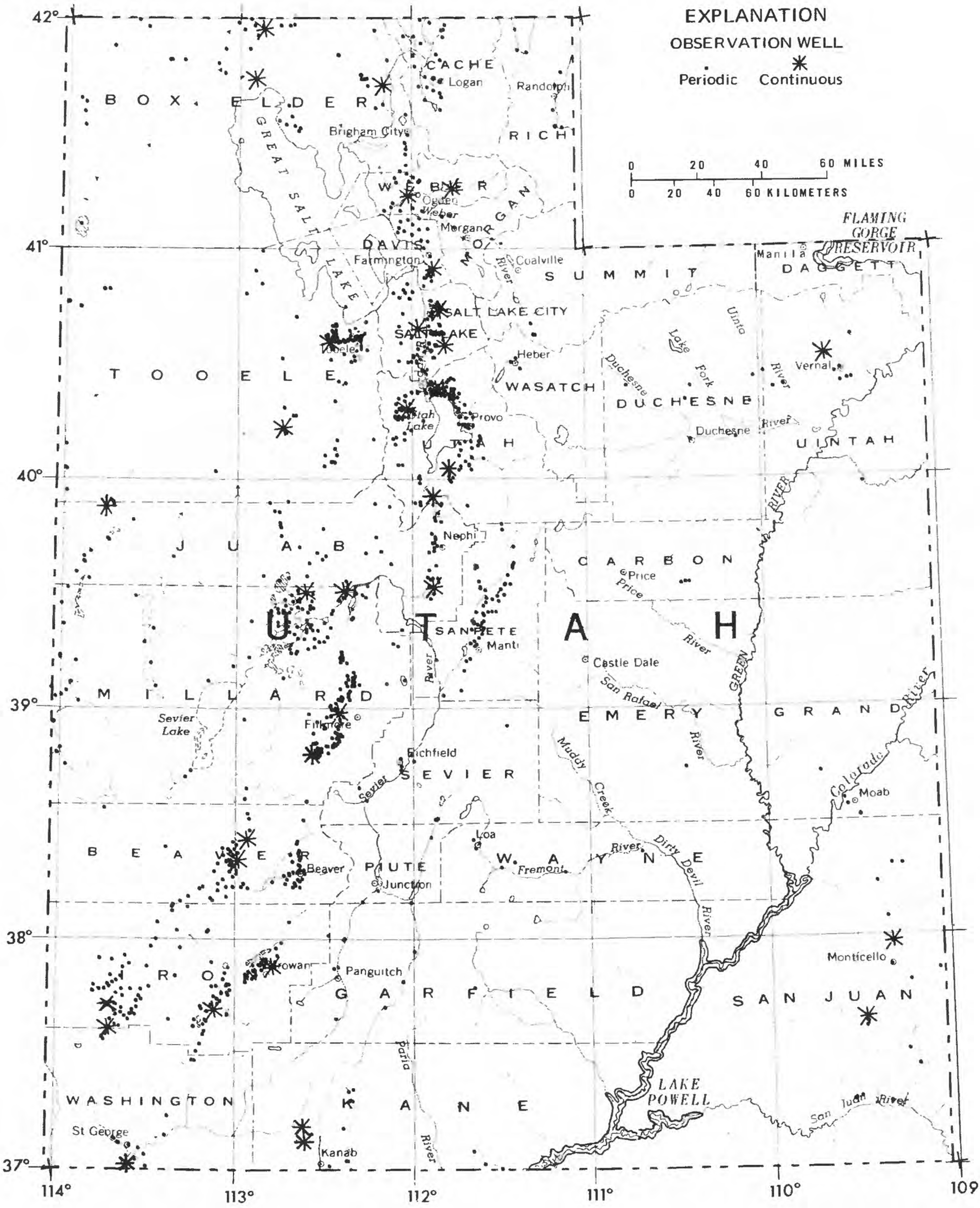


Figure 3. Location of observation wells in which water levels were measured.

Water-Quality, Fluvial-Sediment, and Precipitation Data

Number: UT–00–003; UT–00–004; UT-00-005

Cooperating Agencies: Utah Division of Water Resources; Utah Division of Water Rights; Utah Geological Survey; Bureau of Reclamation; Soil Conservation Service

Staff: L.R. Herbert, Hydrologic Technician, Project Chief (part time)
Other District personnel as assigned

Period of Project: Continuing

Problem: Data on the quality of surface and ground water and variation in precipitation quantity are needed for surveillance, planning, design, and management of water-resources activities. Water-quality problems can affect industries, water-treatment facilities, irrigators, and individuals. Sediment decreases storage in reservoirs, contaminates water supplies, and harms fisheries. Sediment and precipitation data are needed for erosion studies, reservoir design, evaluation of water quality, and water-resources management. Variation in precipitation quantity is needed to compliment the other data collected at the Red Butte Creek benchmark station. Databases are needed to provide the appropriate water-quality, sediment, and precipitation information.

Objectives: To obtain records of precipitation, quality of water from streams and wells, and sediment at selected sites throughout Utah, including Great Salt Lake.

Approach: Use standard methods for the collection and analysis of precipitation data; chemical-quality, fluvial-sediment, and biological samples; and computer storage and publication of data.

Progress: Water samples for chemical analysis were obtained periodically at 15 stream sites (fig. 4). In addition, continuous or daily temperature and/or specific-conductance data were obtained at two of these stream sites. About 200 wells are in the ground-water-quality monitoring program (fig. 5), and complete chemical analysis was obtained from about 70 of these wells. Water from 10 wells and 5 injection wells was sampled in an area of oil-field brine injection in the Uinta Basin. All water-quality data for streams and wells are listed in the annual water-resources data reports. Quarterly measurements of temperature, density, and velocity of flow were made along several verticals through cross sections at both the upstream and downstream sides of the breach through the causeway between the south and north parts of Great Salt Lake. Water quality was monitored in 18 observation wells near the dikes of West Pond. Sediment data were obtained at two sites and periodically at an additional nine sites. Precipitation data were collected at the Red Butte Creek benchmark station at Fort Douglas.

Plans for Next Year: Continue collecting and processing data and preparing records for publication. Continue monitoring water quality in selected wells in the brine-injection area of the Uinta Basin. Collect water-quality samples at selected sites in the Uinta Basin and Juab and Utah Valley areas. Continue collecting and processing sediment data and preparing records for publication. Continue to collect precipitation data at the Red Butte Creek benchmark station.

Reports:

ReMillard, M.D., and others, 1993, Water resources data for Utah, water year 1992: U.S. Geological Survey Water-Data Report UT–92–1.

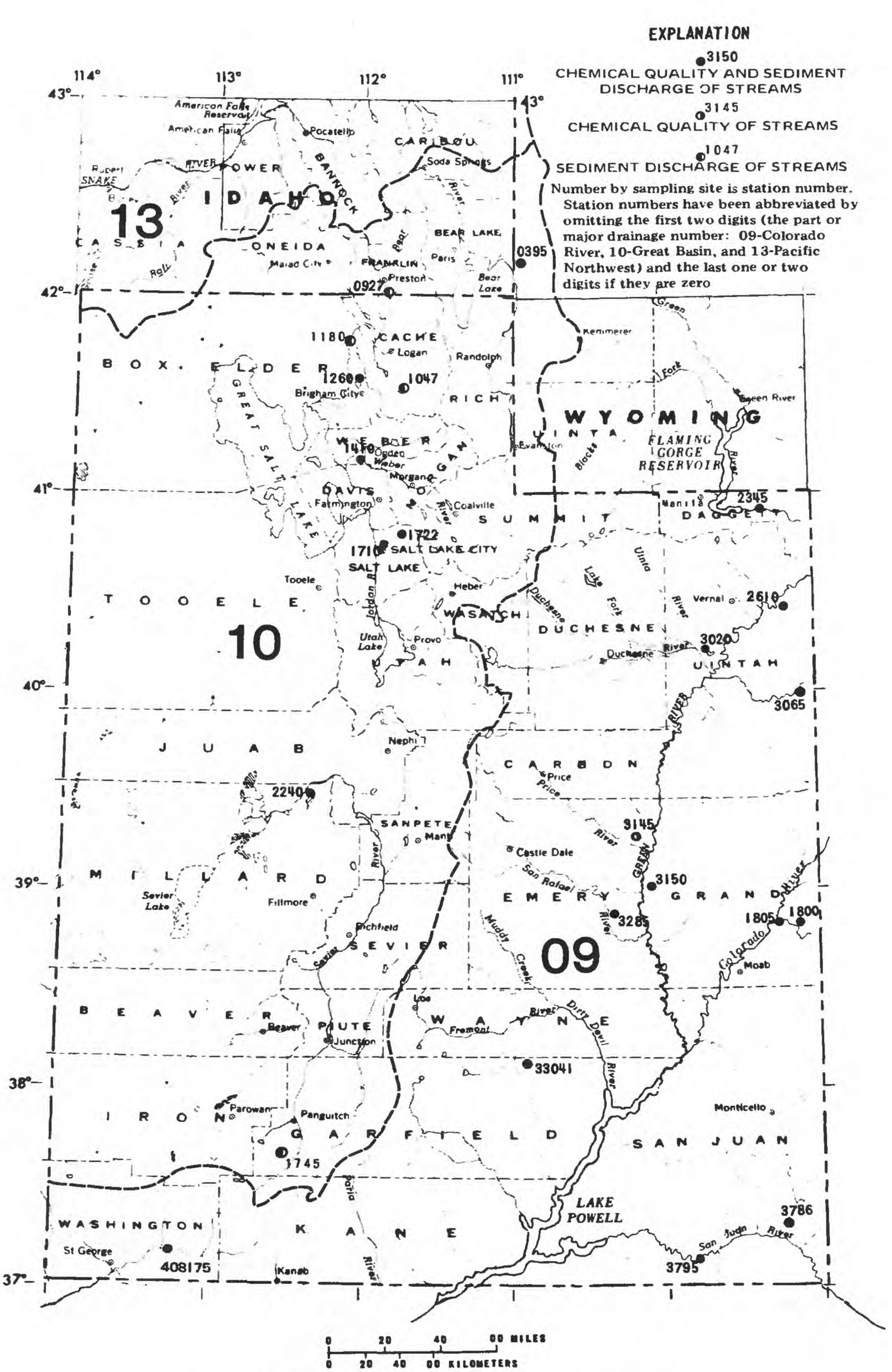


Figure 4. Location of surface-water-quality stations.

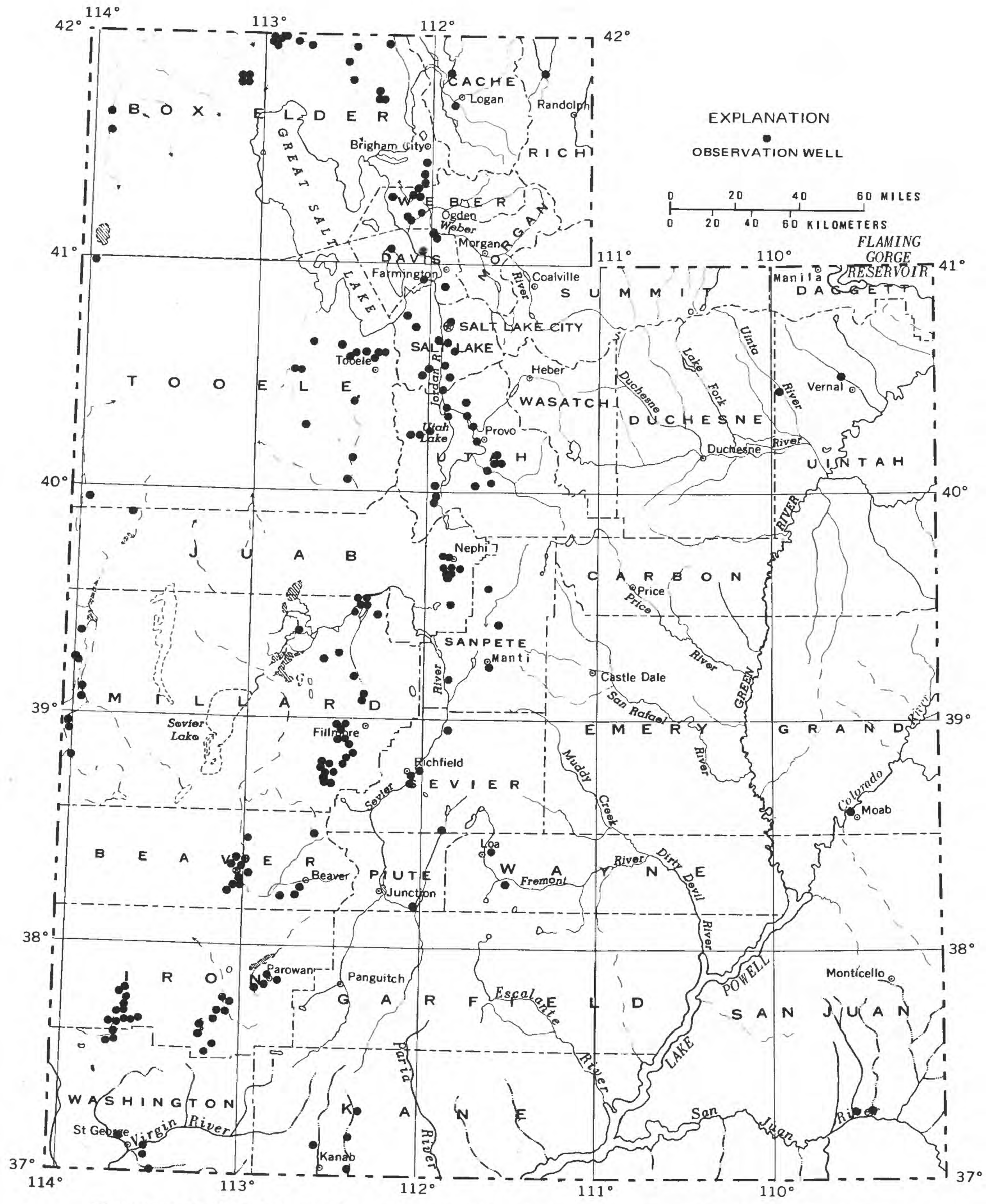


Figure 5. Location of observation wells where water samples were collected for monitoring water quality.

Interpretive Studies

Locations of interpretive studies discussed in this section are shown in figure 6.

Statewide Water Use

Number: UT–00–007

Cooperating Agencies: Utah Division of Water Rights; Utah Division of Water Resources

Staff: H.K. Hadley, Hydrologist, Project Chief (part time)
G.E. Pyper, Hydrologist (part time)
K.K. Wilson, Hydrologic Technician (part time)

Period of Project: Began July 1977, continuing

Problem: In 1977, the U.S. Congress recognized the need for consistent, current, and reliable information on water use for the entire United States and directed the USGS to set up a program to collect, compile, and publish such data. These data are needed to document trends in total use of water and in the different categories of use, and to aid in the management of the Nation's water resources.

Objective: To obtain information about withdrawals and return flows of water for different uses and consumptive use of water in connection with each type of withdrawal.

Approach: Determine total water diversions and consumptive use by verification of user measurements and records and, where possible, by field inventory and measurement of surface-water diversions and selected types of ground-water diversions. Use acreage and crop surveys to aid in estimating consumptive use by irrigation. State personnel are collecting data on public-supply and industrial use; USGS personnel are collecting data on irrigation use.

Progress: Mail surveys were done by the Utah Division of Water Rights to determine water use by about 390 public water suppliers and about 120 major self-supplied and public-supply industries. Text and graphics for a 1985 and 1990 State water-use report were prepared for editorial review. A detailed critique was written on the 1990 compilation.

Plans For Next Year: Write a project proposal to determine consumptive water use in the commercial category for a rapidly growing city in southwestern Utah. Obtain funding for the commercial consumptive use proposal, secure cooperative matching funds, and begin work. Assist the Utah Division of Water Resources with their annual agricultural land-use survey. Continue efforts to improve estimates of irrigation water use by obtaining better and more current data by means of increasing communication with the Soil Conservation Service and the Utah Department of Agriculture, and by netlinking to the Utah Division of Water Resources land-use database.

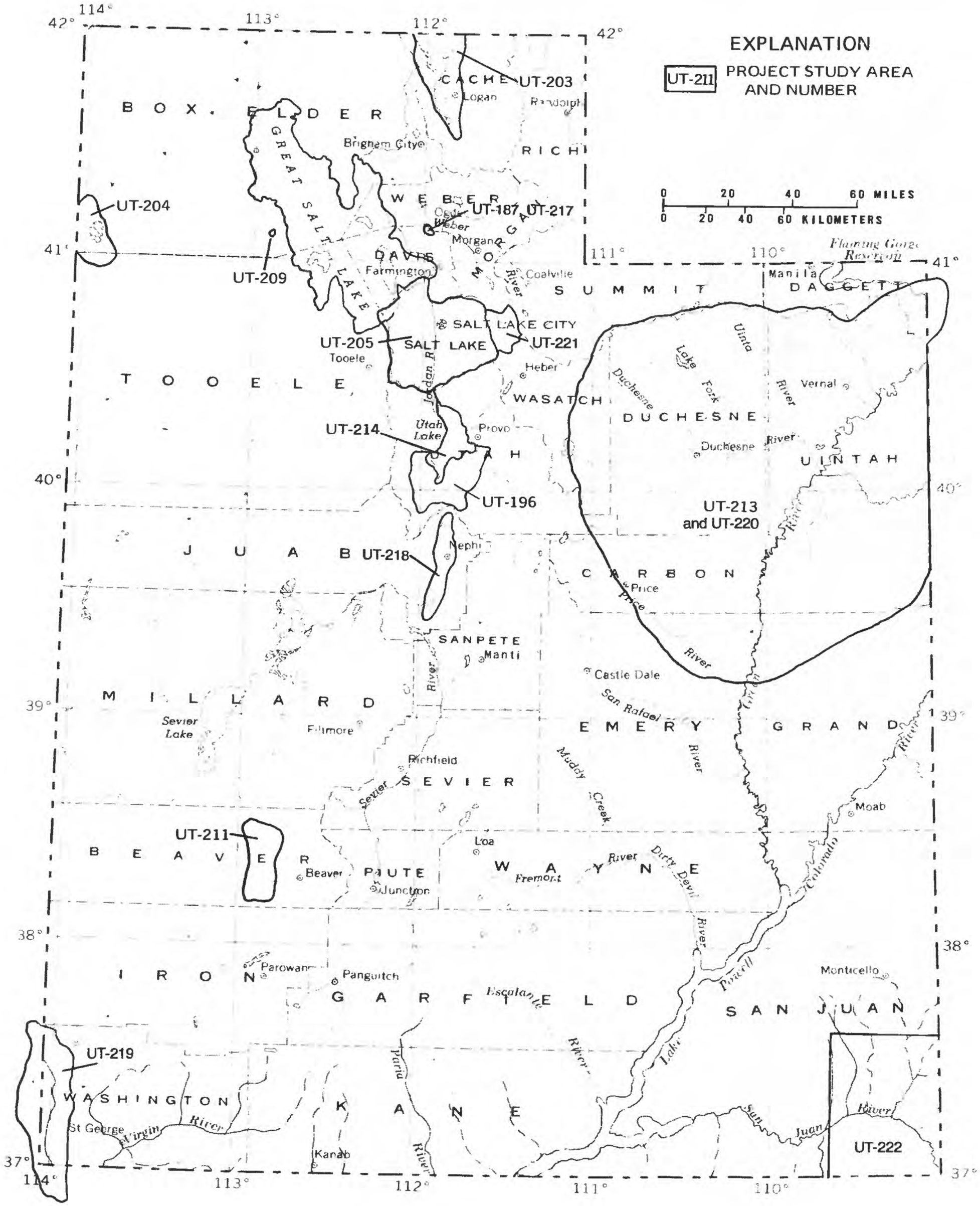


Figure 6. Location of interpretive studies.

Ground-Water Contamination at Hill Air Force Base, Landfills 1 and 2

Number: UT–88–187

Cooperating Agency: U.S. Air Force

Staff: K.M. Waddell, Hydrologist, Project Chief
D.E. Wilberg, Hydrologist
L.J. Gerner, Hydrologist
S.R. Wold, Hydrologist (part time)
R.W. Puchta, Hydrologist (part time)
V.M. Heilweil, Hydrologist
J.L. Mason, Hydrologist (part time)
P.L. Haraden, Hydrologic Technician (part time)
L.C. Conroy, Hydrologic Technician (part time)
Other District and Regional personnel as assigned

Period of Project: October 1987 to September 1993

Problem: Trichloroethylene and benzene have been identified in shallow ground water downgradient from landfills 1 and 2 at Hill Air Force Base, Utah. These sites are near the installation boundary, and the possibility for contaminant migration off the installation exists. Under the Department of Defense Installation Restoration Program, the U.S. Air Force must characterize the wastes, determine the extent of contamination, and determine if remedial action is required.

Objectives: (1) To conduct a remedial investigation/feasibility study at landfills 1 and 2, Hill Air Force Base, to identify the existence of hazardous waste and to evaluate the source, extent, and degree of contamination of ground water; (2) to assess the risk to human health and the environment; and (3) to define and assess alternative actions that will control or eliminate the risk.

Approach: Determine the hazard level of the site so that proper safety equipment can be used. Define the source, extent, and degree of contamination by sampling and analyzing soil gas, by drilling and logging test holes and completing them as monitoring wells, by analyzing borehole-geophysical logs, and by sampling and analyzing drillhole cuttings and water. Conduct surface-geophysical surveys and use data from test holes to characterize the local hydrogeologic system. Measure water levels in monitoring wells to determine directions of ground-water movement. The data collected at the site will be used by a subcontractor to prepare a risk assessment. Construct a three-dimensional computer model of the ground-water flow system to aid in assessing several methods of contamination remediation at the site.

Progress: None.

Plans for next year: Submit reports for Director's approval.

Ground Water in Southern Utah and Goshen Valleys, Utah County

Number: UT–88–196

Cooperating Agency: Utah Division of Water Rights

Staff: L.E. Brooks, Hydrologist, Project Chief
B.J. Stolp, Hydrologist

Period of Project: October 1988 to September 1993

Problem: Southern Utah and Goshen Valleys are along the Wasatch Front, where most of Utah's population is located and where population growth is rapid. Thick basin-fill deposits contain large volumes of good-quality water that has been developed for irrigation, municipal, and industrial use. Further development of ground water, most of which is proposed for municipal use, has been limited because of the probable effects on surface water that drains to Utah Lake and the effects on the lake itself, which is a source of water for irrigation downstream. In addition, many wells flow under artesian pressure, and additional ground-water development would likely cause some wells to stop flowing. The State would like to know the effects that additional ground-water development would have on water levels, surface water, and water quality, and the effects of importing additional surface water, by the Central Utah project, on the ground-water system.

Objectives: (1) To assess current hydrologic conditions in terms of recharge, movement, and discharge of ground water, water levels, ground-water quality, and volumes of ground water in storage; (2) to better define the ground-water system and how its components interact; and (3) to estimate the effects of additional ground-water withdrawals on water levels, water quality, and surface water and the effects of importation of additional surface water on the ground-water system.

Approach: (1) Compile existing data on wells, springs, water levels, ground-water quality, and surface-water flow; (2) inventory or estimate ground-water discharge from wells and springs, to drains and streams, and by evapotranspiration and seepage to Utah Lake; (3) estimate recharge, where feasible, from streams, irrigation, precipitation, and subsurface flow from consolidated rock; (4) conduct aquifer tests to improve knowledge of hydrologic characteristics of the basin fill; (5) construct a three-dimensional digital model of the ground-water system to simulate and better understand ground-water flow, and estimate effects of proposed changes in water use on the system; (6) prepare a basic-data report and an interpretive report for publication by the Utah Department of Natural Resources.

Progress: Completed review and published the basic-data report for the project. Completed steady-state and transient-state calibration of the ground-water flow model, sensitivity analysis, and simulations. Completed the interpretive report, which is now in review.

Plans for Next Year: Complete review and publish the interpretive report. Archive the computer ground-water flow model and geographic information system data.

Reports:

Stolp, B.J., Drumiler, Marilyn, and Brooks, L.E., 1993, Selected hydrologic data for southern Utah and Goshen Valleys, Utah, 1890-1992: Utah Hydrologic-Data Report No. 50.

Ground Water and Ground-Water/Surface-Water Relations in Cache Valley, Cache County, Utah, and Adjacent Part of Idaho

Number: UT–89–203

Cooperating Agencies: Utah Division of Water Resources; Utah Division of Water Rights

Staff: K.A. Kariya, Hydrologist, Project Chief
D.M. Roark, Hydrologist
K.M. Hanson, Hydrologic Technician

Period of Project: September 1989 to December 1992

Problem: Cache Valley is a north-south trending valley of about 660 square miles in northeastern Utah and southeastern Idaho. The State of Utah would like to know the potential for increased ground-water development and the possible hydrologic effects of such development. The State also would like to know how different patterns of ground-water development would affect water levels, streamflow, spring discharge, water quality, and evapotranspiration.

Objectives: (1) To assess current ground-water conditions including water levels, well and spring discharge, ground-water quality, and volumes of water in storage, and to document changes in conditions since the last study in 1967-69; (2) to better define the components of the ground-water system in terms of recharge, movement, and discharge, with emphasis on ground-water/surface-water relations; and (3) to determine how the components of the system interact, and to estimate the effects of additional ground-water withdrawals, in various geographic patterns, on water levels, streamflow, spring discharge, and evapotranspiration.

Approach: Compile available data on wells, springs, water levels, ground-water quality, and streamflow, focusing on post–1969 data, and collect data on wells drilled since the last study in 1967–69. Measure or estimate ground-water discharge from wells and springs, to drains and streams, and by evapotranspiration. Estimate recharge from streams; irrigation, including that from canals; precipitation; and subsurface flow from consolidated rock. Conduct seepage runs on streams to define ground-water/surface-water relations and estimate recharge from and discharge to streams. Prepare a map of the potentiometric surface and, if sufficient data are available, prepare maps showing aquifer thickness. Conduct aquifer tests to improve knowledge of hydraulic characteristics of the basin fill. Construct a three-dimensional digital model of the ground-water system to determine how the components of the system interact and how increased development of ground water in different parts of the valley might affect water levels, spring discharge, streamflow, and evapotranspiration. Prepare a basic-data report and an interpretive report for publication by the Utah Department of Natural Resources.

Progress: Final report was written and submitted for colleague and editorial review.

Plans for Next Year: Submit the report for approval. Publish the report.

Identification and Quantification of Mechanisms Causing Decreasing Salt-Crust Thickness, Bonneville Salt Flats, Western Utah

Number: UT-90-204

Cooperating Agency: Bureau of Land Management

Staff: J.L. Mason, Hydrologist, Project Chief
W.C. Brothers, Hydrologist
G.E. Pyper, Hydrologist (part time)
P.S. Muir, Hydrologic Technician
K.L. Kipp, Hydrologist, National Research Program, Denver, Colorado (part time)

Period of Project: January 1990 to September 1994

Problem: From 1960 to 1988, decrease of the salt-crust thickness at the Bonneville Salt Flats equated to a decrease in volume of 34 million cubic yards (40 million tons). The decrease is of concern to the Bureau of Land Management because the Bonneville Salt Flats are a unique geologic feature and recreation area, and according to management plans drafted in 1985, should be preserved for future generations.

Objectives: (1) To document changes in the hydrologic system of the Bonneville Salt Flats since the Utah District's study by Lines (1979); (2) to establish a data-collection network to monitor changes in water levels, water chemistry, and salt thickness at the Bonneville Salt Flats; (3) to assess the potential for removal of salts from the salt-flats area through wind-driven ponds; and (4) to assess the effects of current brine withdrawals, other human-induced variations, and climatic changes on the hydrologic system.

Approach: (1) Prepare a detailed plan of study and review entire plan with the Bureau of Land Management (BLM) and the Technical Review committee formed by BLM. (2) Define formation and movement of ponds using LANDSAT data and available aerial photography of the salt-flats area. (3) Develop a three-dimensional solute-transport model. (4) Compile data collected or available since the Lines (1979) study, including brine-withdrawal, water-level, chemical-analysis, meteorological, soil-moisture, and other pertinent data for the past 12 years. (5) Locate observation wells drilled during and prior to the Lines study. (6) Establish an observation-well network to measure water levels monthly and collect samples of brine for density analysis. (7) Drill new observation wells on and adjacent to the salt flats. Cores will be collected and analyzed for mineralogical content. Salt thickness and water levels will be measured, samples of brine will be collected and analyzed, and the wells will be added to the observation-well network. Nested wells (adjacent wells completed at different depths) will be part of the drilling plan to determine vertical variation in water levels, water density, and chemistry. One or more production wells (8 inches or larger) and several observation wells near each production well will be drilled for use in an aquifer test or tests. (8) Conduct and analyze aquifer tests. (9) Conduct geochemical studies to estimate geochemical flowpaths and reactions along these paths and to describe processes that may increase or decrease salt thickness and areal extent. (10) Design and construct a transport model to simulate the flow rates, flowpaths, and chemical concentrations and migration of selected constituents. The model will be used to simulate future water levels and ground-water chemistry. (11) Prepare reports documenting the results of the study.

Progress: Water levels were measured in observation wells during October 1992. Greater-than-average precipitation during the winter of 1992-93 resulted in excessive surface ponding that persisted into early summer. Water levels were measured in several observation wells during March and April 1993. Complete water-level measurements were made in May and July 1993. Additional drilling of observation wells included five wells completed to 63 feet to determine vertical hydraulic gradient, seven shallow wells along the western margin to delineate the horizontal hydraulic gradient, and three shallow wells between the salt crust and collection ditch to examine infiltration from surface ponds. Sampling of observation wells for chemical analysis included the 5 new wells completed to 63 feet, 30 shallow wells to make seasonal comparisons with analyses from the previous year, and 12 shallow wells in Pilot Valley. The quantity of tritium, deuterium, and oxygen-18 was determined in samples from several wells to assess possible circulation between surface ponds and the shallow-brine aquifer. The difference in chloride-bromide ratios

between pore fluids and water collected from observation wells indicates the presence of a dual porosity system in the shallow-brine aquifer. Three satellite images that include the Bonneville Salt Flats and Pilot Valley have been obtained for September 1992 and March and August 1993. These images will be used in conjunction with measurements of the salt crust to estimate the volume of salt redistributed by surface ponds during the winter of 1992-93. A three-dimensional solute-transport model of the shallow-brine aquifer underlying the Bonneville Salt Flats is being developed. Boundary conditions have been tested on a simplified version prior to calibration of a finely discretized version.

Plans for Next Year: Continue development and calibration of solute-transport model. Complete interpretation of satellite imagery and finalize estimate of salt redistribution. Use chemical and isotopic data for interpreting groundwater flow direction and identifying hydrologic processes that affect the salt crust. Complete data report. Prepare draft of final interpretive report.

Ground-Water Flow and Solute Migration in Salt Lake Valley, Utah

Number: UT-90-205

Cooperating Agencies: Utah Division of Water Rights; Utah Division of Water Quality; and local municipalities and water agencies

Staff: G.W. Freethey, Project Supervisor (part time)
S.A. Thiros, Hydrologist
P.M. Lambert, Hydrologist
V. M. Heilweil, Hydrologist (part time)
M.F. Bradbury, Hydrologic Technician (part time)

Period of Project: March 1990 through September 1994

Problem: The Utah Divisions of Water Rights and Water Quality are facing a dilemma as ground-water resources are developed in Salt Lake Valley. Currently allocated water rights are thought to exceed the total annual inflow of good-quality ground water to basin-fill sediments in the valley. The Division of Water Rights needs to know the effects of additional ground-water development on the hydrologic system. Both Divisions need to determine the source area for water withdrawn from proposed wells at several locations within the valley to anticipate and prevent migration of poor-quality water to points of withdrawal, and thus to better manage development of the principal aquifer.

Objectives: (1) To better define the quality of water in the shallow unconfined aquifer and the underlying confining unit in Salt Lake Valley; (2) to determine the hydrologic properties of the shallow unconfined aquifer and the confining unit; (3) to better define the valley's ground-water/hydrochemical flow system, including three-dimensional variation of hydrologic properties and ground-water quality; and (4) to provide the Utah Divisions of Water Rights and Water Quality with a means of determining the quantity of water that can be withdrawn from different areas in Salt Lake Valley without causing significant water-level declines and without inducing water with high concentrations of dissolved solids or contaminants to migrate toward wells used for municipal and industrial supply.

Approach: The approach to achieving the objectives will involve several components of field investigation and information interpretation. These components are integrated and each is necessary to accomplish the objectives stated. In general, these components are: (1) determine properties of the shallow unconfined and principal aquifers and the confining unit and chemical composition of the water by drilling, field testing of water-level response to withdrawals from wells, and laboratory testing of cores and water samples; (2) determine the extent of the effects of variable-density fluid on fluid movement; (3) update and refine the existing ground-water-flow model; (4) conduct particle-tracking and solute-transport simulations using the model to increase knowledge about the source and movement of water with large concentrations of dissolved solids; and (5) synthesize collected information and prepare reports.

Progress: The interpretive report has been completed and submitted for supervisory review. Transient-state calibration of the model has been completed. Estimates of storage and specified recharge were adjusted within reasonable ranges to minimize differences between measured and model-computed water-level changes at 47 observation sites. Estimated annual seepage to the Jordan River from ground water was compared with computed values for yearly time steps. The effects of changes in annual precipitation and water use on recharge to the basin fill were defined and analyzed during transient-state calibration. Simulations are based on variations in ground-water recharge resulting from changes in precipitation on the valley floor, precipitation in the mountains, and streamflow at the mouth of canyons. Declines in the quantity of recharge from irrigated land as a result of urbanization of farmlands also are simulated. A report documenting the calibrated model has been submitted for supervisory review.

Plans for Next Year: Work will be focused on particle-tracking analyses that incorporate different water-use conditions and on the development and calibration of solute-transport simulations using the calibrated U.S. Geological Survey MODFLOW model. The particle-tracking analysis delineates travel-time-related three-dimensional capture zones (zones of transport) for selected pumping sites or areas. Flowpaths and travel times of ground water will be defined using the MODPATH program and output from the steady-state simulations. Data-defining parameters for

the particle-tracking and solute-transport analyses will be compiled. Estimates of projected rates of withdrawals for 1994-2019 will be compiled for use in the analyses. Pumping sites for the particle-tracking analysis will be selected, and MODPATH will be run using output from the steady-state and transient-state calibrations. The solute-transport model will be calibrated based on hydrologic conditions for 1969-91. Reports will be written to document the particle-tracking analyses and the results of solute-transport modeling and will be submitted for review.

Characterization of the Hydrology in the Vicinity of the Solid-Waste Landfills, Utah Test and Training Range, Box Elder County, Utah

Number: UT-91-209

Cooperating Agency: U.S. Air Force

Staff: Michael Enright, Hydrologic Technician, Project Chief
W.F. Holmes, Hydrologist (part time)
Other District personnel as assigned

Period of Project: October 1990 to March 1993

Problem: Hill Air Force Base operates two solid-waste landfills at the personnel complex at the Utah Test and Training Range near Puddle Valley. The U.S. Air Force believes it is in their best interest to implement a ground-water-monitoring program that will facilitate compliance with the U.S. Environmental Protection Agency and State of Utah proposed rules. These rules will require owners and operators of solid-waste landfills to pattern their operations after chemically secure hazardous-waste landfills.

Objectives: To design, construct, and implement a ground-water-monitoring system for the basin-fill aquifer at the solid-waste landfills at the Utah Test and Training Range.

Approach: Three monitoring wells will be located to determine the direction and rates of regional and local ground-water movement. Lithologic logs, laboratory geotechnical and chemical analyses of sediments, and geophysical logs will help to qualitatively evaluate the potential for migration of leachates from the landfills through the unsaturated zone to the water table. Hydrologic properties of the principal aquifer will be determined from aquifer tests. Ground-water samples will be collected for chemical analysis to determine if leachates from the landfills have reached the principal aquifer.

Progress: Final report was written, reviewed, approved, and submitted to the U.S. Air Force.

Plans for Next Year: None.

Recharge to Basin-Fill Aquifers from Irrigation, Southwestern Utah

Number: UT-91-211

Cooperating Agency: Utah Division of Water Rights

Staff: D.D. Susong, Hydrologist, Project Chief
Other District personnel, as assigned

Period of Project: October 1991 to September 1994

Problem: Irrigators are converting from flood- to sprinkler-irrigation systems in some areas of Utah and are requesting to increase irrigated acreage based on water saved because of conversion. This change in irrigation methods probably will affect recharge to basin-fill aquifers, and these effects are largely unquantified. An understanding of how this change in irrigation methods might affect the quantity of ground-water recharge to the basin-fill aquifers is needed to manage future ground-water withdrawals and to determine whether it is justified to permit expansion of irrigated acreage based on water savings using sprinkler systems.

Objective: Determine the quantity of recharge to basin-fill aquifers from flood- and sprinkler-irrigation methods.

Approach: Recharge to basin-fill aquifers will be determined by water-budget and infiltration-rate methods. A study site of paired flood- and sprinkler-irrigated fields in the Milford area will be instrumented with (1) monitoring wells and neutron-access tubes, (2) tensiometers, (3) weirs, (4) flow meters, and (5) automated weather stations. The VS2D unsaturated-flow model will be used to evaluate infiltration and downward flow at each site.

Progress: The second year of data collection was completed. The water budget for the flood- and sprinkler-irrigated field has been completed and model calibration is nearly complete. The introductory sections and water-budget section of the report are completed.

Plans for Next Year: The model simulations will be completed and the modeling section of the report will be written. Report will be completed and submitted for review and approval. The objective is to publish the report by the end of the year.

Hydrologic Study of Lower Ashley Creek, Uintah County, and Monitoring for Remedial Activities Related to Selenium Contaminants, Middle Green River Basin, Utah

Number: UT-91-213

Cooperating Agencies: Bureau of Reclamation; U.S. Fish and Wildlife Service

Staff: D.W. Stephens, Hydrologist, Project Chief
Other District personnel, as assigned

Period of Project: October 1990 to September 1994

Problem: Studies completed at Stewart Lake Waterfowl Management Area (WMA), Ashley Creek, and Ouray National Wildlife Refuge (NWR) identified several areas where selenium was adversely affecting the beneficial use of water and creating a hazard to wildlife. The studies showed the source of contamination at Stewart Lake WMA to be drainwater from soils derived from Mancos Shale. Median concentrations of selenium in drainwater discharged to Stewart Lake exceeded the State standard of 5 micrograms per liter (µg/L) established for wildlife protection and were as high as 140 µg/L. The lake was an effective sink for dissolved selenium and retained 75 percent of the total inflow load in sedimentary deposits. Selenium concentrations in waterbird tissue at Stewart Lake WMA were high, ranging from 1.9 micrograms per gram (µg/g) (dry weight) in Canada goose muscle to 87 µg/g in American coots.

The studies showed that the source of contamination in Ashley Creek was inflow of shallow ground water and surface water that originates from a sewage-lagoon system and flows through Mancos Shale, mobilizing selenium. Selenium concentrations in the ground water seeping into Ashley Creek were as large as 16,000 µg/L. Waterfowl contained selenium concentrations as high as 50.3 µg/g in liver and 27.2 µg/g in muscle tissue.

Selenium contamination of ponds at Ouray NWR was limited to a small area on the western part of the refuge, and the studies showed the contamination to be a result of seepage of shallow ground water into ponds used by waterfowl. The Bureau of Reclamation needs additional information on selenium contamination in the middle Green River Basin and assistance in designing a monitoring system to evaluate any remedial activities they may undertake.

Objectives: Further define the hydrologic system for Ashley Creek and complete a selenium mass-balance model. Design and implement a monitoring program for selenium contamination at Stewart Lake WMA, Ouray NWR, and in the Green River that will provide data needed to evaluate possible remedial actions. Formulate and evaluate potential remedial actions.

Approach: (1) Sample water and sediment to determine the sources of selenium entering Ashley Creek and the Green River; (2) quantify the extent of sediment contamination in ponds at Ouray NWR and in Stewart Lake; (3) design a monitoring program to assess changes in the aquatic systems with time and in response to remedial action in the middle Green River Basin; and (4) obtain public input on potential remedial options and then assemble and evaluate options to select the preferred package for remediation.

Progress: Additional samples of sediment and water indicated that selenium from U.S. Department of the Interior projects did not constitute an environmental threat within the Vernal unit, and further consideration of this area was limited to providing expertise needed to resolve the selenium issues associated with the Vernal sewage lagoons. The areal extent of selenium in bottom sediment at Ouray NWR and Stewart Lake WMA was determined and will be used for remediation planning at both areas. A water-quality monitoring program was implemented for Stewart Lake WMA, Ouray NWR, and the Green River and will be carried forward until remediation of the areas is complete and verified. Several public meetings were held and the 85 options for remediation were reduced to 7 alternative packages.

Plans for Next Year: Continue monitoring at Stewart Lake WMA, Ouray NWR, and sites on the Green River. Finalize the preferred alternative packages and, in cooperation with the public, select the preferred alternative for remediation. Complete the Environmental Impact Statement for the Jensen Unit (Stewart Lake WMA) and prepare documentation needed to secure funding. Complete analysis of independent remediation alternatives for Ouray NWR in cooperation with the U.S. Fish and Wildlife Service.

Investigation of Springs in and Adjacent to Utah Lake, Utah County, Utah

Number: UT-91-214

Cooperating Agency: Central Utah Water Conservancy District

Staff: R.L. Baskin, Hydrologist, Project Chief
L.E. Spangler, Hydrologist (part time)
W.F. Holmes, Hydrologist (part time)

Period of Project: February 1991 to September 1993

Problem: The Central Utah Project (CUP) is a State/Federal project to develop water in the Colorado River Basin of eastern Utah for diversion to and use in the Great Basin of western Utah. As part of the CUP, some of the freshwater streamflow to Utah Lake, in Utah Valley, will be diverted for use in Utah and Salt Lake Valleys. As a result of this potential diversion of freshwater before it flows into Utah Lake, the salinity of the lake is predicted to rise. In an effort to reduce the salinity of the lake, the Central Utah Water Conservancy District (CUWCD), the operator of CUP, would like to control and divert sources of saline-water inflow to Utah Lake. The CUWCD needs information on the discharge of saline and freshwater springs to Utah Lake to quantify water and chemical budgets for the lake and manage water quality.

Objectives: The objectives of the project are (1) to study known thermal saline springs in the Bird Island-Lincoln Point area of Utah Lake to identify, as closely as possible, their geologic source; to determine, if possible, the paths that thermal saline water takes to points of discharge in and adjacent to Utah Lake; and to obtain better estimates of the location, discharge, and quality of water from known thermal saline springs; and (2) to study previously unidentified thermal saline springs and other major saline and freshwater springs in and adjacent to Utah Lake to determine their location, discharge, and quality of water.

Approach: For known thermal springs, (1) compile and evaluate data from all significant studies in and adjacent to Utah Lake, and evaluate all studies of geothermal ground water along the Wasatch Front and the relevance of these studies to thermal springs in Utah Lake; (2) conduct hydrologic reconnaissance of all springs and wells that can be inventoried readily on land or in shallow water in the Bird Island-Lincoln Point area; (3) map lake-bed topography at Bird Island and Lincoln Point to help define geologic conditions related to spring locations; (4) conduct a geophysical (marine seismic) survey of the part of Utah Lake around Bird Island and Lincoln Point (about 40 miles of profiles) to help estimate the paths that thermal saline water might take to the lake; (5) conduct an aquifer/interference test using a well completed in consolidated rock at or near Lincoln Point; and (6) conduct a thermal mass-balance survey of Utah Lake in the vicinity of Bird Island and Lincoln Point.

For previously unidentified springs, (1) compile and evaluate all studies of Utah Lake and its known springs; (2) conduct a thermal-imagery survey of Utah Lake to help locate all springs; (3) measure discharge of selected freshwater springs and use measurements to develop a relation between thermal anomalies and discharge that can be used to estimate the discharge of other springs; and (4) collect water samples from representative springs for chemical analysis, including selected isotope analysis.

Progress: The topographic and bathymetric surveys of shore/near-shore areas have been completed. The surveys include the topography of on-shore travertine and tufa deposits, known spring locations, locations of flumes, wells, and springs monitored during the interference test, submarine topography to a depth of about 5 feet, and notes on the composition of bottom materials encountered during the bathymetric survey.

Nineteen springs above the current level of Utah Lake in the Lincoln Point-Bird Island area have been found and their discharge measured. Two submarine springs located near Bird Island have been identified and discharges measured beneath the surface of the lake.

All major springs above current lake level in the Lincoln Point-Bird Island area have been measured for temperature, pH, and specific conductance. Three of the larger springs and three wells in the Lincoln Point area have been sampled for analysis of major constituents. One of the large springs also has been sampled for tritium analysis.

Stable-isotope (oxygen/deuterium) samples have been collected from three springs and three wells. Water from the two submarine springs located at Bird Island has been measured for temperature, pH, and specific conductance, and samples have been collected for analysis of major constituents. In addition, a spring above current lake level on Bird Island has been measured for temperature, pH, and specific conductance, and water for laboratory analysis of major constituents has been collected.

An interference test was completed in the Lincoln Point area by pumping from an existing well. Observation points included one nearby well, a staff gage installed in a spring-fed pond, and four flumes installed to measure spring discharge. Discharge, pH, temperature, and conductivity of water from the pumped well, and water level or stage at the observation points, were measured during the test period.

The marine-seismic survey has been completed in the area between Lincoln Point and Bird Island. Thirteen cross sections were completed with geographic control determined using a global positioning system. The geographic data have been reduced, entered into the computer, and plotted on maps. The original geophysical data have been copied onto work sheets, and evaluation of the data is complete. An interpretive report has been prepared and is in review.

Thermal data have been collected for the entire lake and the data have been returned to Utah for evaluation. Processing of the data is complete and an interpretive report is being prepared.

Data collection for the project has been completed. This first interpretive report has been approved by Headquarters and is currently being prepared for printing. The second interpretive report has undergone supervisory review and is being prepared for colleague review. The third interpretive report is nearly complete and should enter the review process in April 1994.

Plans For Next Year: Print and distribute the first interpretive report. Complete review of and print the interpretive report on the results of the marine-seismic survey. Prepare a technical report on methods of investigation (journal article) for the thermal imaging survey and submit for review. Prepare a final interpretive report on results from thermal imaging survey, results of water-quality analyses, stable-isotope studies, geothermometer calculations, and other associated investigations.

Geochemistry of Contaminated Area near Landfills 1 and 2, Hill Air Force Base, Utah

Number: UT-92-217

Cooperating Agency: U.S. Air Force

Staff: Kidd Waddell, Hydrologist, Project Supervisor (part time)
D.E. Wilberg, Hydrologist, Project Chief
Briant Kimball, Hydrologist (part time)

Period of Project: October 1991 to September 1993

Problem: Remedial Investigation (RI) of landfills 1 and 2, which make up much of Operable Unit 4 at Hill Air Force Base, Utah, was begun by the USGS as project UT-187 in July 1988. Data collected as part of the RI have shown the need for a more detailed geochemical investigation to verify the location of the sources of sulfate and the types of compounds from which sulfate was derived near landfill 1. Mass-balance computations that used the major inorganic ions could not distinguish whether sulfate was from gypsum board, which possibly was disposed of in landfill 1, or from reactions between sulfuric-acid waste and the soil and aquifer matrix. Also, data were not adequate to determine if observed dissolved trace metals were associated with leachates that may have seeped from the landfill.

Objectives: (1) To determine the location of the source of the sulfate, (2) to determine the compound(s) from which the sulfate is derived, (3) to distinguish between trace metals that originate from the source area (landfill 1) and those that occur naturally, and (4) to estimate the probable fate of the sulfate and other associated major inorganic contaminants.

Approach: Additional wells were drilled during 1992, both upgradient and downgradient from landfill 1. Ground water was sampled along apparent flowpaths that include both contaminated and uncontaminated areas and analyzed for stable isotopes of sulfur, hydrogen, oxygen, carbon, and nitrogen, and major ions and metals.

Progress: All chemical analyses were completed and data have been prepared for geochemical interpretation. Modeling was initiated but not completed.

Plans for Next Year: Complete modeling and submit journal article for review.

Ground Water in Juab Valley, Juab County, Utah

Number: UT-92-218

Cooperating Agencies: Central Utah Water Conservancy District; East Juab County Water Conservancy District

Staff: S.A. Thiros, Project Chief (full time)
J.I. Steiger, Hydrologist (part time)
H.K. Hadley, Hydrologist (part time)
B.J. Stolp, Hydrologist (part time)

Period of Project: January 1992 to September 1995

Problem: Water will be imported into Juab Valley, mostly for irrigation, and possibly through Juab Valley to the Sevier River Basin, as part of the Central Utah Project. The Central Utah Water Conservancy District wants to optimize the size of the pipeline delivering water to and through Juab Valley and needs to know how much of local peak demand can be met by ground water. The East Juab County Water Conservancy District wants to optimize use of water in the valley, including local surface water, local ground water, and imported water, and needs information on ground water and the effects of its development in order to integrate ground-water use and development into the overall water-management plan for Juab Valley.

Objectives: (1) To assess current ground-water conditions and document changes since previous studies during 1962-66; (2) to define and quantify the ground-water system of the valley—aquifers and aquifer coefficients, estimated recharge, movement, estimated discharge, and water quality; (3) to evaluate current and potential sources of ground-water contamination and salinity in the southern end of the valley; and (4) to provide a tool to understand the valley's ground-water system and to estimate the effects of changes in ground-water withdrawals or recharge on water levels, natural discharge, and water quality.

Approach: (1) Compile all available data and inventory significant new wells and selected springs; (2) measure water levels in wells and prepare a potentiometric-surface map; (3) use drillers' logs to improve definition of aquifers and to map the recharge area; (4) conduct aquifer tests to improve definition of aquifer coefficients; (5) estimate and measure the components of recharge and discharge; (6) identify areas of ground-water quality deterioration and analyze water samples to better define water-quality problems; and (7) construct and calibrate a three-dimensional model of ground-water flow.

Progress: Potentiometric contours were mapped from water levels measured in the valley during March and September 1993. Water levels in 27 wells have been measured on a monthly basis since March 1993. Irrigation wells in the valley were visited in July to measure discharge rates and to provide data needed to estimate annual withdrawals. Multiple-well aquifer tests were done in Nephi and near Levan. Slug tests were done at five wells, and the specific capacity of selected wells in the valley was determined from drillers' logs.

Gain-loss studies were done on Salt Creek and nearby ditches during August and November 1993. Streamflow records and statistics for streamflow-gaging stations in the area have been compiled. Water-quality samples were collected from 24 hydrologic-data sites (16 wells, 5 springs, and 3 surface-water sites), mainly in the northern part of Juab Valley, during July and August 1993. Data to be analyzed include major ion concentrations and oxygen-18/oxygen-16 and deuterium/hydrogen ratios. A ground-water flow model for Juab Valley is being constructed.

Plans for Next Year: The budget components of the ground-water system will be estimated. Arrays representing estimates of aquifer properties and recharge and discharge rates for the valley will be developed and added to the ground-water flow model. These arrays will be refined so the model can more accurately simulate water levels measured in wells. A report addressing the objectives of the study will be written.

Hydrologic Reconnaissance of the Beaver Dam Wash Area of the Virgin River Basin, Washington County, Utah, Mohave County, Arizona, and Lincoln County, Nevada

Number: UT-93-219

Cooperating Agencies: Utah Division of Water Resources; Nevada Department of Conservation and Natural Resources, Division of Water Resources; Arizona Department of Water Resources; and Bureau of Land Management

Staff: G.E. Pyper, Hydrologist, Project Chief (part time)
W.F. Holmes, Supervisory Hydrologist (part time)
M. Enright, Lead Hydrologic Technician (part time)

Period of Project: December 1992 to September 1995

Problem: The area that includes southwestern Utah, southeastern Nevada, and the northwestern corner of Arizona is one of the fastest-growing areas in the western United States. The three States would like to know the extent of water resources in the Beaver Dam Wash drainage basin, an undeveloped basin that includes parts of all three States and in which little is known about surface- and ground-water resources. The States also would like to know the potential effects of developing water in the riparian areas of the basin.

Objectives: (1) Improve understanding of surface water and surface-water quality, including estimating average annual flow at selected locations and mapping perennial reaches; (2) improve understanding of ground water by defining aquifers; estimating recharge, discharge, direction of movement, aquifer properties, and storage; and defining quality; (3) define surface-/ground-water relations; and (4) estimate a water budget for Beaver Dam Wash and determine annual surface- and ground-water flow from Beaver Dam Wash to the Virgin River.

Approach: (1) SURFACE WATER: Compile available surface-water data, correlate data from the new streamflow-gaging station in Beaver Dam Wash with nearby long-term stations to estimate long-term flow at the site, install a stream gage at the mouth of the wash, install a crest-stage gage at Lytle Ranch, use channel geometry to estimate average flow at selected locations on major tributaries, map perennial reaches of streams from the air, and sample surface water for chemical analysis; (2) GROUND WATER: Compile available ground-water data; inventory and sample wells and springs; construct potentiometric-surface maps; conduct geophysical surveys to define basin-fill thickness and character; drill, log, and sample test holes at one or more sites and conduct simple aquifer tests; conduct an aquifer test in the lower part of the basin where producing wells exist; use collected data to estimate quantity of ground water in storage; and conduct a reconnaissance survey of the outcrops of Navajo Sandstone in the upper part of the wash to estimate ground-water conditions; (3) SURFACE-/ GROUND-WATER RELATIONS: Conduct seepage runs, at low flows, of major perennial reaches; and use available aerial reconnaissance, seepage, and ground-water data to classify reaches as seasonally or perennially gaining or losing; and (4) WATER BUDGET AND OUTFLOWS: Using data from the stream gage at the mouth of the wash and estimates of long-term flow, estimate surface-water outflow to the Virgin River; using cross-sectional area of saturated basin fill from geophysical data, the hydraulic gradient from water levels in the lower part of the basin, and hydraulic conductivity inferred from aquifer tests, estimate ground-water outflow to the Virgin River valley; and using precipitation, seepage, stream gage, channel-geometry, ground-water withdrawal, evapotranspiration, and outflow data and estimates, estimate a water budget for Beaver Dam Wash.

Progress: Topographic and geologic map coverage of the vicinity have been obtained, a literature search has been completed, and available hydrologic, geologic, and climatic data for the area have been compiled. A stream gage at Beaver Dam, Arizona, near the mouth of Beaver Dam Wash, and a crest-stage gage at Lytle Ranch, about 20 miles upstream of the mouth, were installed. Sixty-seven wells were inventoried and 16 water-quality samples were collected. A water-level recorder on a well (600 feet deep) at Beaver Dam, Arizona, was installed. A seepage run from Motoqua to the mouth of Beaver Dam Wash was completed on April 14, 1993. A repeat seepage run was done on April 16, 1993, as a quality-control check. Aerial photographs of the wash were taken in June to determine areas of native vegetation (phreatophyte) in the flood plain. Arrangements were made with Utah State University (Dr.

Thomas Hardy) to obtain previously taken infrared photographs of the wash to determine change in vegetation resulting from flooding. The project work plan was written and distributed to the three States for review and comments. A meeting with personnel of the Bureau of Land Management (BLM) and U.S. Fish and Wildlife Service was held to determine the requirements necessary to obtain a right-of-way permit to do geophysical surveys and test drilling in an area designated Categories 1 and 2 desert tortoise habitat. An environmental assessment was prepared (and modified many times as requirements and jurisdiction changed) and submitted to BLM.

Plans for Next Year: From October 1993 through September 1994, (1) conduct earth-resistivity and seismic-refraction surveys of the unconsolidated basin-fill deposits along four roughly east-west traverses across the basin, with a connecting traverse north-south roughly along the floodplain of the wash (total length of survey lines to be about 40-50 miles); (2) select sites and drill test wells (four or five wells); (3) run simple aquifer tests and a more comprehensive test in the channel fill at the mouth of the wash; (4) complete a late-year seepage run and map areas of vegetation in the wash; (5) complete precipitation distribution map by altitude; (6) make preliminary estimate of average ground-water flow to the Virgin River valley; (7) make preliminary estimate of the volume of recoverable ground water in storage in the drainage and in each State's part of the area, if feasible; (8) make preliminary estimate of water budget for the wash; and (9) write report.

Data Synthesis of Results of Investigations Conducted Under the U.S. Department of the Interior National Irrigation Water Quality Program

Project Number: UT-93-220

Cooperating Agency: U.S. Department of the Interior, National Irrigation Water Quality Program

Staff: D.L. Naftz, Project Chief

Period of Project: October 1992 through September 1995

Problem: Extensive geochemical and hydrologic data from 25 sites in the western United States has been collected during geochemical studies conducted under the Department of Interior's National Irrigation Water Quality Program. The multivariate data set provides an opportunity to identify the geochemical and hydrologic characteristics of landscapes in which trace elements have been identified in irrigation runoff. Because of the large geographic coverage of this database, these characteristics then can be used to determine where other irrigation-induced water-quality problems may occur in other parts of the United States and in other countries.

Objectives: The overall objective is to identify geochemical commonalities and differences that affect water quality in irrigated areas in the western United States. Specific objectives of the project are to (1) use the constructed database to identify, using multivariate statistics, pattern-recognition modeling, and classification technique, how the hydrologic and geologic setting and geochemical and biologic processes link human activities to determine the magnitude, seasonality, and extent of contamination problems; (2) develop the capability to determine where irrigation drainage water-quality problems might occur so that problem areas can be identified; and (3) identify weaknesses in the data and offer suggestions to future investigators to improve data collection.

Approach: Normative salt assemblages, ionic ratios, and stable isotopes will be studied separately and together to evaluate commonalities and differences in trace-element source areas and geochemical weathering cycles among the 25 study sites. Although marine shales are common trace-element sources, little is known about trace-element source minerals or their weathering cycles, which mobilize the trace elements. The geochemical computer program SNORM will be used to calculate salt norms from the chemical analyses of water samples. The results from the SNORM calculations will be coupled with pattern-recognition modeling techniques to identify important trace-element weathering reactions. Results of the pattern-recognition modeling will be used to construct a geochemically based classification model using soft independent modeling by class analogy algorithms. This classification model can then be used to evaluate the potential for trace-element production in other areas without corresponding trace-element water-quality data applied to other areas.

Progress: Pattern-recognition software and associated computer hardware were purchased and assembled. Initial interpretation of the data was completed, and two papers and an abstract were prepared. A third paper on pattern-recognition analysis of selenium-producing landscapes in irrigated areas of the western United States is currently in preparation.

Plans for Next Year: Obtain Director's approval of paper currently in preparation. Present results of salt-norm calculations at the 1994 American Water Resources Association Summer Symposium. Continue data interpretation including pattern-recognition and classification modeling. Contribute to summary report.

Water Resources of Synderville Basin, Park City, and Surrounding Communities, Summit County, Utah

Project Number: UT-93-221

Cooperating Agency: Utah Division of Water Rights

Staff: L.E. Brooks, Hydrologist
Paul Downhour, Hydrologic Technician

Period of Project: July 1993 to September 1997

Problem: For this study, the Park City area is defined as the southwestern corner of Summit County, including the valley area generally south of and straddling Interstate 80 through which East Canyon Creek flows (Snyderville Basin), the area around Park City, including Prospector Square and Deer Valley, and the area from Richardson Flat to Tollgate Canyon. Population in this area has substantially increased from 1980 through 1993, and much of this increase has occurred since 1987. Housing, industrial, and commercial development in the area continues to increase, and ski areas plan to increase snow-making operations.

These activities are placing increasing demands on the ground- and surface-water resources in the area. One of the major constraints on development of additional residential areas and commercial activities is water supply. Surface water in the area is part of the Weber River drainage basin and is considered to be fully appropriated. There are concerns about the effect of increased withdrawals of ground water on springs, surface-water flows, and water levels in existing wells.

The quality of water in the Park City area is suitable for domestic purposes, but could decline with developing industry or if centralized sewage treatment is not able to keep up with the increase in housing developments. At least two public water suppliers have indicated that sulfate concentrations in water being pumped are increasing. The reason certain dissolved constituents are increasing is not known but could be related to changes that have occurred in the hydrologic system as a result of past development.

Objectives: The purpose of the study is to provide water-resources planners and managers with quantitative information on water resources in the Synderville Basin-Park City area. Specific objectives of the study are to (1) define and describe the lateral and vertical extent of the principal aquifers in the area; (2) describe the hydrologic system including hydrologic properties of the aquifer, surface-water discharge and variability, ground-water recharge, rate and direction of movement, discharge, storage, and water use; (3) improve existing water budgets of the area to give managers a more accurate tool to use for planning additional development; (4) define and describe the interaction of surface and ground water; (5) describe the chemical quality of the surface and ground water, and identify potential causes of increasing dissolved-solids concentrations; and (6) describe the hydrologic and hydrochemical effects that could be expected to occur as development creates a steadily increasing need for more water.

Approach: (1) Collect hydrologic and geologic data that can be used to define the geometry of the principal aquifers; (2) formulate a concept of the hydrologic system and recharge and discharge using aquifer tests, fracture analysis, precipitation records, water-level data, water-use data, spring and streamflow measurements, and water-quality data; (3) define the chemical quality of surface and ground water and identify potential causes of increasing dissolved-solids concentrations; (4) if possible, develop tools to examine the water-balance relations in the project area; (5) prepare a report describing the analysis of the data and results of the study; and (6) prepare a report documenting the data collected.

Progress: The project proposal and planning document were prepared. Inventory of municipal wells and creation of hydrologic and geologic databases has begun.

Plans for Next Year: (1) Complete municipal inventory and check accuracy of reported municipal water use; (2) establish monthly water-level monitoring network and inventory sites to be used to collect water levels for determining potentiometric surface; (3) install streamflow-gaging stations, water-level recorders, and climate stations, and (4) compile existing geologic data.

Using Multivariate Statistics, Pattern Recognition, and Surface-geophysical Techniques to Define Possible Migration Pathways of Saline Water into Fresh Ground Water, Aneth Area, Utah

Project Number: UT-93-222

Cooperating Agencies: Utah Division of Oil, Gas, and Mining; Bureau of Land Management; Bureau of Reclamation; U.S. Environmental Protection Agency

Staff: D.L. Naftz, Project Chief
L.E. Spangler, Hydrologict (part time)

Period of Project: October 1, 1991, to September 30, 1995

Problem: Many wells that penetrate the Navajo aquifer in the area of the Greater Aneth Oil Field yield water that is slightly to very saline, which is anomalous for this aquifer in southern and southeastern Utah. During the last 25 years, salinity levels have increased in several water wells completed in the Navajo aquifer. The most substantial increase is near the town of Aneth. This increase may have resulted from the injection of oil-production water or from upward migration of brines from underlying salts. Because neither the extent nor the severity of the problem is known with any accuracy, an understanding of the regional hydrology and geochemistry of the Navajo aquifer is necessary to better evaluate the extent of contamination and the remedial measures that are required to alleviate continued migration of the saline brines.

Objectives: (1) To identify conservative and nonconservative inorganic, isotopic, and organic geochemical constituents that can be used to define the source(s) and path(s) of the saline water in the freshwater aquifers, and (2) to use the geochemical data from objective 1 in forward and inverse mixing models (EMMA and PCA) and the geochemical pattern-recognition model PIROUETTE to identify and quantify different source waters throughout the freshwater aquifers.

Approach: The investigation will be completed in two distinct phases: (1) Collect and compile new and existing geologic, geochemical, and hydrologic information and define end-member waters from the data using bivariate techniques, and (2) identify saline sources and mixing ratios by using multivariate statistical techniques.

Progress: Initial interpretation of the data is complete. Paper on initial results was presented at the meeting of the American Association of Petroleum Geologists. The first in a series of interpretive reports was completed and submitted for technical review. Except for three remaining wells, geochemical and hydrologic data-collection activities were completed.

Plans for Next Year: This project is a continuation of project UT-198, which was completed with the publication of a basic-data report. Plans are to complete the well-sampling program for inorganic and organic chemical constituents which was begun under project UT-198, develop an updated potentiometric-surface map of the Navajo aquifer, conduct a 1-week survey to determine if geophysical methods will be useful in plume identification, begin interpretation of the multivariate geochemical data, prepare an interpretive journal article entitled, "Using geochemical techniques to identify sources of saline water in the Navajo aquifer in southeastern Utah," and submit it for review and approval.