Water-Related Scientific Activities of the U.S. Geological Survey in Nevada, Fiscal Years 1989-90

Compiled by M. Teresa Foglesong

U.S. GEOLOGICAL SURVEY

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U.S. DEPARTMENT OF THE INTERIOR

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CONVERSION FACTORS AND DEFINITIONS

Multiply	*By*	*To Obtain*
acre-foot	1,233	cubic meter
acre-foot per year	0.001233	cubic hectometer per year
foot	0.3048	meter
inch	25.40	millimeter
mile	1.609	kilometer
square mile	2.590	square kilometer

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 1989 began October 1, 1988, and ended September 30, 1989).

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MESSAGE FROM THE NEVADA DISTRICT CHIEF

The U.S. Geological Survey has been collecting water-resources data in Nevada since 1890. Most of the projects that constitute the current Nevada District program can be classified as either basic-data acquisition or hydrologic interpretation. About 25 percent of the program focuses on collection and dissemination of basic data on Nevada water resources, including operation of streamflow gages and ground-water level networks, and monitoring of the quality of ground and surface water. The remaining 75 percent of our program involves interpretive hydrologic investigations and research.

About 51 percent of our activities are in cooperation with State and local agencies. Technical projects and data collection supported by other Federal agencies make up about 26 percent of the program, and the remaining 23 percent consists of fully funded USGS data collection, interpretive projects, and research.

Water conditions in most of Nevada during fiscal years 1989 and 1990 (autumn 1988 to autumn 1990) continued to be very dry, a continuation of drought conditions that began in late 1986. Streams draining the Sierra Nevada, and to a lesser extent the Humboldt River in northeastern Nevada, have been the most seriously affected.

The major water-resource issues facing the Nation today are water availability, competition for available water, deteriorating water quality, optimal management of water resources, and climatic variation and its effect on water resources. Areas of concern in Nevada are directly related to the above issues and include water allocation in the Truckee-Carson River basin; water-supply needs of Las Vegas and Reno-Sparks, including water-importation plans; irrigation return-flow in general and contamination of the Stillwater Wildlife Management Area in particular; hydrologic effects of weapons testing at the Nevada Test Site; assessment of potential long-term effects of the proposed nuclear-waste repository at Yucca Mountain; and drought in Nevada.

Future water-resource issues in Nevada are likely to center on several concerns. Foremost is water supply for, and environmental effects of, the rapidly growing population centers at Las Vegas, Reno, and Elko. Other concerns are the effects of operations at the Nevada Test Site, management of interstate rivers such as the Truckee-Carson and Colorado Rivers, hydrologic and environmental effects at heavily mined areas, and water-quality management in the Lake Tahoe Basin.

William J. Carswell, Jr.
Nevada District Chief
U.S. Geological Survey
Water Resources Division

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 is to publish and disseminate the earth-science information needed to understand, plan the use of, and 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 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.

BASIC MISSION AND PROGRAM OF THE WATER RESOURCES DIVISION

The mission of the Water Resources Division (WRD) is to provide the hydrologic information and understanding needed to manage the Nation's water resources for the benefit of the people of the United States. To accomplish this mission, the WRD, in cooperation with local, State, and Federal agencies, uses a wide variety of investigative and interpretive techniques to collect and transfer hydrologic information to the water-user community. The WRD undertakes this mission while adhering steadfastly to the concept of scientific method and the maintenance of an unbiased stance in the midst of often highly controversial political issues.

Programs sponsored by the WRD in Nevada include:

- Data collection to aid in the evaluation of the quantity, quality, and use of Nevada's water resources;
- Analytical and interpretive water-resources appraisals to describe the occurrence, quality, and availability of surface and ground water in Nevada;
- Basic and problem-oriented research in hydraulics, hydrology, and related fields of science and engineering;
- Public dissemination of water-resources data and results of water-resources investigations through reports, maps, computerized information services, and other forms of release;
- Scientific and technical assistance in hydrology to other Federal, State, and local agencies.

NEVADA DISTRICT, WRD

Organization

The Nevada District is responsible for water-related U.S. Geological Survey activities in Nevada. The Nevada District has a staff of about 130 employees, most of whom are in the District office in Carson City; about 30 are in the Subdistrict Office in Las Vegas, and 3 are in a field office in Elko. The Las Vegas office became a Subdistrict Office in the autumn of 1989--an administrative change that provides this rapidly growing part of the Nevada District greater autonomy and versatility. These staffing figures represent more than a 100-percent increase from levels of 5 years ago and reflect a trend toward increased interest in State water-resource issues. Figure 1 shows the organization and responsibilities of the various units within the Nevada District. Basic data on water resources in Nevada are collected throughout the State by personnel from the three offices; figure 2 shows the areas of responsibility for each office.

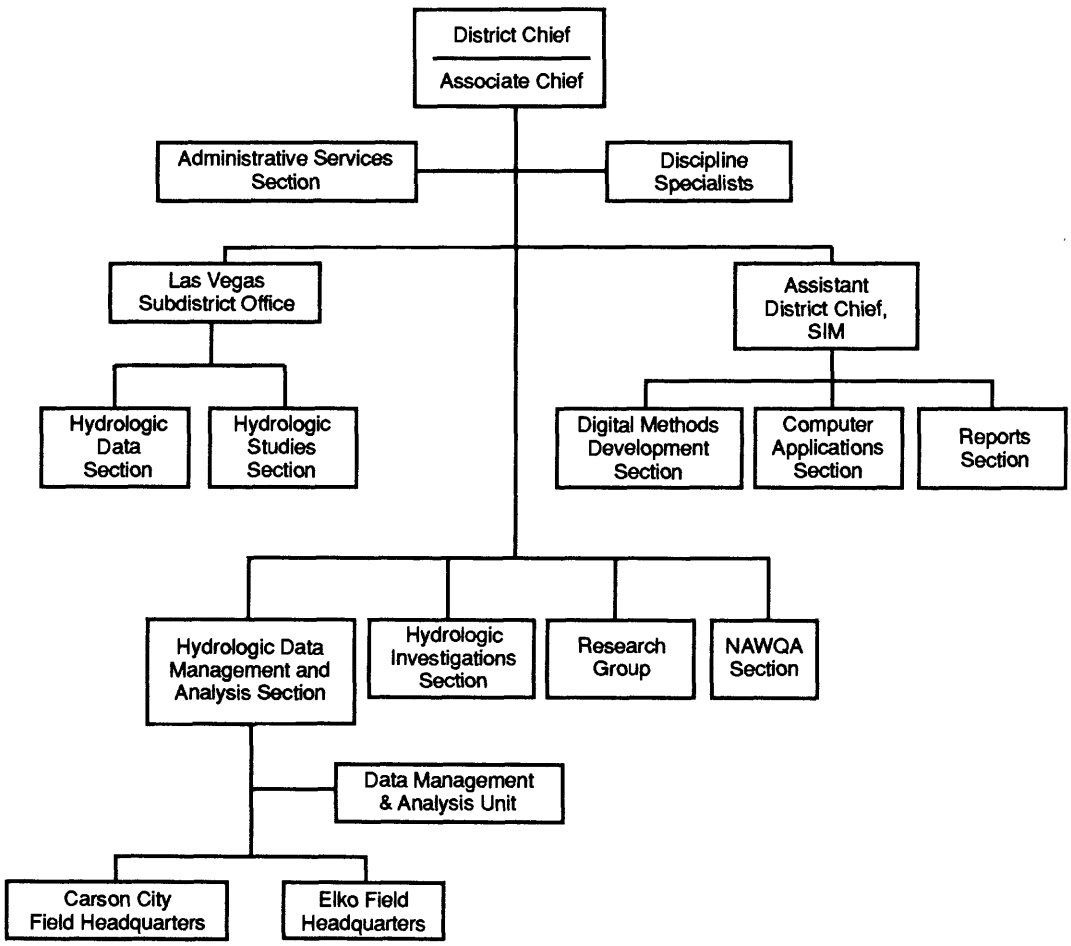


FIGURE 1.–Nevada District organizational structure. NAWQA, National Water Quality Assessment; SIM, Scientific Information Management.

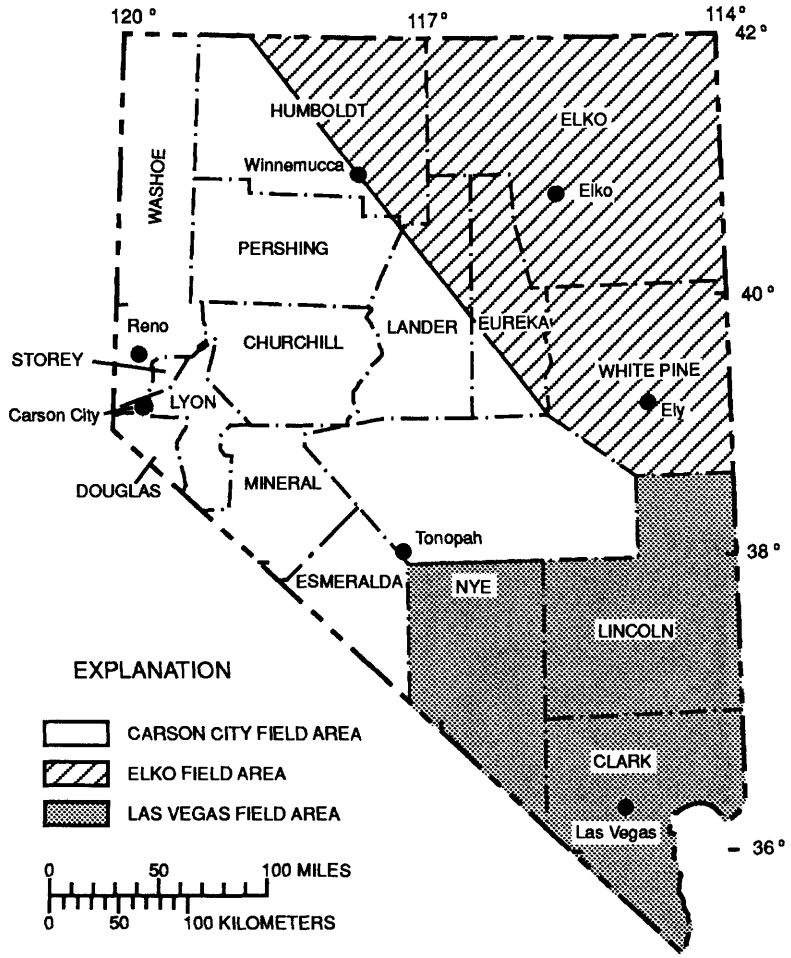


FIGURE 2.–Geographic areas of responsibility for basic-data collection by Nevada District field offices.

The addresses of the three field offices are listed below; inquiries regarding projects described in this report should be directed to the Nevada District office in Carson City.

Nevada District Office
705 North Plaza Street, Room 224
Carson City, Nevada 89701
(702) 887-7600

Las Vegas Subdistrict Office
1500 E. Tropicana, Suite 201
Las Vegas, Nevada 89119
(702) 295-1770

Elko Field Office
P.O. Box 1044
Elko, Nevada 89801
(702) 738-5322

Funding and Cooperating Agencies

Programs of the Water Resources Division in Nevada are funded as follows:

1. Federal Program--funding is appropriated directly to the Geological Survey by the U.S. Congress for projects of national interest;

2. Cooperative Program--funding is shared equally by the USGS and interested State or local agencies; and

3. Other Federal Agencies (OFA) Program--funding is supplied by Federal agencies requesting technical assistance from the USGS.

Total funds and sources of those funds for fiscal years 1989, 1990, and 1991 are listed in table 1 and shown in figure 3. Total funds have increased from $5.9 million in fiscal year 1989 to $7.9 million for fiscal year 1991. Lists of cooperating agencies active during the period 1989-90 are in tables 2 and 3.

TABLE 1.--*Nevada District budget, fiscal years 1989-91*
(in thousands of dollars)

	Fiscal year		
	1989	1990	1991
Federal program	$1,478	$1,405	$1,847
OFA reimbursable program	1,763	2,301	2,110
Cooperative program			
Federal share	1,280	1,295	1,828
State and local share	1,280	1,295	1,828
Unmatched	101	401	319
TOTAL FUNDING	$5,902	$6,697	$7,932

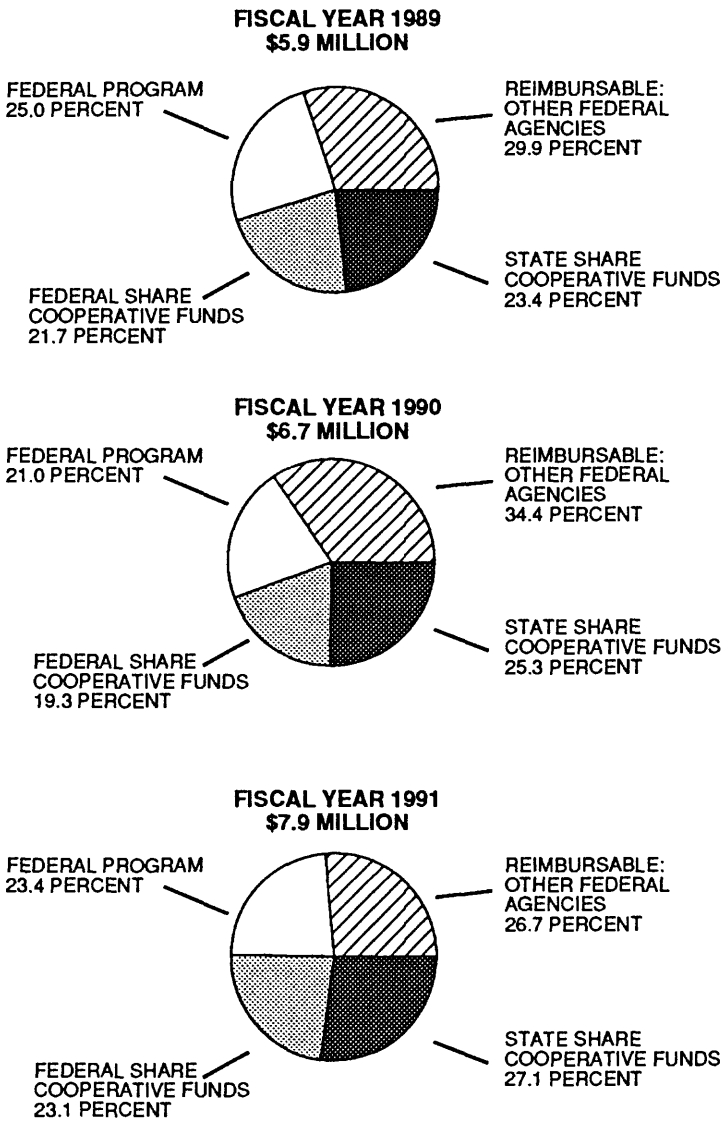


FIGURE 3.--Source of funds in fiscal years 1989-91. Proportion of total funds in each program category is shown.

TABLE 2.--*Cooperating State and local agencies*

State agencies	Local agencies
California Department of Water Resources	Carson City Public Works Department
Nevada Bureau of Mines and Geology	Carson-Truckee Water Conservancy District
Nevada Department of Conservation and Natural Resources	Carson Water Subconservancy District
Division of Environmental Protection	City of Las Vegas
Division of Water Resources	City of North Las Vegas
Nevada Department of Human Resources	City of Reno
Bureau of Consumer Health Protection Services	City of Sparks
Nevada Department of Transportation	Clark County Regional Flood Control District
Nevada State Senate, Interim Finance Committee	Clark County Sanitation District
University of Nevada	Douglas County
Desert Research Institute	Elko County
Mackay School of Mines	Las Vegas Valley Water District
	Regional Water Planning and Advisory Board--Reno-Sparks and Washoe County
	South Tahoe Public Utility District
	Summit Lake Paiute Indian Tribe
	Tahoe Regional Planning Agency
	Truckee-Carson Irrigation District
	Walker River Irrigation District
	Washoe County Department of Comprehensive Planning
	Washoe County Department of Public Works

TABLE 3.--*Cooperating Federal agencies*

Army Corps of Engineers	Department of the Interior	Federal Emergency Management Agency
Board of Water Commissioners	Bureau of Land Management	Federal Water Master
Department of Defense	Bureau of Reclamation	Forest Service
Department of Energy	Fish and Wildlife Service	National Park Service

Technical Resources

Computer Facilities

The Nevada District operates a Prime 6350 super minicomputer in the Carson City office to maintain computerized data bases; process graphic information; analyze remote-sensing imagery; model hydrologic systems; and perform word processing, computer graphics, mathematical processing, and a variety of other functions. This system is a node in the Distributed Information System of the Water Resources Division which links the U.S. Geological Survey headquarters in Reston, Va., with WRD offices across the Nation (see figure 4). Dedicated communication lines link the Nevada District field offices in Elko and Las Vegas, and offices of some cooperators, directly to the District Office in Carson City. The computer system supports more than 100 simultaneous-user processes. Peripheral hardware includes more than 5 gigabytes (5,000,000,000 bytes) of online, high-speed disk storage; more than 80 user terminals; large- and small-scale plotters; large- and small-scale digitizers; mechanical and laser printers; flood-alert and real-time data networks; and mechanical, electronic, and digital-data recorders.

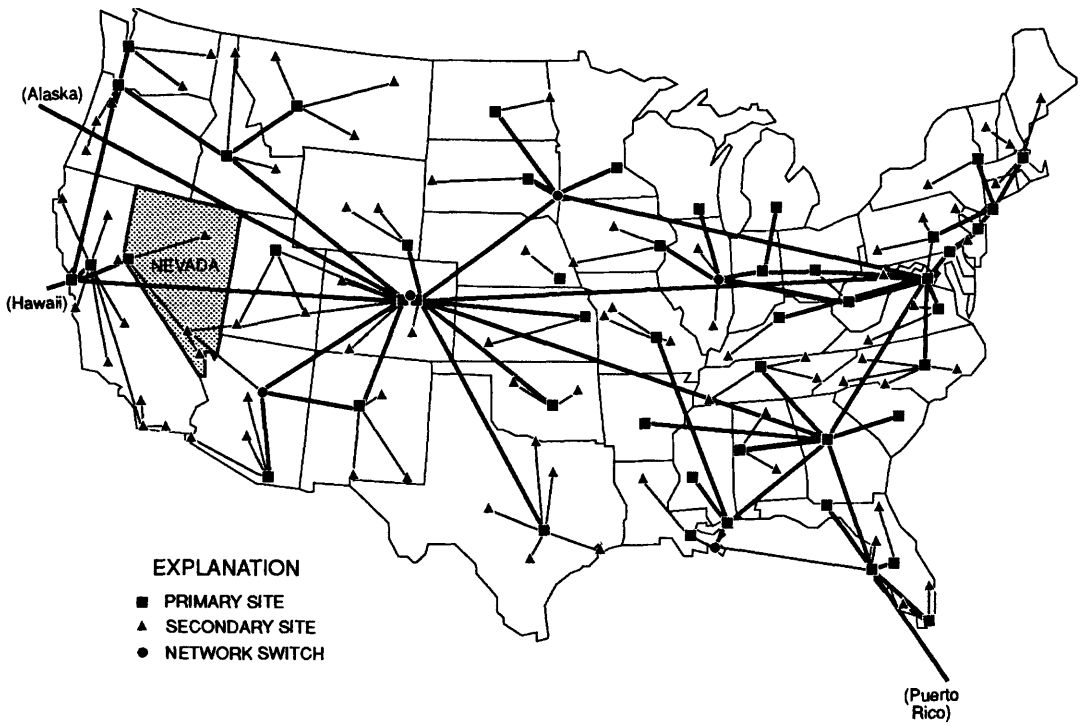


FIGURE 4.--National computer network of the Water Resources Division.

The primary storage function of the Nevada District computer system is to maintain the National Water-Information System (NWIS) data bases. NWIS includes several subsidiary data bases: Automated Data Processing System (ADAPS), supporting continuous (hourly or more frequently) surface-water, ground-water, and water-quality data; Ground-Water Site Inventory (GWSI); Water Quality Data (WQDATA); and Water Use (WUSE). Information collected as part of basic-data programs and interpretive studies is stored in NWIS data bases at all WRD District offices. Data are nationally aggregated in the National Water-Storage and Retrieval data base (WATSTORE), which is maintained on a large mainframe computer at U.S. Geological Survey headquarters in Reston.

The Nevada District computer system also supports Geographic-Information System (GIS) software and data bases. GIS technology integrates spatial descriptors (points, lines, and polygons) normally displayed as map features, with associated numerical and text data normally presented in tabular form (land-use, hydrographic characteristics, water quality, and other hydrologic data). The integrated system combines features of both computer-aided mapping systems and comprehensive relational data bases, and provides analytic, interpretive, and display capabilities that are difficult or impossible to achieve with conventionally structured data bases. The GIS can be directly linked to other computer systems both within and outside the Nevada District.

The computational functions of the Nevada District computer system are diverse. Generation of 2- and 3-dimensional models of complex hydrologic systems is perhaps the most demanding application. The complete system is capable of handling a variety of surface-water, ground-water, and climate models that include steady- and non-steady-state simulations of hydraulic, water-quality, and biologic processes for a variety of model-boundary conditions.

Image processing of remotely sensed data for hydrologic studies is also done on the Nevada District computer system. Digital images from airborne and satellite-borne sensors are used to analyze and interpret rock, soil, vegetation, snow, open water, and other characteristics. The images are capable of being integrated with basic data from NWIS and GIS data bases and with results from hydrologic and geophysical models. Inhouse image-processing facilities include both mini- and micro-computer hardware and software. Products can be generated at a variety of scales using local plotters, and large-format film processing is available through Regional USGS offices.

Geophysics

The Nevada District uses surface- and borehole-geophysical methods pertinent to hydrologic problems. A variety of surface-geophysical instrumentation, and computer software to process the data, are maintained within the District. Instrumentation includes two seismographs capable of monitoring "P" and "S" waves, two gravimeters, a magnetometer, and an electrical-resistivity array. In addition, many types of geophysical methods and instrumentation are available elsewhere within the U.S. Geological Survey for District use: surface methods (electromagneto-tellurics, very low frequency, resistivity, and ground-penetrating radar); airborne methods (radiometrics, magnetics, and side-looking radar); and borehole methods (short- and long-normal resistivity, acoustic velocity, neutron, gamma density, natural gamma, temperature, flowmeter, and televiewer).

Water-Quality Analysis

Water-quality investigations are another important part of Nevada District operations. The District maintains mobile field laboratories with instrumentation for analysis of pH, specific conductance, dissolved oxygen, and bacteria counts, and onsite processing of water samples for analysis in the laboratory. Mobile and inhouse laboratory facilities are maintained for sample preparation and storage, reagent preparation, and instrument calibration and repair. The USGS National Water-Quality Laboratory in Arvada, Colo., which does production analyses and state-of-the-art research, is used for detailed laboratory analyses. Analytical support also is provided by cooperators and contract laboratories.

Electronic Data Collection

Many studies undertaken by the Nevada District now involve some form of electronic data acquisition. Electronic field monitors and data loggers are used for continuous, fixed interval, and event monitoring or sampling in areas where frequent site visits are not practical. Electronic recording of water-quality data, water levels in wells and streams, and climatologic parameters related to evapotranspiration are the most common applications.

Field monitors are used to record water-quality characteristics--pH, specific conductance, and dissolved oxygen--in studies such as those at Stillwater National Wildlife Management Area. Hourly well-water levels are monitored electronically in the eastern part of the State to determine aquifer response to earth-tide dilations. Two systems are used for remote transmission of data. Data-collection platforms transmit data to geosynchronous satellites that relay the data through the DIS computer network to the District data bases. Direct line-of-site radio telemetry is also in use, such as in the Clark County Flood-Alert System that provides real-time monitoring of precipitation and streamflow for 20 sites. The District uses electronic instrumentation and other techniques for direct determination of bare-soil evaporation and transpiration.

Community Involvement and Other Nevada District Activities

As part of its responsibility to provide water-resources information to the public, the U.S. Geological Survey staff participates in several activities in addition to data collection and hydrologic investigations.

Committee Involvement.--Members of the Nevada District staff serve on a wide variety of committees and advisory boards. Recent examples include: American Society of Testing Materials Standards Committee, California Special Advisory Committee on Vadose-Zone Monitoring, Carson River Mercury Site Technical Advisory Committee, Desert Research Institute Advisory Council on Water Resources Research, Federal-State Resource Action Council, Governor's Technical Advisory Committee for the Carson River, Lake Tahoe Interagency Monitoring Program Committee, Mackay School of Mines Advisory Board, Nevada Nonpoint-Source Pollution Task Force, Nevada Operations Office Environmental Action Committee (DOE), Nevada Water Resources Association (NWRA), NWRA Education Committee, Reno Area Federal Executive Council, Southern Nevada Federal Executive Association, and the Truckee River Operating Agreement Committee, the Truckee River Operating Strategy Committee, and the Truckee River Water-Quality Technical Advisory Committee.

Environmental Impact Statements.--Staff members frequently review Environmental Impact Statements for Federal, State, and local agencies to verify the accurate interpretation of hydrologic data presented in the statements.

Education.--The Nevada District is involved in a continuing effort to actively participate in the educational community. Presentations on basic hydrology and general earth-science concepts are given at local schools; formal classes on hydrologic techniques are prepared for local universities; and students from universities, junior colleges, and high schools are employed in work-study programs in the Survey.

Public Information.--The Nevada District serves as a focal point for the general public regarding map and earth-science questions. Staff members answer questions on regional hydrology and geology, basic-science concepts, USGS publications, and other related items.

WATER CONDITIONS IN NEVADA

Surface Water

Most of Nevada is semiarid to arid and has little precipitation and stream runoff in most years. Typically, as much as 75 percent of Nevada's precipitation falls during the winter months. Only the highest mountains produce more than 1 inch of average annual runoff. Three of the principal mountain sources of runoff are the Sierra Nevada, near the western boundary of the State, and the Ruby and Jarbidge Mountains in the northeast.

Nevada has no large rivers. The largest streams in the State are the Humboldt River, which drains the Ruby and Jarbidge Mountains; the Truckee, Carson, and Walker Rivers, which drain parts of the Sierra Nevada in California as well as Nevada; and the Muddy and Virgin Rivers, which flow into the Colorado River in the southeast part of the State (figure 5). Many of these rivers are controlled by dams, reservoirs, and diversions. Of the mentioned rivers, only the Humboldt and Muddy Rivers begin and terminate within Nevada.

After two extremely dry years in northern Nevada, drought conditions were ameliorated to some extent in water year 1989 (October 1, 1988, through September 30, 1989). However, flows in major streams were still below average--from 60 to 80 percent of average in Sierra Nevada streams and from 80 to 100 percent in most Humboldt basin streams. The Colorado River, although controlled, discharged at 89 percent of its long-term average.

In water year 1990, severe drought again resumed in northern Nevada. Streamflow in streams draining the Sierra Nevada and in the Humboldt basin was about 40 to 50 percent of the average. The Colorado River below Hoover Dam flowed at 92 percent of the long-term average. Three significant floods occurred in southern Nevada during the summer. Two of the floods, caused by intense local rains, severely affected the central urban area of Las Vegas; three people were killed and damages exceeded $3 million.

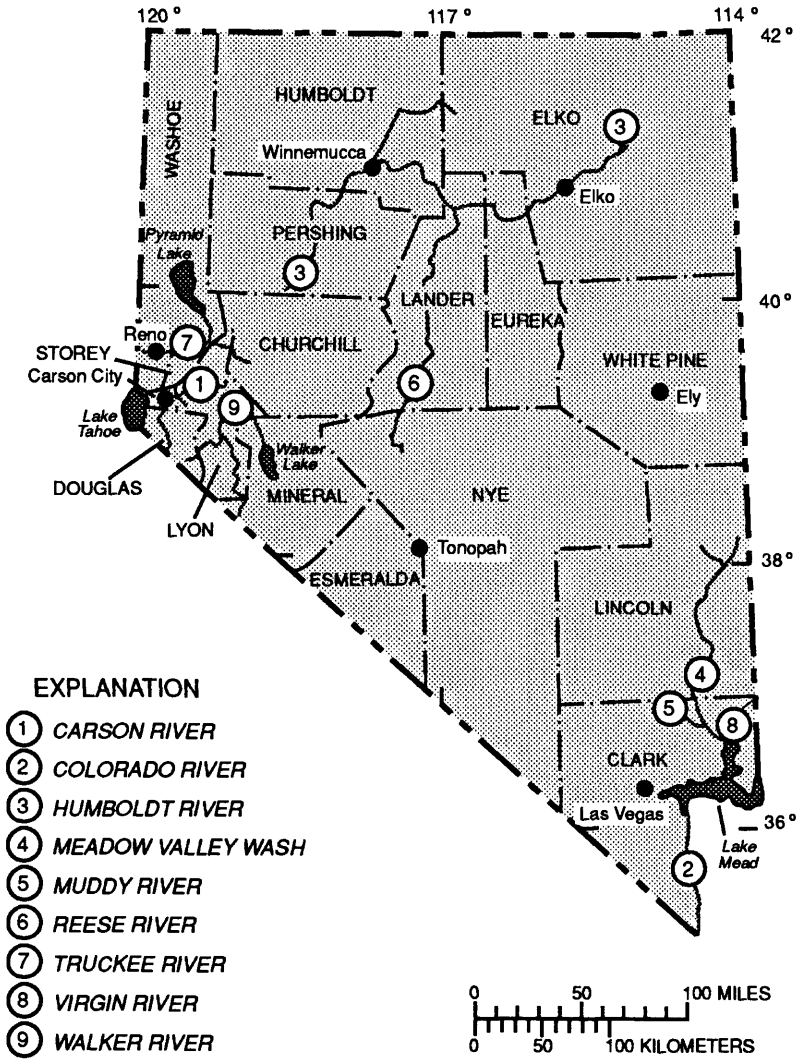


FIGURE 5.--Principal streams and lakes in Nevada.

Surface-Water Quality

The quality of surface water in Nevada varies greatly from place to place, as well as seasonally. Concentrations of dissolved solids are higher in the southern part of the State than in the northern part, and are dependent to a large extent on water discharge. Concentrations usually are greatest during periods of low streamflow, and lowest during periods of high streamflow due to dilution by precipitation or snowmelt runoff.

Surface-water quality did not change significantly in most streams during the period 1989-90; however, data from a few areas are worthy of note. High mercury concentrations in surficial soil and bottom sediments of the lower Carson River drainage system, the result of 19th-century ore-milling operations associated with the Comstock Lode, have generated recent environmental concern. Continued urbanization in the Las Vegas metropolitan area has accelerated sediment erosion and increased sediment transport in Las Vegas Wash because of increased discharge from wastewater effluent and urban runoff. Increased streamflow during the 1989-90 period also caused an increase in dissolved-solids load in lower Las Vegas Wash near Lake Mead.

Ground Water

Development of ground-water supplies in Nevada continued at increasing rates during 1989-90. Drillers' logs of approximately 3,600 wells were submitted to the State Engineer's office; 1,600 were for wells drilled in 1989 and 2,000 were for wells drilled in 1990. The number of logs submitted in 1990 was the highest of any year on record. Of the 3,600 logs submitted during the 2-year period, approximately two-thirds were of wells drilled for domestic use; the remainder were of wells drilled for exploration, industrial and public supply, and irrigation use.

As in previous years, most wells were drilled in unconsolidated deposits of sand, gravel, silt, and clay that partly fill the numerous basins in Nevada. Most development occurs in these basins, where water is readily obtained from unconsolidated deposits at relatively shallow depth and where well yields are more predictable than in the mountains. Consolidated igneous, metamorphic, and sedimentary rocks underlie the basins and crop out in adjacent mountains. Some consolidated rocks, particularly those that are fractured, can yield substantial quantities of water. Development of consolidated-rock aquifers became more common during the 1980's but, as of 1990, is still minor compared to the development that has occurred in the unconsolidated basin-fill aquifers.

Ground-water levels fluctuate in the short and long term in response to seasonal and climatic changes in recharge and discharge. Water levels generally rise during late winter and early spring in response to runoff supplied from snowmelt in the mountains. They generally decline during the summer, fall, and early winter, when recharge is small and discharge by evapotranspiration and pumpage is large. Long-term climatic changes can also affect water-level trends over a period of years. Water levels in many wells in the State declined during the late 1970's when there were two consecutive drought years, rose during the first half of the 1980's when there were several consecutive wet years, and significantly declined during the second half of the 1980's when there were four consecutive drought years. In developed basins, heavy summer pumping causes seasonal water-level fluctuations that generally are superimposed on a long-term declining trend caused by pumping ground water from storage.

Drought

At the beginning of the 1991 water year, northern Nevada was faced with the prospect of a fifth consecutive year of drought. According to the State Climatologist, the present drought rivals the statewide drought of the 1930's, considered to be the worst in this century. Unless streamflow exceeds average, all surface-water users will be severely affected in the summer of 1991 because of the low streamflow and the lack of carry-over storage. As of the last quarter of 1990, the Lake Tahoe level was 1.0 foot below the natural rim, the lowest level since the winter of 1934-35.

MAJOR WATER ISSUES IN NEVADA

Urban Water Use

The population in Nevada increased by more than 63 percent in the 1970's, and by almost 50 percent in the 1980's (see figure 6). The population of Nevada in 1990 was about 1.2 million, according to the U.S. Bureau of the Census. The major growth centers in Nevada are the southeast (Las Vegas), the northwest (Reno-Sparks, Carson City, and Minden-Gardnerville), and the mining districts near Elko.

The Truckee River, which flows from Lake Tahoe through the Reno-Sparks metropolitan area to Pyramid Lake, is the major source of water for the Reno-Sparks area. Water rights for the Truckee River are entirely allocated, water-use restrictions have been imposed in the metropolitan area for four out of the past five summers, and few local resources are left to support the continuing population growth. This has prompted the search for ground-water sources in an ever-widening region of northwestern Nevada.

Las Vegas has two sources of water supply: Lake Mead and the basin-fill aquifer beneath the city. Water levels in the basin-fill aquifer near city wells have declined as much as 10-15 feet since 1985, with seasonal fluctuations of approximately 30 feet. The Colorado River water stored in Lake Mead is fully allocated, with approximately 300,000 acre-feet set aside for Las Vegas. Currently, this allocation is not fully utilized; however, population growth and the associated demand for water is expected to exceed this allocation within the next decade. To obtain additional supplies, the Las Vegas Valley Water District filed applications in 1989 to withdraw 60,000 acre-feet of surface water from the Virgin River and to pump 804,000 acre-feet per year of ground water in 27 basins that lie generally to the north of Las Vegas Valley.

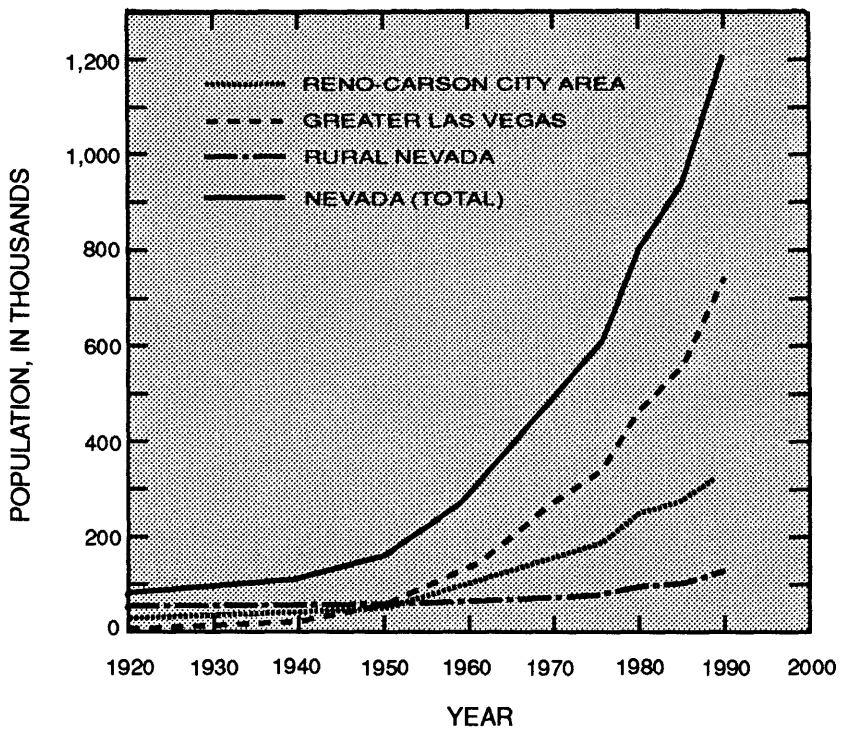


FIGURE 6.--Nevada population trends, 1920-90.

However, current (mid-1991) plans propose pumping of only about 186,000 acre-feet per year from 21 basins. The filings have been opposed, and more than 3,600 protests were filed with the State Engineer during 1990.

The Elko-Carlin area, although less densely populated than major cities of the State, was one of the fastest growing areas in the State during 1989-90. The most pressing water-related problem at present for Elko is inadequate sewage facilities, and consequently the wastewater-treatment plant is being upgraded. Carlin normally derives 100 percent of its water from large springs adjacent to the town. Two years ago Newmont Mining Company drilled a production well for the town; however, this well is used only during periods of high demand, usually during the summer.

The USGS in Nevada is involved in four projects that address the issue of water resources near urban areas. Ground-water appraisals are being made of Smoke Creek Desert north of Reno, of the southern Nevada carbonate-rock aquifers near Las Vegas, and of pumping effects on the Maggie Creek area near Carlin; and a short-term reconnaissance is being made of hydrologic conditions along the Carlin Trend, an area in northeastern Nevada. The reconnaissance study is expected to be expanded into a regional study of the hydrology of the Carlin Trend and adjacent areas. A ground-water appraisal of the Honey Lake basin, which was completed in 1990, addressed some of the issues associated with exporting ground water from the basin to the Reno-Sparks area.

Water Allocation in the Truckee-Carson River Basin

Allocation of surface water in the Truckee and Carson River basins of California and Nevada has been in litigation since the late 1800's. Basic issues involve division of the resources between the States, and competing demands in Nevada among (1) urban use in the booming Reno-Sparks area (mid-Truckee River); (2) Indian and endangered-species fishery requirements at Pyramid Lake (terminus of Truckee River); and (3) irrigation, fish, and waterfowl needs in Fallon and the Stillwater Wildlife Management Area (WMA) (lower Carson River). Public Law 101-618, the Fallon Paiute-Shoshone Tribal Settlement Act of 1990 and the Truckee-Carson-Pyramid Lake Water Rights Settlement Act, was signed into law in November 1990. Section 205 of the Act will require negotiation and implementation of an interagency operating agreement and operating plan for the Truckee River. The Act specifies that final ratification of the operating agreement and plan are to be in place no later than November 1997.

Water allocation in the Truckee and Carson Rivers is managed under a number of Federal Court decrees by an "interim" (since the mid '30s) Federal Water Master. Major reservoirs and diversions on the Truckee and lower Carson Rivers are U.S. Bureau of Reclamation (USBR) projects, but most are operated under contract by the Truckee-Carson Irrigation District (TCID).

The USGS operates 50 streamflow-gaging stations and 9 water-quality monitoring stations in the Truckee and Carson River basins. The Truckee River Water-Quality Assessment Program developed a calibrated daily nutrient and oxygen model for the Truckee River to address some of the water-quality issues. This work indicated that a daily or hourly streamflow model will be required before more detailed water-quality models can be developed.

Pyramid Lake Requirements

In response to the Pyramid Lake Indian Tribe and U.S. Fish and Wildlife Service legal challenges, the USBR adopted a new set of Operating Criteria and Practices in 1988 for the TCID Truckee River diversions. The result will significantly reduce streamflow diversion to the Newlands Irrigation Project at Fallon in favor of increased flows to Pyramid Lake. The environmental effects of the resultant changes in water allocation within, and between, these two river basins will be addressed as part of the requirements of Public Law 101-618.

Irrigation-Induced Contamination at the Stillwater Wildlife Management Area

The Stillwater Wildlife Management Area (WMA) is one of four international shore-bird reserves. Irrigation drainage from the Newlands Irrigation Project, which contains elevated concentrations of dissolved solids and potentially toxic trace elements, is the principal source of water to the Stillwater WMA. In a physical environment having some similarities to the Kesterson area in California, contaminants that have exceeded biological criteria include selenium, arsenic, boron, and mercury.

The water-supply and water-quality issues are complicated by legal and environmental pressures on the U.S. Bureau of Reclamation to reduce diversions from the Truckee River to the Newlands Project, potentially resulting in greatly reduced inflows to the Stillwater WMA. Among the solutions provided in Public Law 101-618 is the allocation of at least $9 million in Federal funds, to be matched by State funds, for the purchase of agricultural water rights to guarantee a secure water supply to the Stillwater WMA. Approximately 4,700 acre-feet of irrigation water rights were purchased for Stillwater WMA during 1989-90 by the U.S. Fish and Wildlife Service and conservation groups. This redistribution of significant amounts of water in the Fallon area may have long-term effects on water levels and water quality in local shallow aquifers currently used for domestic water supplies.

Nevada District project activities in the area include the ongoing Stillwater Irrigation-Drainage Project of the U.S. Department of the Interior, and the USGS National Water-Quality Assessment (NAWQA). The pilot NAWQA project focuses on the study of ground-water quality in the Carson River basin. The western Basin and Range NAWQA project includes the study of ground and surface water of the Truckee and Carson River basins and Las Vegas Valley.

Weapons-Testing Hydrology at the Nevada Test Site

The Nevada District provides support to the U.S. Department of Energy by studying the hydrologic effects of weapons testing. Nuclear weapons have been tested at the Nevada Test Site (NTS) since the early 1950's. The site was chosen because of its remote location, government ownership, and interior drainage system (Great Basin). Long-term studies of basin-and-range hydrology have identified regional aquifers that may allow radionuclides introduced into the subsurface environment to migrate beyond the NTS boundary. Studies are continuing that will determine the potential for radionuclides to be transported within these aquifers.

Proposed Nuclear-Waste Repository at Yucca Mountain

In December 1987, the U.S. Congress identified Yucca Mountain, near the Nevada Test Site, as a potential location for the Nation's first high-level nuclear-waste repository. The proposed repository is to be completed by 2010 and would be expected to contain nuclear waste for at least 10,000 years.

The Water Resources Division in Nevada assists the Yucca Mountain Project Branch by studying the paleohydrology and flooding potential in the Yucca Mountain area. The District also operates data-monitoring networks to support individual Yucca Mountain Project studies of unsaturated and saturated ground-water flow.

PROJECTS FUNDED IN FISCAL YEARS 1989-90

(p. 19 follows)

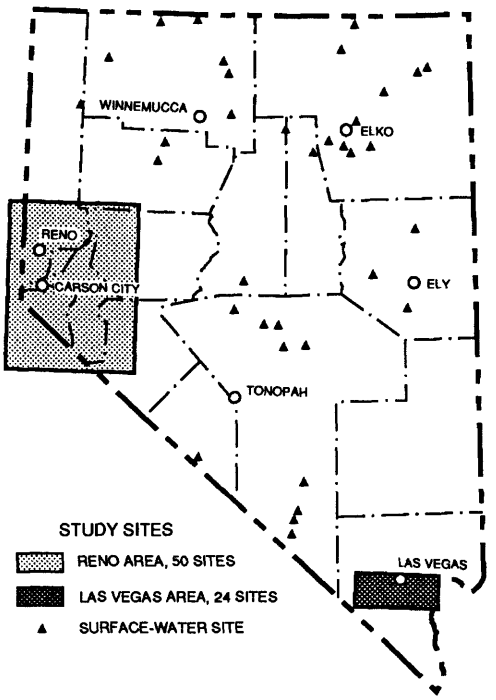
Surface-Water Data Network (*Project 001*)

Location: Statewide in Nevada and eastern California.

Project Chief: Richard D. Hayes.

Period of Project: Continuous since 1894.

Cooperating Agencies: Carson City Public Works Department, Carson-Truckee Water Conservancy District, Carson Water Subconservancy District, City of Las Vegas, City of Reno, City of Sparks, Clark County Regional Flood Control District, Clark County Sanitation District, Douglas County, Federal Water Master, Las Vegas Valley Water District, Nevada Department of Conservation and Natural Resources, South Tahoe Public Utility District, Summit Lake Paiute Indian Tribe, Truckee-Carson Irrigation District, U.S. Army Corps of Engineers, U.S. Board of Water Commissioners, U.S. Bureau of Land Management, U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, Walker River Irrigation District, Washoe County Department of Comprehensive Planning, and Washoe County Department of Public Works.



Problem: Surface-water runoff is highly variable, both areally and seasonally, throughout the State. Information is needed for surveillance, planning, design, hazard warning, and management. These data are particularly relevant 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 support such ongoing needs.

Objectives: A network of surface-water stations is maintained to collect data needed for (1) assessment of water resources, (2) operation of reservoirs and industries, (3) waste disposal and pollution control, (4) water-quality estimations, (5) compact and legal requirements, (6) analysis of short-term variability and long-term trends for forecasting, and (7) research.

Approach: The stage and discharge of lakes and streams are measured using standard U.S. Geological Survey methods. Data-collection intervals are determined in accordance with the principal purpose of each site.

Progress and Significant Results, Fiscal Years 1989-90: Continuous streamflow monitoring at year-round and irrigation-season stations continued throughout 1989-90. The number of year-round sites and irrigation-season sites increased in 1990. In addition, stage measurements were made at various lakes and reservoirs. All data were processed and stored in the National Water Information System (NWIS) computer data base. The 1987, 1988, and 1989 annual water-data reports were published.

Plans for Fiscal Year 1991: Statewide surface-water data collection, computation, and compilation will continue. Field surveys and computations for indirect measurements of flow where gages have not yet been located will be made as needed. The 1990 data report will be compiled and prepared for publication after USGS approval.

Publications, Fiscal Years 1989-90:

Blackstun, D.E., and Cox, E.A., 1990, Automated data collection for detection of flood hazards in Clark County, Nevada [abs.], *in* Balthrop, B.H., and Baker, E.G., compilers, U.S. Geological Survey National Computer Technology Meeting--Program and Abstracts, May 7-11, 1990: U.S. Geological Survey Open-File Report 90-161, p. 4.

Pupacko, Alex, La Camera, R.J., Riek, M.M., and Swartwood, J.R., 1989, Water resources data, Nevada, water year 1987: U.S. Geological Survey Water-Data Report NV-87-1, 256 p.

-----1989, Water resources data, Nevada, water year 1988: U.S. Geological Survey Water-Data Report NV-88-1, 271 p.

Pupacko, Alex, Van Gordon, L.C., Swartwood, J.R., and Collins, R.P., 1990, Water resources data, Nevada, water year 1989: U.S. Geological Survey Water-Data Report NV-89-1, 342 p.

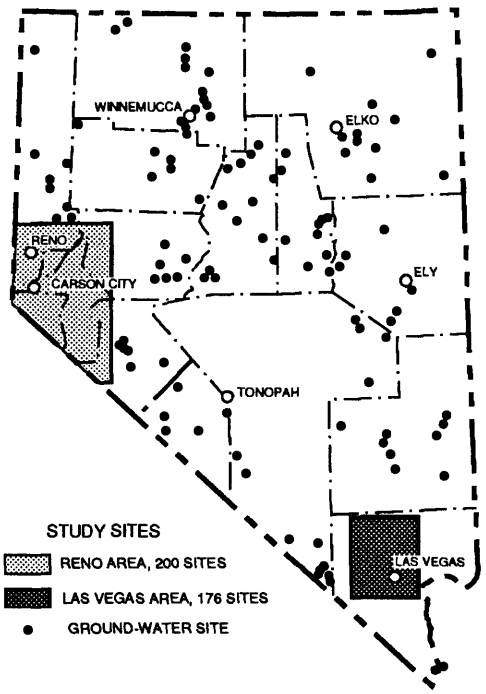
Ground-Water Data Network (*Project 002*)

Location: Statewide in Nevada.

Project Chief: Richard D. Hayes.

Period of Project: Continuous since 1945.

Cooperating Agencies: Carson City Public Works Department, City of Las Vegas, Douglas County, Las Vegas Valley Water District, and Nevada Division of Water Resources.



Problem: The long-term response of regional aquifers throughout the State to natural climatic variations and induced stresses is largely unknown. Proper planning and management of State water resources requires long-term information so that trends can be defined, problems ascertained, and ameliorative actions taken. Measurements of recharge to and discharge from ground-water systems provide a data base from which to evaluate the effects of management and development, and assist in the prediction of future supplies.

Objectives: Long-term records provide information to identify trends in ground-water levels in response to natural climatic variations and induced stresses within the State. The data are used by national, State, and local planners to (1) assess the ground-water resource, (2) predict future conditions, (3) detect and define pollution and supply problems, and (4) provide information for management of the resource.

Approach: A regionally representative network of wells is maintained to allow measurement of water levels in most basin-fill aquifers within the State. The wells are situated, if possible, away from areas of direct human impact such as residential, agricultural, or industrial areas. Measurements are made at approximately the same times each year to reduce seasonal effects. New wells are added to the network as old wells are destroyed, local land use changes, or as other needs arise.

Progress and Significant Results, Fiscal Years 1989-90: Ground-water data collection, computation, and compilation continued. Entry and verification of basic records for depth to water in wells and discharge from springs at sites included on the routine Statewide network were completed. The Nevada State Engineer was supplied with multicolor graphics showing the number of wells drilled by proposed use in each county, compared to Statewide drilling activity for calendar years 1984-90. Approximately 60 new sites were funded and added to the Statewide network for routine ground-water data collection, computation, and compilation. An additional 50 wells were added to the Statewide network to assist the Nevada Bureau of Mines and Geology in collecting water-level information as part of their subsidence project. The 1987, 1988, and 1989 annual data reports were compiled and published.

Plans for Fiscal Year 1991: Ground-water data collection, computation, and compilation will continue. Data entry and verification of basic records for depth-to-water in wells and discharge from springs at sites included on the Statewide network will be completed. The 1990 annual data report will be compiled and prepared for publication after USGS approval.

Publications, Fiscal Years 1989-90:

Note: This list also includes reports approved for publication during fiscal years 1989-90 but published in 1991.

Pupacko, Alex, La Camera, R.J., Riek, M.M., and Swartwood, J.R., 1989, Water resources data, Nevada, water year 1987: U.S. Geological Survey Water-Data Report NV-87-1, 256 p.

-----1989, Water resources data, Nevada, water year 1988: U.S. Geological Survey Water-Data Report NV-88-1, 271 p.

Pupacko, Alex, Van Gordon, L.C., Swartwood, J.R., and Collins, R.P., 1990, Water resources data, Nevada, water year 1989: U.S. Geological Survey Water-Data Report NV-89-1, 342 p.

Wood, D.B., 1988, Water-level changes associated with ground-water development in Las Vegas Valley, Nevada, 1978-79: Nevada Division of Water Resources, Information Report 30, 34 p.

-----1988, Water-level changes associated with ground-water development in Las Vegas Valley, Nevada, 1979-81: Nevada Division of Water Resources, Information Report 31, 41 p.

-----1991, Water-level changes associated with ground-water development in Las Vegas Valley, Nevada, 1981-83: Nevada Division of Water Resources, Information Report 32, 75 p.

-----1991, Water-level changes associated with ground-water development in Las Vegas Valley, Nevada, 1983-85: Nevada Division of Water Resources, Information Report 33, 70 p.

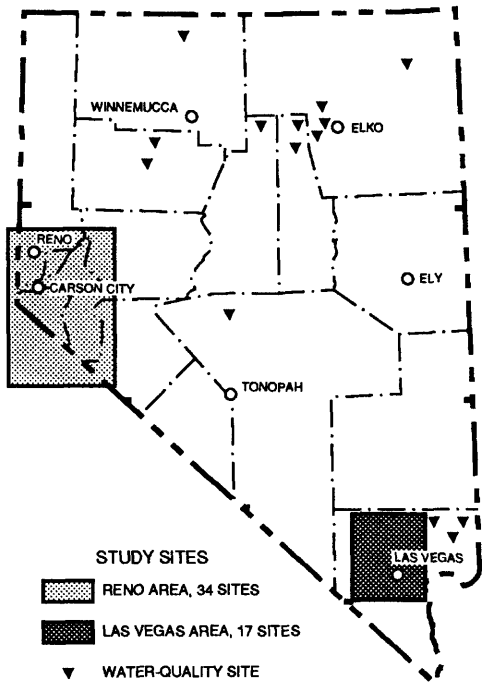
Water-Quality Data Network (*Project 003*)

Location: Statewide and eastern California.

Project Chief: Richard D. Hayes.

Period of Project: Continuous since 1939.

Cooperating Agencies: City of Las Vegas, Douglas County, Nevada Division of Environmental Protection, Nevada Division of Water Resources, U.S. Army Corps of Engineers, U.S. Bureau of Land Management.



Problem: The physical, chemical, and biological quality of surface water is highly variable and must be monitored to identify local influences, seasonal trends, and long-term trends. Long-term records of standardized water-quality data provide information that must be maintained for management and planning.

Objectives: Evaluation of regional water quality requires a base knowledge of spatial and temporal variability and trends with which to compare current conditions. Analysis of the data will allow identification of short-term and long-term trends, provide an early warning of developing water-quality problems, and provide information for Federal management of interstate waters. The data base serves national, State, and local planners.

Approach: A network of water-quality stations for surface water has been established to provide information about variation in sediment loads and physical, chemical, and biological characteristics. Standard USGS methods of water-sample collection, preservation, and analysis are used.

Progress and Significant Results, Fiscal Years 1989-90: Sampling activities increased from 29 active sites in water year 1989 to 89 active sites in water year 1990. In 1990, 103 samples were taken at additional sites for possible future network development. All data were stored in the National Water Information System (NWIS). The annual water-data reports for 1987, 1988, and 1989 were compiled and published.

Plans for Fiscal Year 1991: The quality of data-collection techniques, analytical work utilizing various statistical techniques, and station descriptions will be refined and will improve as a result of better equipment and new sampling techniques. New personnel will be trained in the collection and review of water-quality data. The 1990 annual data report will be compiled and prepared for publication after USGS approval.

Publications, Fiscal Years 1989-90:

Note: This list also includes reports approved for publication during fiscal years 1989-90 but published in 1991.

Garcia, K.T., and Jacoboni, J.M., 1991, Data on ground-water quality in the Winnemucca District of the U.S. Bureau of Land Management, northwestern Nevada, 1934-87: U.S. Geological Survey Open-File Report 89-424, 150 p.

Pupacko, Alex, La Camera, R.J., Riek, M.M., and Swartwood, J.R., 1989, Water resources data, Nevada, water year 1987: U.S. Geological Survey Water-Data Report NV-87-1, 256 p.

-----1989, Water resources data, Nevada, water year 1988: U.S. Geological Survey Water-Data Report NV-88-1, 271 p.

Pupacko, Alex, Van Gordon, L.C., Swartwood, J.R., and Collins, R.P., 1990, Water resources data, Nevada, water year 1989: U.S. Geological Survey Water-Data Report NV-89-1, 342 p.

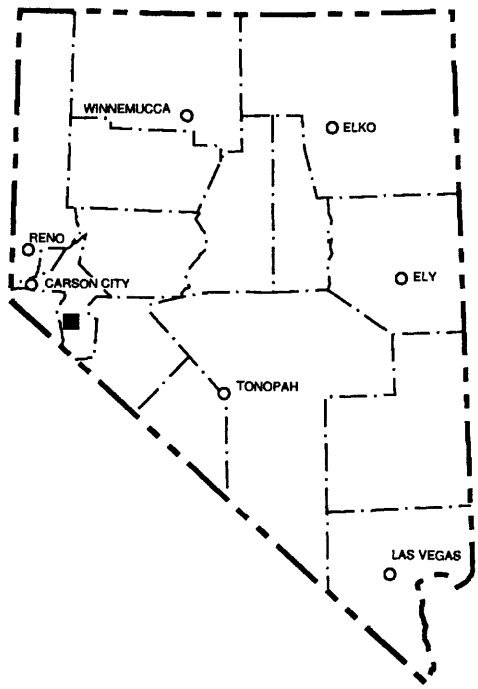
National Trends Network for Monitoring Atmospheric Deposition (*Project 005*)

Location: Smith Valley in Lyon County.

Project Chief: Richard D. Hayes.

Period of Project: Continuous since 1985.

Cooperating Agency: None (U.S. Geological Survey program).



Problem: Acid precipitation has caused adverse ecological and economic consequences in the eastern United States. In the western United States, the chemical composition and variability of wet atmospheric deposition is largely unknown due to a lack of quantitative data. However, industrial and vehicular emissions, which are known to cause acid precipitation in the east, are also found in the west.

Objectives: This study is part of a nationwide program to quantify the chemical properties of wet atmospheric deposition. The focus of this study is to sample and analyze precipitation to determine variations and trends with respect to time.

Approach: A single atmospheric-deposition sampler is being operated in Smith Valley, Nev. The sampler is checked weekly and samples are collected and analyzed for pH and specific conductance when sufficient precipitation occurs.

Progress and Significant Results, Fiscal Years 1989-90: Eighteen samples that contained adequate quantities of precipitation for field determination of pH and specific conductance were collected and analyzed in 1989. Twenty-three samples were collected and analyzed during 1990. Wetfall data were published in the annual data summaries of the National Atmospheric Deposition Program.

Plans for Fiscal Year 1991: Sample collection and compilation of data from the Smith Valley site will continue.

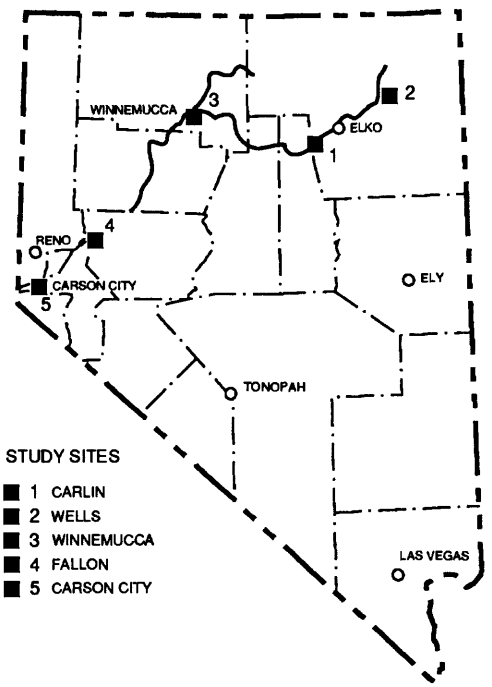
Flood-Insurance Studies (*Project 006*)

Location: Northern Nevada.

Project Chief: Rhea P. Williams.

Period of Project: Continuous since 1985.

Cooperating Agency: Federal Emergency Management Agency.



Problem: Flooding in arid regions can be devastating because most rain occurs in the spring, when rain-on-snow events are likely, and sparse vegetation and compacted desert soils allow little infiltration of rainfall and snowmelt. Excessive overland flow is also a consequence of locally intense thunderstorms. The National Flood Insurance Act of 1968 provides that the Federal Emergency Management Agency (FEMA) operate a flood-insurance program through the Federal Flood Insurance Administration. FEMA needs information from flood studies in selected areas to determine appropriate flood-insurance premiums.

Objectives: The objectives of this study are to develop the most efficient procedures for attaining the information and accuracy required by FEMA on flood frequency and inundated areas, and to determine 100-year-flood boundaries.

Approach: Precipitation, river-stage, and discharge measurements that are collected as part of the surface-water data network will be used. Flood frequencies will be estimated from long-term measurements of river stages and discharge or from regional flood-frequency analyses. River slopes, channel and flood-plain dimensions, drainage networks, and runoff characteristics of drainage basins will be estimated from maps, where possible, or measured directly. Areas of potential inundation will be estimated using ground surveys, photogrammetry, and other available data in conjunction with flood-frequency estimates, hydraulic analysis, and, as appropriate, drainage-basin models.

Progress and Significant Results, Fiscal Years 1989-90: Flood data were compiled for the Wells area and the Humboldt River was studied using aerial photography. Flood data were collected for the Wells area and the Humboldt River near Winnemucca. Studies are in final review for publication by FEMA. The analysis and text were completed for the Carlin study and published by FEMA. Flood data were collected at sites along the Carson River near the Carson City-Douglas County line and in the Fallon area.

Plans for Fiscal Year 1991: Analysis of the Carson River and Fallon data will be completed and the results will be published by the Federal Emergency Management Agency in a flood insurance-rate map.

Water Use in Nevada (*Project 007*)

Location: Statewide.

Project Chief: E. James Crompton.

Period of Project: Intermittent since October 1978.

Cooperating Agency: Nevada Division of Water Resources.

Problem: Nevada is the driest state in the Nation, and it also has the fastest growing population. Water-use data are critically needed for the planning and management of this resource. In addition to obtaining water-use data, methods need to be developed for improving the collection of the data. More efficient ways of storing and retrieving the data, to be compatible with other computer-storage systems, also need to be developed.

Objectives: The objective is to provide water-use information for the optimum utilization and management of the State's water resources. The study provides for the collection, storage, and dissemination of water-use data to complement the available water-quantity and water-quality information. The data-storage system is designed to handle site-specific and aggregated water-use data to meet the needs of local users, the U.S. Geological Survey, and other Federal agencies.

Approach: Information is to be compiled on the basis of the smallest unit feasible, usually individual points of diversion or withdrawal. Three major advantages of using this approach are: (1) more sources of reliable information are available at smaller scales, (2) compilations detailed enough to provide specific information about small areas are very much in demand at a local level, and (3) larger scale requirements may be satisfied by summing the small-scale information.

Progress and Significant Results, Fiscal Years 1989-90: A poster display, "How Nevada Dealt its Water in 1985," was presented at the Nevada Water Resources Association Conference in Carson City in 1989. Another poster display, "Trends in Nevada's Public-Supply Water Use," was presented at the Nevada Water Resources Association Conference in Las Vegas in 1990. Several meetings were held with the Nevada State Engineer and Nevada Bureau of Consumer Health Protection Services on increasing the exchange of interagency information. The 1985 Nevada water-use report was completed and placed in review. A proposal was prepared for a water-use study in Fish Lake Valley, using a Geographic-Information System, as well as a proposal for an inventory of public-supply water use in Nevada.

Plans for Fiscal Year 1991: Data collected on Nevada water-use in 1990 will be compiled. Review of the 1985 water-use report will be completed and it will be prepared for publication after USGS approval. A software package for storage and retrieval of water-permit information will be developed for use by the Nevada State Engineer. Work on other interpretive projects will begin and water-use programs with other State and regional agencies will be developed.

Publications, Fiscal Years 1989-90:

Crompton, E.J., Frick, E.A., and Thiel, C.A., 1989, How Nevada dealt its water in 1985 [abs], *in* Foglesong, M.T., Bunch, R.L., and Myers, C.W., compilers, Water resources for expanding State needs: Annual Conference, Nevada Water Resources Association, Carson City, Nev., March 1989, Program Information and Selected Abstracts, unpaginated.

Crompton, E.J., and Swartwood, J.R., 1990, Trends in Nevada's public-supply water use [abs.], *in* Nevada decision point--Which water course to the future?: Annual Conference, Nevada Water Resources Association, Las Vegas, Nev., February 1990, Program Information and Abstracts, unpaginated.

Frick, E.A., and Carman, R.L., 1990, Nevada water supply and demand, *in* Carr, J.E., Chase, E.B., Paulson, R.W., and Moody, D.W., compilers, National water summary 1987--Hydrologic events and water supply and use: U.S. Geological Survey Water-Supply Paper 2350, p. 353-360.

Smith, J.L., Quinn, G.W., and Crompton, E.J., 1990, Use of Landsat data for identification and mapping of irrigated agricultural lands in Fish Lake Valley, Nevada [abs.], *in* Nevada decision point--Which water course to the future?: Annual Conference, Nevada Water Resources Association, Las Vegas, Nev., February 1990, Program Information and Abstracts, unpaginated.

Flood Investigations of Nevada Streams (*Project 036*)

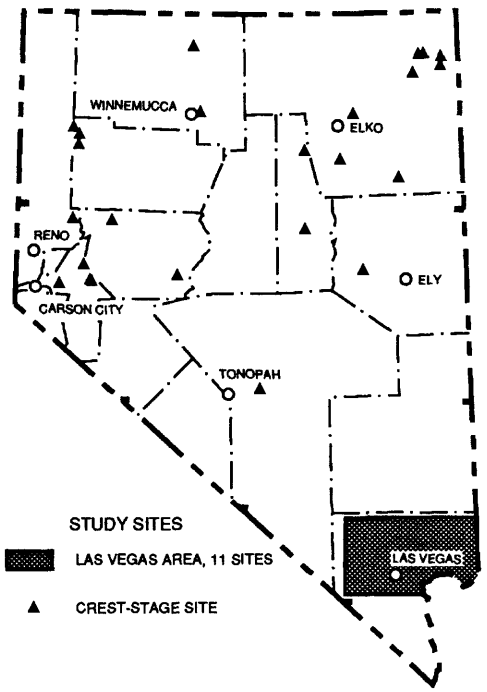
Location: Statewide.

Project Chief: Rhea P. Williams.

Period of Project: Continuous since 1961.

Cooperating Agency: Nevada Department of Transportation.

Problem: The design of hydraulic structures within stream channels depends on accurate estimations of flood frequency and related debris-flow magnitude. Flood-recurrence intervals generally cannot be estimated on the basis of channel characteristics alone; long-term records of peak-flow measurements also are necessary. The Nevada Department of Transportation needs flood data to assist in the design of hydraulic structures for highways.



Objectives: The purposes of this study are to appraise the flood frequency and magnitude of Nevada streams and to provide data for use in the design of highways and hydraulic structures.

Approach: Crest-stage gages to measure peak-streamflow stages have been installed, and are being maintained and operated. Periodic visits to the sites are made to verify flood records, maintain equipment, and make indirect measurements. Each crest-stage site is monitored for at least 10 years to provide data showing flood frequency and magnitude.

Progress and Significant Results, Fiscal Years 1989-90: Peak-streamflow data were collected at 37 sites throughout Nevada during 1989 and at 35 sites during 1990. All peak-flow data for the 1989 water year were submitted for publication in the annual water-data report. A flood-frequency report was prepared for review. Data collection and investigations of mud- and debris-flow areas continued.

Plans for Fiscal Year 1991: Data collection and investigation of mud- and debris-flow areas will continue. Review of the flood-frequency report will continue and it will be prepared for publication after USGS approval. Data for inclusion in the 1990 annual data report will be reviewed.

Publications, Fiscal Years 1989-90:

Pupacko, Alex, La Camera, R.J., Riek, M.M., and Swartwood, J.R., 1989, Water resources data, Nevada, water year 1987: U.S. Geological Survey Water-Data Report NV-87-1, 256 p.

-----1989, Water resources data, Nevada, water year 1988: U.S. Geological Survey Water-Data Report NV-88-1, 271 p.

Pupacko, Alex, Van Gordon, L.C., Swartwood, J.R., and Collins, R.P., 1990, Water resources data, Nevada, water year 1989: U.S. Geological Survey Water-Data Report NV-89-1, 342 p.

Pumping Effects on Devils Hole (*Project 049*)

Location: Ash Meadows, Amargosa Desert, southern Nevada.

Project Chief: Craig L. Westenburg.

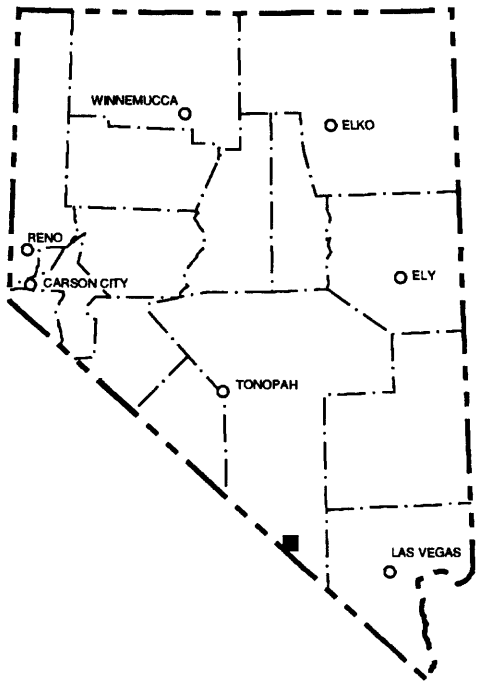
Period of Project: 1970-89.

Cooperating Agency: National Park Service.

Problem: Devils Hole is the sole habitat of an endangered species, the Devils Hole pupfish. Water levels in Devils Hole and nearby springs are significantly affected by wells pumping in Ash Meadows. Lowered water levels have a deleterious effect on the pupfish by lessening the growth of algae on which the fish feed.

Objectives: Water levels in Devils Hole and nearby springs were to be monitored to determine effects of wells pumping in Ash Meadows.

Approach: Measurements of water levels in Devils Hole and nearby wells and of discharge of springs and flowing wells were made on a monthly or more frequent basis.



Progress and Significant Results, Fiscal Years 1989-90: Spring-flow and ground-water data were collected and analyzed. A report on water-resources data for the Devils Hole area, July 1978-September 1988, was approved for publication. The project was terminated in October 1989, when the National Park Service assumed the data-collection activities.

Publications, Fiscal Years 1989-90:

Westenburg, C.L., (in press), Water-resources data for the Devils Hole area, Nye County, Nevada, July 1978 - September 1988: U.S. Geological Survey Open-File Report 90-381.

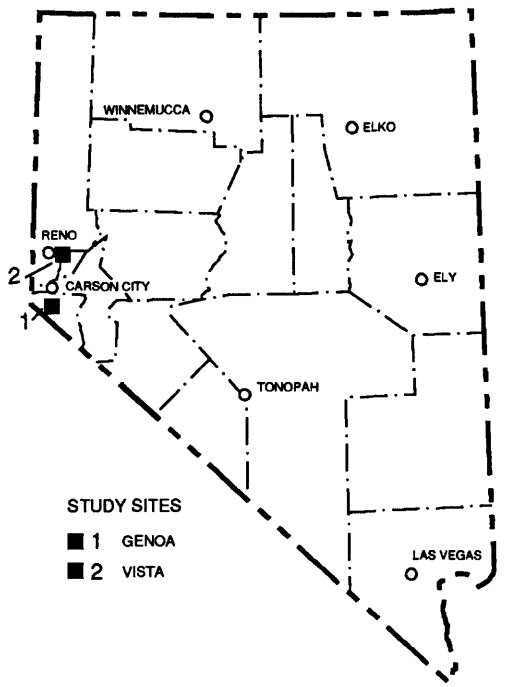
Environmental Hydrologic Studies (*Project 056*)

Location: Western and southern Nevada.

Project Chief: Patrick A. Glancy.

Period of Project: Continuous since 1973, encompassing individual short-term studies.

Cooperating Agencies: Nevada Bureau of Mines and Geology, Nevada Division of Environmental Protection, Nevada Bureau of Consumer Health Protection Services.



Problem: Nevada is an area of striking contrasts in landscapes, geohydrologic conditions, and land and water use, resulting in a variety of geologic and hydrologic hazards. Assessments are needed to (1) assist planners, developers, and water users in avoiding adverse consequences of hazards, and (2) develop new techniques for predicting and evaluating environmental, geologic, and hydrologic hazards.

Objectives: Individual problem-oriented studies are to be made in different parts of the State to (1) map areas subject to flooding and related fluvial hazards, (2) characterize areas of shallow ground water, (3) develop and transfer techniques for sampling volatile organic constituents in water, (4) determine distribution of radon in water-supply wells and springs, and (5) transfer techniques to cooperative agencies.

Approach: Information is obtained from published reports and original field work, such as mapping of flood-prone areas, evaluating fluvial-debris movement, collecting data on water levels and well yields, and sampling water from wells and springs. Analytical results are interpreted.

Progress and Significant Results, Fiscal Years 1989-90: Reports on general hydrogeology and on flood and related debris-flow hazards for the area encompassed by the Genoa topographic quadrangle were written and placed in review. A report on wellhead protection was also prepared for review. A workshop on sampling for volatile organics was held for the Nevada Bureau of Consumer Health Protection Services. Water samples were collected and analyzed. A report on the occurrence of radon was presented at the Geological Society of America meeting in Spokane, Wash.

Plans for Fiscal Year 1991: Review of the reports will continue and they will be prepared for publication after USGS approval.

Publications, Fiscal Years 1989-90:

Lico, M.S., Hughes, J.L., and Welch, A.H., 1989, Hydrogeologic controls on the occurrence of radon-222 in ground water in west-central Nevada [abs.]: Geological Society of America, Abstracts with Programs, v. 21, no. 5, p. 106.

Maurer, D.K., (in press), General hydrogeology of the Vista quadrangle [Nevada]: Nevada Bureau of Mines and Geology Urban Maps Series, Vista Folio, scale 1:24,000.

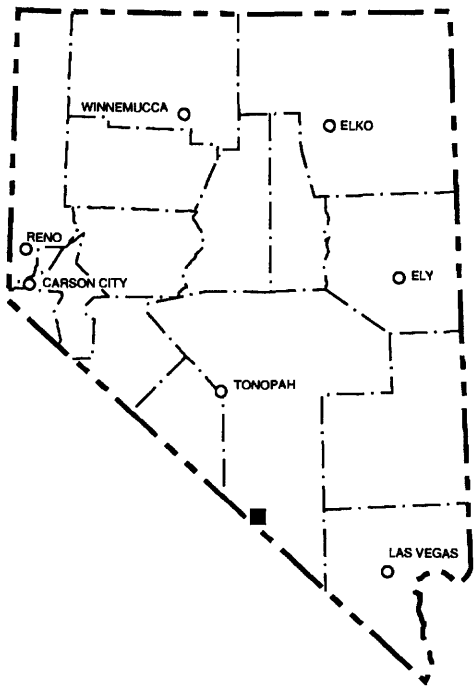
Beatty Disposal-Site Investigation (*Project 072*)

Location: Amargosa Desert near Beatty, Nevada.

Project Chief: David E. Prudic.

Period of Project: Continuous since 1976.

Cooperating Agency: None (U.S. Geological Survey program).



Problem: Solid, low-level radioactive waste has been buried at a site near Beatty, Nev., since 1962. Processes affecting the movement of water in the dry sediments are not understood. Therefore, the rate of migration of radioactive solutes cannot be determined for present climatic conditions.

Objectives: The potential transport rates and extent of downward migration of radionuclides within and beneath the burial trenches will be estimated. Methods for measuring properties of and water movement in dry alluvial soils will be developed. An analysis of how trench construction modifies the natural site environment also will be made. The results of these studies will be used to (1) evaluate the geohydrologic suitability of the existing site for waste containment and (2) contribute information for the development of guidelines and criteria for selecting future burial sites.

Approach: Ground-water levels downgradient from the burial site and experimental trenches are being monitored. The amount of water and the potential for movement are being measured in both the undisturbed soil and within experimental trenches containing simulated waste. Other physical and chemical properties of the undisturbed soil profile and experimental trench backfill, such as structural stability and grain-size distribution, also are being characterized. The vertical variability of these properties is being evaluated through statistical analysis. Structural stability of the trenches is being monitored, and ground-water samples are being collected and analyzed.

Progress and Significant Results, Fiscal Years 1989-90: Reliability of soil-moisture instruments at the shaft facility and experimental trenches was evaluated. The collection of meteorologic data continued and the weather station equipment was upgraded. Analysis of soil-water contents and water potentials measured between 1984 and 1988 at the shaft site was completed. Water samples collected from six wells in August 1989 were analyzed for dissolved major and minor constituents, radionuclides, and stable isotopes. Water from all wells sampled contained similar concentrations of dissolved chemical constituents that are typical of ground water in the area. Laboratory determination of saturated hydraulic conductivity of undisturbed soil-profile and trench-backfill samples was completed. Soil-water contents and water potentials measured at the experimental trench facility indicated that infiltrated waters have not penetrated more than 1 meter below the surface of the trench covers. Water that infiltrated the trench covers and water from the undisturbed soils adjacent to and beneath the trenches have not come in contact with the simulated waste.

Plans for Fiscal Year 1991: Additional data from the weather station, shaft facility, and experimental trench facility will be collected and evaluated. Any malfunctioning psychrometers at the shaft will be replaced. Laboratory characterization of the physical properties of the undisturbed soil and trench backfill will be completed. Evaluation of neutron-probe calibration for measurement of soil-water content in large-diameter access tubes will be completed. Measurement of bare-soil-evaporation rates from experimental trench covers will begin.

Publications, Fiscal Years 1989-90:

Andraski, B.J., 1989, Physical properties of trench backfill at a simulated burial site for low-level radioactive waste near Beatty, NV [abs.]: 80th Annual Meeting, American Society of Agronomy, Anaheim, Calif., December 1988, Program of Agronomy Abstracts, v. 80, p. 178.

-----1989, Water movement and trench stability at a simulated arid burial site for low-level radioactive waste near Beatty, Nevada: American Nuclear Society and Geological Society of America, Nuclear waste isolation in the unsaturated zone--Focus '89, Las Vegas, Nev., September 1989, Proceedings, p. 166-173.

-----1990, Rubber-balloon and drive-core sampling for determining bulk density of an alluvial desert soil [abs.]: Agronomy Abstracts, 1990 Annual Meetings, San Antonio, Texas, October 1990, p. 208.

-----1990, Soil-water movement at a simulated burial site for low-level radioactive waste near Beatty, Nevada--First year results [abs.] *in* Nevada decision point--Which water course to the future?: Annual Conference, Nevada Water Resources Association, Las Vegas, Nev., February 1990, Program Information and Abstracts, unpaginated.

Beutner, M.L., and Andraski, B.J., 1989, Comparison of standard and simplified hydrometer methods for textural analysis of a desert soil near Beatty, Nevada [abs.]: 81st Annual Meeting, American Society of Agronomy, Las Vegas, Nev., October 1989, Program of Agronomy Abstracts, v. 81, p. 184.

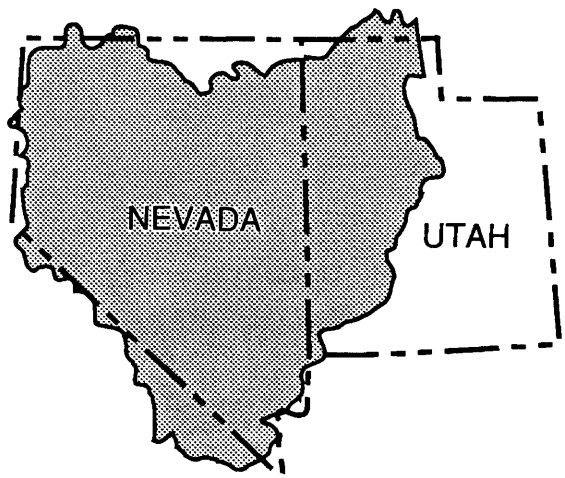
Brown, R.G., and Nichols, W.D., 1990, Selected meteorological data for an arid climate over bare soil near Beatty, Nye County, Nevada, November 1977 through May 1980: U.S. Geological Survey Open-File Report 90-195, 48 p.

Fischer, J.M., 1990, Geohydrology of the near-surface unsaturated zone adjacent to the disposal site for low-level radioactive waste near Beatty, Nevada, *in* Bedinger, M.S., and Stevens, P.R., eds., Safe disposal of radionuclides in low-level radioactive-waste repository sites--Low-level radioactive-waste disposal workshop, U.S. Geological Survey, July 11-16, 1987, Big Bear Lake, Calif., Proceedings: U.S. Geological Survey Circular 1036, p. 57-61.

Prudic, D.E., and Dennehy, K.F., 1990, Topic I--Induced changes in hydrology at low-level radioactive-waste repository sites, *in* Bedinger, M.S., and Stevens, P.R., eds., Safe disposal of radionuclides in low-level radioactive-waste repository sites--Low-level radioactive-waste disposal workshop, U.S. Geological Survey, July 11-16, 1987, Big Bear Lake, Calif., Proceedings: U.S. Geological Survey Circular 1036, p. 2-4.

Regional Analysis of Aquifer Systems in the Great Basin (*Project 091*)

Location: Nevada, western Utah, and parts of adjacent states.



Project Chief: James R. Harrill.

Period of Project: 1980-91.

Cooperating Agency: None (U.S. Geological Survey program).

Problem: The Great Basin contains an extensive regional ground-water system of about 200 valley-fill aquifers which, in some places, are underlain and interconnected by permeable, consolidated rock. This system has been included in a national program of Regional Aquifer-System Analysis (RASA). The Great Basin area of Nevada and Utah is experiencing increasing demands for water. Demand in many areas has reached the point where careful management is needed to meet anticipated future needs. This study was needed to provide understanding of the system at a regional scale, which is essential for wise management of the resource.

Objectives: The general objectives were to (1) describe, both hydraulically and geochemically, the present ground-water system and the ground-water system as it existed before development; (2) analyze the changes which led to the present condition of the system; (3) tie together, in a regional analysis, the results of prior studies dealing with individual segments of the system; and (4) provide predictive capabilities through which the effects of further ground-water development can be estimated.

Approach: Widespread hydrologic problems and areas typical of the Great Basin were identified, a detailed study was made, and results were regionalized and incorporated into an overall analysis of the Great Basin. The initial effort was concentrated in two general directions: (1) a description and regional analysis of aquifers and (2) a series of detailed studies to produce information that would have transfer value to similar areas. The final effort will draw results together into a comprehensive regional analysis.

Progress and Significant Results, Fiscal Years 1989-90: The regional hydrogeology report was submitted for USGS approval. Professional Paper 1409-H, on Stagecoach Valley, was approved in September 1989 for publication, and is in press.

Plans for Fiscal Year 1991: Review of the regional geochemistry report will be completed. Work on other reports will continue and a draft manuscript of the summary report will be written and submitted for review. The project will end in September 1991.

Publications, Fiscal Years 1989-90:

Burbey, T.J. and Prudic, D.E., (in press), Conceptual evaluation of regional ground-water flow in the carbonate-rock province of the Great Basin, Nevada, Utah, and adjacent states: U.S. Geological Survey Professional Paper 1409-D.

Carman, R.L., 1989, Data on evapotranspiration in phreatophyte areas, Smith Creek Valley and Carson Desert, west-central Nevada, 1983: U.S. Geological Survey contribution; available only from National Technical Information Service, U.S. Department of Commerce, Springfield, VA 22161. Accession numbers PB-89 167 399 (text) and PB-89 167 407 (magnetic tape).

-----(in press), Measurement of evapotranspiration in phreatophyte areas, Smith Creek Valley and Carson Desert, west-central Nevada, 1983: U.S. Geological Survey Water-Resources Investigations Report 89-4118.

Harrill, J.R., Gates, J.S., and Thomas, J.M., 1988, Major ground-water flow systems in the Great Basin Region of Nevada, Utah, and adjacent states: U.S. Geological Survey Hydrologic Investigations Atlas HA-694-C, 2 sheets, scale 1:1,000,000.

Harrill, J.R., Gates, J.S., Thomas, J.M., and Mifflin, M., 1988, Ground-water flow systems in the Great Basin, *in* Mifflin, M.D., Region 5, Great Basin, *in* Back, W., Rosenshein, J.S., and Seaber, P.R., eds., Hydrogeology; Boulder, Colo., Geological Society of America, The Geology of North America, v. O-2, plate 3, scale 1:1,000,000.

Harrill, J.R., and Preissler, A.M., (in press), Ground-water flow and simulated effects of development in Stagecoach Valley, a small, partly drained basin in Lyon and Storey Counties, western Nevada: U.S. Geological Survey Professional Paper 1409-H.

Harrill, J.R., Welch, A.H., and Preissler, A.M., (in press), Hydrogeochemical evidence for subsurface inflow to Stagecoach Valley, Lyon County, Nevada, *in* Subitzky, Seymour, ed., Selected papers in the hydrologic sciences: U.S. Geological Survey Water-Supply Paper 2340.

Hines, L.B., (in press), Quantification of natural ground-water evapotranspiration in Smith Creek Valley, Lander County, Nevada, *in* Subitzky, Seymour, ed., Selected papers in the hydrologic sciences: U.S. Geological Survey Water-Supply Paper.

Plume, R.W., 1989, Use of aeromagnetic data to define boundaries of a carbonate-rock aquifer in east-central Nevada, *in* Subitzky, Seymour, ed., Selected papers in the hydrologic sciences: U.S. Geological Survey Water-Supply Paper 2330, p. 1-10.

Plume, R.W., and Carlton, S.M., 1988, Hydrogeology of the Great Basin region of Nevada, Utah, and adjacent states: U.S. Geological Survey Hydrologic Investigations Atlas HA-694-A, 1 sheet, scale 1:1,000,000.

Thomas, J.M., Carlton, S.M., and Hines, L.B., 1989, Ground-water hydrology and simulated effects of development in Smith Creek Valley, a hydrologically closed basin in Lander County, Nevada: U.S. Geological Survey Professional Paper 1409-E, 57 p.

Thomas, J.M., Welch. A.H., and Preissler, A.M., 1989, Geochemical evolution of ground water in Smith Creek Valley, a hydrologically closed basin in central Nevada, U.S.A.: Applied Geochemistry, v. 4, p. 493-510.

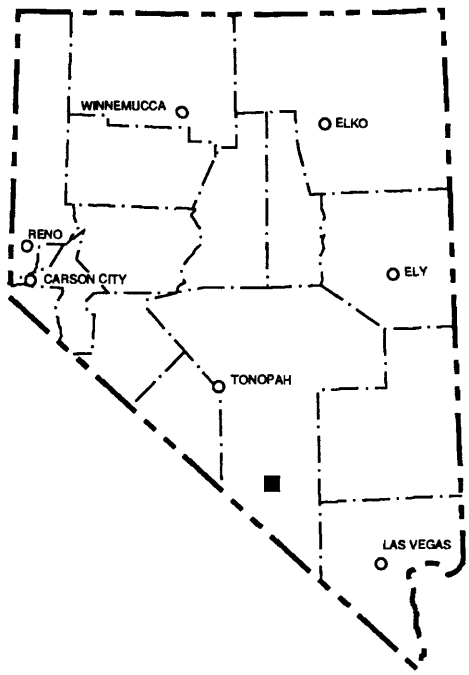
Investigations of Flood-Hazard Potential at the Nevada Test Site, Southern Nevada (*Project 105*)

Location: Yucca Mountain, Nevada Test Site.

Project Chief: Patrick A. Glancy.

Period of Project: Continuous since 1981.

Cooperating Agency: U.S. Department of Energy.



Problem: Yucca Mountain is being considered as a storage site for high-level nuclear waste. Flooding and associated sediment movement is a continual natural hazard at Yucca Mountain and at the Nevada Test Site (NTS). Engineering designs for all types of waste-storage facilities, including critically sensitive ones, require that the hazards be defined. Current flood-prediction capability is inhibited by an inadequate understanding of the natural processes involved, shortages of hydrologic data, and inadequate technology to interpret the data.

Objectives: This study is intended to increase knowledge and understanding of flood processes at Yucca Mountain by (1) adding needed data on precipitation, runoff, and debris transport to the data base to enhance predictive capability; (2) expanding the data base of high-flow events; and (3) collecting information on prehistoric floods. The data are intended to be of use to other hydrologic studies as well.

Approach: A two-pronged approach that will improve the data base is planned: (1) An ongoing hydrologic data-collection program to investigate storm and runoff events will be the main focus of the study; this will include collection of precipitation and streamflow data. (2) Paleohydrologic data-collection and interpretation techniques will be applied to determine those that are workable, and new techniques will be devised as necessary.

Progress and Significant Results, Fiscal Years 1989-90: The Yucca Mountain Project stop-work order continued to be in effect. Routine data collection was authorized and continued. Surface-water monitoring was intense due to several major floods in southern Nevada during June-September 1990, and valuable flood data were collected. The scientific study plan and quality-assurance plans and procedures were written, reviewed, revised, and implemented.

Plans for Fiscal Year 1991: The study plans will be finalized, and other prerequisites for returning to full-work status will be addressed. Data collection will continue.

Publications, Fiscal Years 1989-90:

Glancy, P.A., and Whitney, J.W., 1989, Recent hydrogeologic changes in lower Las Vegas Wash, Clark County, Nevada [abs.]: Eos, American Geophysical Union Transactions, v. 70, no. 43, p. 1124.

Remote Sensing in Hydrology (*Project 109*)

Location: Statewide.

Project Chief: J. La Rue Smith.

Period of Project: 1981-89.

Cooperating Agency: Mackay School of Mines, University of Nevada.

Problem: Nevada is the driest state in the Nation, averaging less than 10 inches per year of precipitation. The demand for water by the rapidly expanding population frequently exceeds the available supply. Agricultural practices account for greater than 90 percent of the total consumptive water use in Nevada. As the demand for potable and irrigation water increases, the need for comprehensive planning and management tools becomes critical to sound management of State water resources.

Objectives: Digital remote-sensing techniques will be developed and used to obtain water-resources data on a regular and reliable basis.

Approach: A State water-data analysis system using standard remote-sensing methods will be developed to provide information for water management. The data-analysis system will be designed to (1) monitor and inventory land use in Nevada as related to water resources, (2) map regions of agriculture and phreatophytic plant growth where intense transpiration occurred, (3) map structural features for use in well-siting studies, (4) integrate remote-sensing and GIS (Geographic-Information Systems) data bases, and (5) offer the required flexibility to respond to present and future needs for water-resources information.

Progress and Significant Results, Fiscal Year 1989: Landsat Multispectral Scanner data were used to identify phreatophyte zones in the Smoke Creek Desert area of western Nevada. Data from the Landsat thematic mapper and advanced very-high-resolution radiometer sources were investigated for use in determining evapotranspiration in Smith Creek Valley in central Nevada. The cooperator discontinued funding and the project was terminated in October 1989.

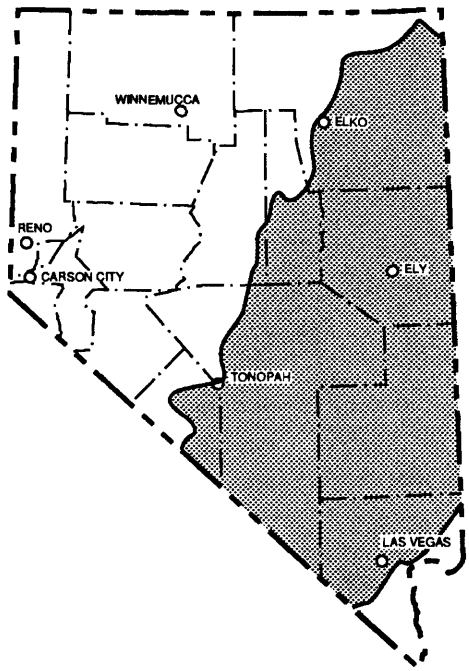
Nevada Carbonate-Rock Aquifers (*Project 128*)

Location: Eastern Nevada.

Project Chief: Donald H. Schaefer.

Period of Project: Continuous since 1984.

Cooperating Agencies: City of North Las Vegas; Desert Research Institute; Las Vegas Valley Water District; Nevada Division of Water Resources; Nevada State Legislature, Interim Finance Committee; and U.S. Bureau of Reclamation.



Problem: Demand for water in Las Vegas and smaller towns in eastern Nevada is growing and additional supplies may be needed from ground-water sources outside the local basins. Previous assessments of the water resources of eastern Nevada indicate that the carbonate-rock aquifers are a potential ground-water source, but insufficient data are available upon which to base a decision for the location of major supply wells. Because of the high cost of developing wells in the carbonate aquifers, the location of wells needs to be based on adequate data and sound hydrologic reasoning. Testing and monitoring of selected wells is needed to insure continued availability of water supplies.

Objectives: The carbonate aquifers of eastern Nevada were studied in order to determine the location and, where possible, the cause of units with high transmissivity, storage capacity, and good water quality. Areas with potential for siting of high-production wells were to be selected for test drilling and evaluation.

Approach: Initial studies focused on the southern part of the carbonate-rock province; later phases were aimed at the central and northern parts of the carbonate-rock province. Detailed hydrologic, chemical, and geologic analyses of springs and wells already available were used to gain understanding of the carbonate-rock hydrology and to site other test wells. Test wells drilled by the Geological Survey and the Bureau of Reclamation were used to determine aquifer properties. Areal studies, including remote-sensing, geological, geophysical, geochemical, and meteorological surveys were used in conjunction with the well-test data to define areas in which high-production wells may be sited.

Progress and Significant Results, Fiscal Years 1989-90: Four reports, including a summary of the first 3 years of work, were published and others placed in review.

Plans for Fiscal Year 1991: Review of the reports will be completed and they will be prepared for publication after USGS approval.

Publications, Fiscal Years 1989-90:

Note: This list also includes reports approved for publication during fiscal years 1989-90 but published in 1991.

Berger, D.L., 1989, Uses of seismic refraction in water-resource investigations [abs.], *in* Foglesong, M.T., Bunch, R.L., and Myers, C.W., compilers, Water resources for expanding State needs: Annual Conference, Nevada Water Resources Association, Carson City, Nev., March 1989, Program Information and Selected Abstracts, unpaginated.

Berger, D.L., Schaefer, D.H., and Frick, E.A., 1990, Principal facts for gravity stations in the Elko, Steptoe Valley, Coyote Spring Valley, and Sheep Range areas, eastern and southern Nevada: U.S. Geological Survey Open-File Report 89-30, 13 p.

Dettinger, M.D., 1988, Evaluation of ground-water resources in a structurally extended terrain--Geologic considerations in the eastern Great Basin, Nevada and Utah [abs.]: Eos, American Geophysical Union Transactions, v. 69, no. 44, p. 1185.

-----1989, Distribution of carbonate-rock aquifers in southern Nevada and the potential for their development--Summary of findings, 1985-88: Carson City, Nev., Program for the Study and Testing of Carbonate-Rock Aquifers in Eastern and Southern Nevada, Summary Report No. 1, 37 p.

-----1989, Reconnaissance estimates of natural recharge to desert basins in Nevada, U.S.A., by using chloride-balance calculations: Journal of Hydrology, v. 106, no. 1/2, p. 55-78.

-----1990, Nevada's carbonate-rock aquifers--some basic information [abs.], *in* Nichols, Martha, Foglesong, M.T., and Topping, M.A., compilers, Water--Liquid gold: Annual Conference, Nevada Water Resources Association, Carson City, Nev., February 1987, Program Information and Selected Abstracts, unpaginated.

-----(in press), Geohydrology of areas being considered for exploratory drilling and development of the carbonate-rock aquifers in southern Nevada--Preliminary assessment, 1984: U.S. Geological Survey Water-Resources Investigations Report 90-4077.

Johnson, M.J., (in press), Micrometeorological measurements at Ash Meadows and Corn Creek Springs, Nye and Clark Counties, Nevada, 1986-87: U.S. Geological Survey contribution to National Technical Information Service.

Schaefer, D.H., Morris, T.M., and Dettinger, M.D., (in press), Hydrogeologic and geophysical data for selected wells and springs in the Sheep Range area, Clark and Lincoln Counties, Nevada: U.S. Geological Survey Open-File Report 89-425.

Thomas, J.M., 1988, Delineation of regional ground-water flow systems in southern Nevada using isotopic and chemical data [abs.]: Geological Society of America Abstracts with Programs, v. 20, no. 7, p. A363.

Thomas, J.M., Lyles, B.F., and Carpenter, L.A., 1991, Chemical and isotopic data for water from wells, springs, and streams in carbonate-rock terrane of southern and eastern Nevada and southeastern California, 1985-88: U.S. Geological Survey Open-File Report 89-422, 24 p.

Nevada Test Site, Weapons Hydrology (*Project 130*)

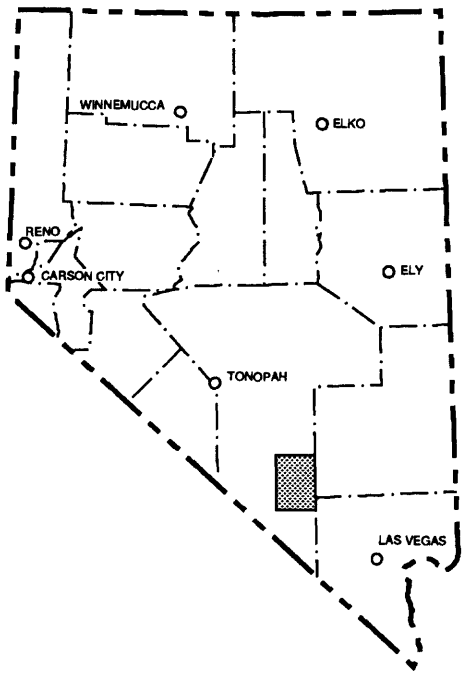
Location: Nevada Test Site, Nye County, Nevada.

Project Chief: William B. Scott.

Period of Project: Continuous since 1985.

Cooperating Agency: U.S. Department of Energy.

Problem: Underground nuclear-weapons testing at the Nevada Test Site (NTS) creates the potential for long-term contamination of ground-water supplies by radionuclides. Also, the location and design of underground nuclear-test sites requires hydrologic information.



Objectives: The regional ground-water flow system underlying the NTS will be characterized. The potential for radionuclide migration related to underground nuclear-weapons testing will be investigated, and other hydrologic expertise will be provided in support of the Department of Energy (DOE), Hydrology/Radionuclide Migration Program.

Approach: Several studies will be proposed, designed, and developed to obtain data necessary to meet the objectives. A network of selected test holes and wells will be established to collect hydrogeologic data. Data will be stored in computerized USGS data bases.

Progress and Significant Results, Fiscal Years 1989-90: Hydraulic testing was made on exploratory hole UE4t during January, February, and May of 1989. A Geographic-Information System (GIS) was developed that focused on well siting and data verification. A significant accomplishment in 1990 was the drilling of hole UE3e-4 to collect geologic cores from a predetermined radioactive spot. The cores were used to aid in determining how radionuclides in this area moved through the subsurface environment. The USGS-WRD Borehole Geophysics Research Group, Denver, Colo., obtained acoustic televiewer, thermal flowmeter, and temperature logs of the borehole. The 1987 progress report was approved for publication. Data-collection activities continued.

Plans for Fiscal Year 1991: An additional test hole proposed as part of the Hydrology/Radionuclide Migration Program will be planned, drilled, and tested. Several reports begun during FY 89 will be completed. Water levels in selected wells, test holes, and emplacement holes at the NTS will continue to be measured. Geohydrologic data will be compiled, verified, and entered into the USGS data base. Data coverage for the GIS will be expanded and used for data analysis, management, and presentation. Conceptual proposals for additional studies at the NTS will be prepared and submitted to DOE. A formal plan for quality-assurance implementation will be developed. Hydrologic support to the DOE Environmental Restoration Program will be provided to assist in the study of environmental effects of nuclear activity at the Nevada Test Site.

Publications, Fiscal Years 1989-90:

Note: This list also includes reports approved for publication during fiscal years 1989-90 but published in 1991.

Arteaga, F.E., Savard, C.S., Johnson, M.E., and Stone, J.C., 1991, Hydrogeologic data from selected wells and test holes in and adjacent to the Nevada Test Site, Nye County, Nevada: U.S. Geological Survey Open-File Report 87-536, 23 p.

Hawkins, W.L., Trudeau, D.A., and Mihevc, T.M., 1990, Hydrologic testing in exploratory drill-hole Ue4t, Yucca Flat, the Nevada Test Site, *in* Olsen, C.W., and Carter, J.A., eds., Proceedings of the fifth symposium on containment of underground nuclear explosions [September 1989]--Volume 2: Santa Barbara, Calif., Mission Research Corp, p. 141-159.

Scott, W.B., 1990, Hydrologic activities of the U.S. Geological Survey in support of the Radionuclide Migration Program, Nevada Test Site and vicinity, Nye County, Nevada, fiscal year 1987: U.S. Geological Survey Open-File Report 90-105, 13 p.

Scott, W.B., and Morgan, C.O., (in press), Hydrologic activities of the U.S. Geological Survey in support of the radionuclide migration program, Nevada Test Site, Nye County, Nevada, fiscal year 1986: U.S. Department of Energy Summary Report for 1986.

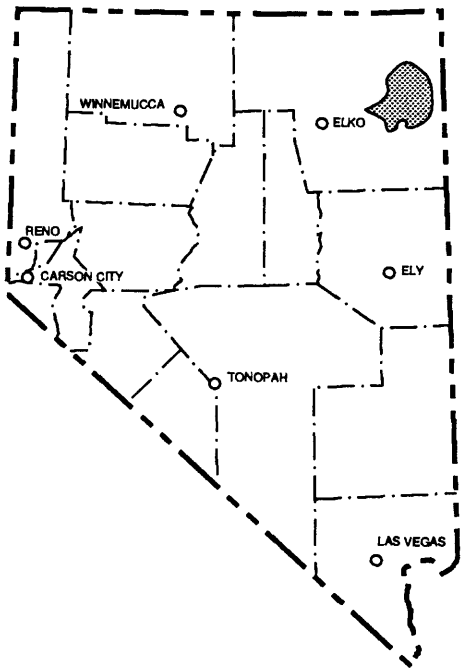
Water-Resources Evaluation of the Thousand Springs Valley Area (*Project 131*)

Location: Elko County, Nevada.

Project Chief: Richard L. Young.

Period of Project: 1985-89.

Cooperating Agency: Elko County.



Problem: Very little basic hydrologic information has been collected for the Thousand Springs Valley area of northeastern Nevada. Interest in the water resources of the area is growing, mainly because of the proposed construction of a coal-fired power plant. Available data are insufficient for estimating the water-resource potential in the area.

Objectives: Surface-water runoff, ground-water recharge, and ground-water discharge measurements were necessary to provide information for a hydrologic appraisal of the area. Because future changes in water use may affect water quality, data on surface-water and ground-water quality also were needed.

Approach: Six data-collection networks were established: (1) three high-altitude precipitation gages, (2) three continuous-recording streamflow stations, (3) four peak-streamflow stations, (4) staff gages on two reservoir spillways, (5) two springs for flow measurements, and (6) 32 wells for water-level measurements.

Progress and Significant Results, Fiscal Year 1989: Data collection and interpretation continued during 1989. Seepage measurements and water-quality sampling were made on a quarterly basis. Data were published in the annual water-data reports. The project was completed in May 1989.

Publications, Fiscal Year 1989:

Pupacko, Alex, La Camera, R.J., Riek, M.M., and Swartwood, J.R., 1989, Water resources data, Nevada, water year 1987: U.S. Geological Survey Water-Data Report NV-87-1, 256 p.

-----1989, Water-resources data, Nevada, water year 1988: U.S. Geological Survey Water-Data Report NV-88-1, 271 p.

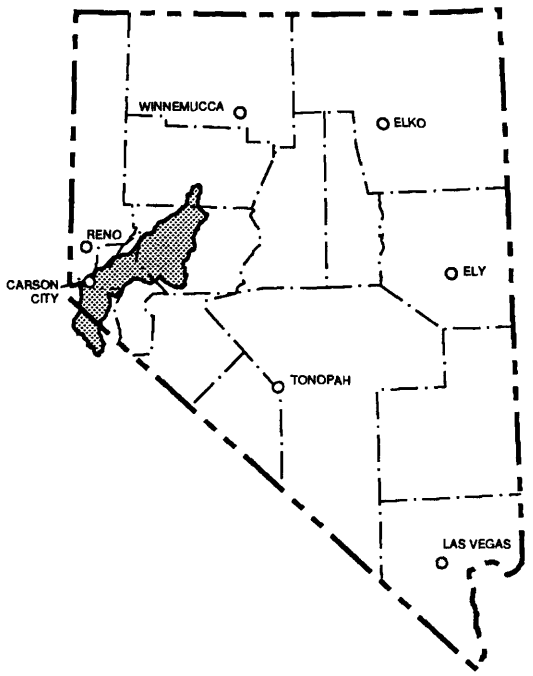
Ground-Water Quality in the Carson River Basin (*Project 142*)

Location: Western Nevada and eastern California.

Project Chief: Alan H. Welch.

Period of Project: 1986-91.

Cooperating Agency: None (U.S. Geological Survey program).



Problem: The response of aquifer systems to contamination are controlled largely by geology, hydrology, water withdrawals, and land use. Areas such as the Carson River basin, in which these factors differ over short distances, are most likely to show the largest effects. Studies in these areas should produce results with high transfer value to other areas.

Objectives: The National Water Quality Assessment (NAWQA) program is designed to (1) determine the occurrence and areal distribution of selected trace elements, manmade organic compounds, and other chemical substances that affect the uses of ground water and that are widespread within the study area; (2) identify and describe zones that are known or likely to have specific water-quality problems; (3) identify and describe zones that, in relation to land use and geologic and hydrologic conditions, are susceptible to future degradation with respect to specific substances; and (4) explore relations of different types of degraded ground-water quality to land use, hydrology, and other pertinent factors.

Approach: Existing data on ground-water quality will be inventoried and statistically summarized. On the basis of this initial analysis, a program to collect additional data to more completely describe the quality of the aquifers with respect to water use will be designed and implemented. The data will be used to define the relations of observed water quality to geohydrologic and land-use factors.

Progress and Significant Results, Fiscal Years 1989-90: Wells in the Carson River basin were sampled for organic and inorganic constituents including pesticides, freon, radon, and uranium. Intensive studies of shallow ground-water quality were made in Carson Valley and the Carson Desert. Results of a study of ground-water quality in the urban part of Eagle Valley indicate that the quality of shallow ground water in urban areas has been affected by synthetic organic compounds. Some nitrate concentrations were greater than 10 milligrams per liter, the Nevada State Drinking-Water Standard. The highest concentrations are within the top 10 feet of the aquifer. Radon concentrations are highest in the upper part of the basin, and locally exceed 10,000 picocuries per liter. Freon data were evaluated as an indicator of "young" ground water.

A retrospective report was published as U.S. Geological Survey Open-File Report 89-382. A report on the hydrogeology of Churchill and Dayton Valleys, journal articles on ground-water quality in the Carson City urban area and on radionuclides in the Carson basin, a water-supply paper on the aqueous geochemistry of Carson and Eagle Valley, a data report, reports on the geochemistry of Dayton and Churchill Valleys and on the Carson Desert, and a final summary report were prepared for review.

NAWQA Liaison Committee meetings were hosted in 1990. Presentations were made at the USGS Second National Symposium on Water Quality in Orlando, Fla., the Nevada Water Conference in Las Vegas, and at meetings of the International Congress of Geochemistry and Cosmochemistry, the Geological Society of America, the National Water Well Association, and the American Geophysical Union.

Plans for Fiscal Year 1991: Reports will be completed and submitted for USGS approval and publication. A less intensive monitoring program will begin.

Publications, Fiscal Years 1989-90:

Hughes, J.L., Lico, M.S., and Welch, A.H., 1989, Hydrogeologic controls on the distribution of radon-222 in ground water of west-central Nevada [abs.], *in* Pederson, G.L., and Smith, M.M., compilers, U.S. Geological Survey Second National Symposium on Water Quality--Abstracts of the Technical Sessions, Orlando, Florida, November 12-17, 1989: U.S. Geological Survey Open-File Report 89-409, p. 40-41.

Lawrence, S.J., and Whitney, Rita, 1990, Shallow ground-water quality in the vicinity of a small urban area in west-central Nevada [abs.], *in* Nevada decision point--Which water course to the future?: Annual Conference, Nevada Water Resources Association, Las Vegas, Nev., February 1990, Program Information and Abstracts, unpaginated.

Sertic, K.A., 1989, Chlorofluorocarbon compounds in ground water--A possible management tool [abs.], *in* Pederson G.L., and Smith, M.M., compilers, U.S. Geological Survey Second National Symposium on Water Quality--Abstracts of the Technical Sessions, Orlando, Florida, November 12-17, 1989: U.S. Geological Survey Open-File Report 89-409, p. 87.

Thomas, J.M., Welch, A.H., and Gunderson, L.S., 1990, Distribution and sources of radon-222 in ground water in the Carson River basin, western Nevada and eastern California, U.S.A., [abs.]: Eos, American Geophysical Union Transactions, v. 71, no. 43, p. 1305.

Welch, A.H., Plume, R.W., Frick, E.A., and Hughes, J.L., 1989, Ground-water-quality assessment of the Carson River basin, Nevada and California--Analysis of available water-quality data through 1987: U.S. Geological Survey Open-File Report 89-382, 115 p.

Welch, A.H., Thomas, J.T., and Gunderson, L.S., 1990, Distribution and sources of uranium in ground water in the Carson River basin, western Nevada and eastern California, U.S.A. [abs.]: Eos, American Geophysical Union Transactions, v. 71, no. 43, p. 1305.

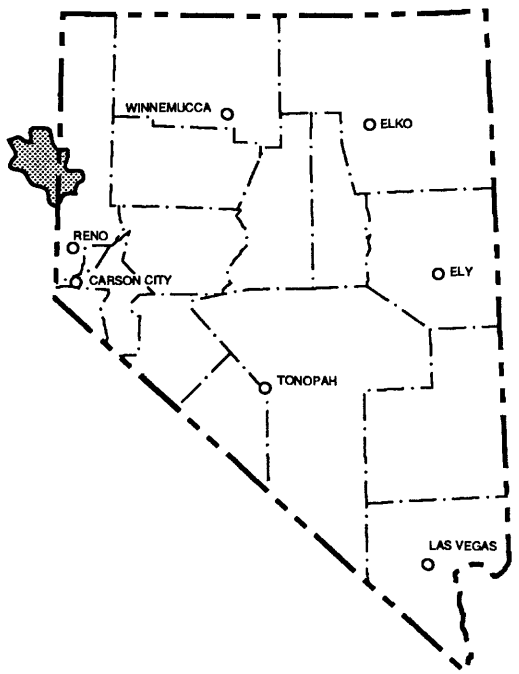
Ground-Water Study of Honey Lake Valley (*Project 144*)

Location: Washoe County, Nevada, and Lassen County, California.

Project Chief: Elinor H. Handman.

Period of Project: 1987-90.

Cooperating Agencies: California Department of Water Resources and Nevada Division of Water Resources.



Problem: Development of the Reno-Sparks area is increasing; nearly all economically available surface water has been allocated and the demand for ground water continues to grow. Use of water from aquifers in the Honey Lake basin is under consideration, but decisions concerning development of the aquifers are complicated by the institutional constraints of withdrawal from an interstate source, as well as the physical limitations of ground-water availability in a semiarid area. Therefore, an appraisal of the ground-water budget was needed.

Objectives: The objectives of this study were to determine the hydraulic characteristics of the aquifers and components of the ground-water budget. A digital model was to be developed to evaluate and quantify the ground-water budget in the eastern part of the Honey Lake Valley area, including the Nevada-California State line. Reports to disseminate the results of the study were to be produced in a format and language appropriate for use by water managers, water users, and public officials.

Approach: Phase I included assembly and evaluation of existing data, reconnaissance-level data collection, planning for additional study, and flow-model development. Phase II involved collection of additional data to fill the needs identified in Phase I, development of a water budget, and revision of the model. Phase III included completion of the water budget and flow model and preparation of the final report.

Progress and Significant Results, Fiscal Years 1989-90: Additional data were collected, analyzed, and interpreted. Two reports were completed and published. An atlas report on the surface-water hydrogeology of the basin was completed. A report that includes data sets used in the digital model was written and placed in review. The project ended September 1990.

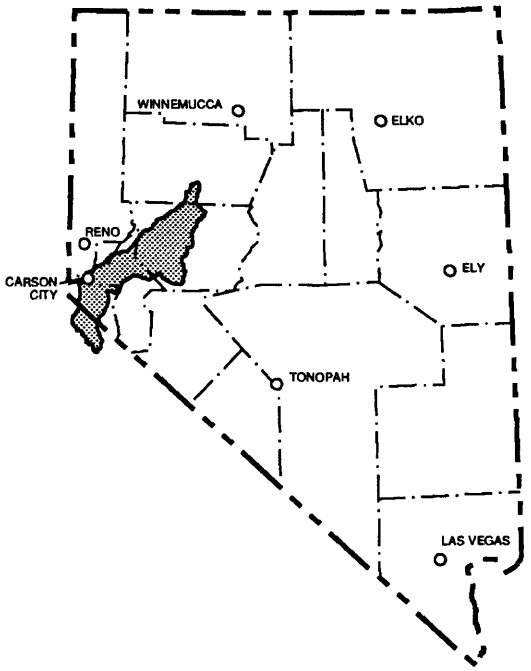
Publications, Fiscal Years 1989-90:

Handman, E.H., 1990, Principal results of a ground-water study of Honey Lake Valley, California and Nevada: U.S. Geological Survey Open-File Report 90-155, 2 p. (Water Fact Sheet).

Handman, E.H., Londquist, C.J., and Maurer, D.K., 1990, Ground-water resources of Honey Lake Valley, Lassen County, California, and Washoe County, Nevada: U.S. Geological Survey Water-Resources Investigations Report 90-4050, 112 p.

Rockwell, G.L., 1990, Surface-water hydrology of Honey Lake Valley, Lassen County, California, and Washoe County, Nevada: U.S. Geological Survey Open-File Report 90-177, 2 sheets.

Relations between Soil and Ground-Water Chemistry in the Carson River Basin (*Project 145*)



Location: Northwestern Nevada and eastern California.

Project Chief: Elizabeth A. Frick (Georgia District).

Period of Project: Continuous since 1987.

Cooperating Agency: None (U.S. Geological Survey program).

Problem: Within the Carson River basin, environmentally significant concentrations of elements such as arsenic, selenium, molybdenum, boron, lithium, and uranium are present in the unsaturated zone of some, if not most, of the basin-fill aquifers. Few historical data are available on the areal and vertical distribution of trace elements in the soils and aquifers of the Carson basin; however, two other projects are collecting water- and soil-chemistry data (see projects 142 and 148). A computerized Geographic-Information System (GIS) will aid in analysis of relations between the geochemistry of soils and shallow-aquifer material and the geochemistry of underlying shallow ground water.

Objectives: The objectives of this project are to (1) develop a GIS to store, manage, and integrate data on the areal distribution of selected trace inorganic constituents in soils, shallow-aquifer materials, and ground water; related bedrock geology; and hydrologic factors in the Carson River basin; (2) use GIS and other software to analyze, present, and relate data; and (3) analyze and interpret relations between the geochemistry of soils and rocks and the quality of ground water in the Carson River basin.

Approach: A GIS will be developed for the Carson River basin using computer software to store, manage, and integrate the data. Data on geology, soil and water chemistry, and land use will be assembled and put in digital form. The GIS and related data bases will be used to test hypotheses relating areal and vertical patterns in trace-element geochemistry of soils and ground-water quality to geology and land use.

Progress and Significant Results, Fiscal Years 1989-90: GIS coverages were completed, and data for the geochemistry of soils, aquifer materials, and shallow ground water were compiled in a consistent data base. A variety of statistical tests have been made of potential geochemical relations among the sampled media. Drafts of the study reports were started.

Plans for Fiscal Year 1991: An interpretive report of results and a report documenting the data base will be completed and placed in review.

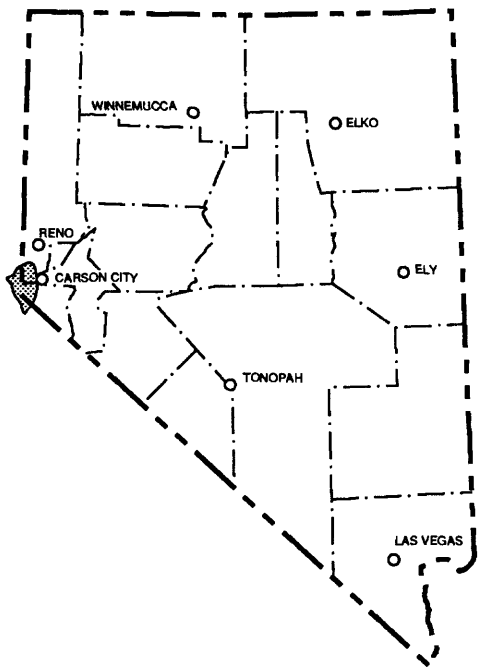
Geographic-Information System for the Lake Tahoe Basin (*Project 146*)

Location: Lake Tahoe Basin, California and Nevada.

Project Chief: Kenn D. Cartier.

Period of Project: Continuous since 1987.

Cooperating Agency: Tahoe Regional Planning Agency.



Problem: Resource assessment, land and resource management, and basic research relating to hydrology in the Lake Tahoe Basin have been hampered by the lack of a common, basin-wide geographic data base. Data collected for diverse purposes at varying scales are stored by individual agencies with different reporting conventions and standards. Previously, a great deal of effort was expended to reduce duplication in monitoring efforts and to cross-reference data sources for the basin. Existing data need to be recompiled at uniform scales (1:6,000, and 1:24,000) and automated into a consistent Geographic-Information System (GIS).

Objectives: The objective of this study is to develop a geographic data base, TEGIS (Tahoe Environmental Geographic-Information System), that can be used for exchange of water-resource data between the U.S. Geological Survey and other agencies, particularly the TRPA (Tahoe Regional Planning Agency). TRPA will use TEGIS to manage, analyze, and display data in support of land- and water-resource management.

Approach: A pilot GIS will be designed, tested, and refined for the Washoe County part of the Lake Tahoe Basin (31 square miles). The major steps in completing the pilot project will be to (1) define needs and objectives, (2) design a data base, (3) compile and inventory data, (4) complete thematic mapping and integrate and automate the maps, (5) demonstrate GIS, and (6) develop computer software to allow simultaneous multiuser access. Cartographic and thematic data in TEGIS will include five major classes of information: permit information, assessor data, land-transfer data, natural-resource data, and monitoring data. After completion of the pilot project, the GIS will be expanded to other parts of the basin.

Progress and Significant Results, Fiscal Years 1989-90: The pilot study was completed for the Mt. Rose and Marlette Lake 1:24,000-scale quadrangles, and the results were presented to TRPA. A menu-driven system was developed for displaying GIS maps and querying the data base; it also was presented to TRPA. Digital line-graph files were acquired for the basin for hydrography, transportation, and boundary themes. Information from U.S. Soil Conservation Service soils maps, U.S. Forest Service timber-stand maps, and geologic maps, and monitoring-site data from several sources were added to the data base. GIS coverages were developed for soils, geology, riparian zones, and monitoring sites. Data entry techniques were further refined.

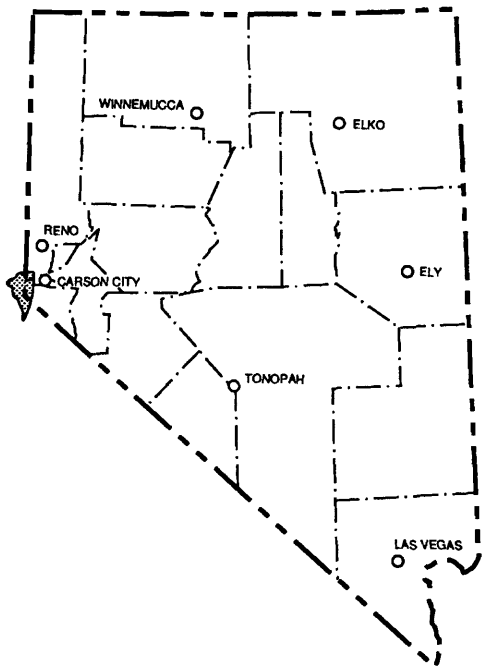
Plans for Fiscal Year 1991: Maps of GIS coverages for natural-resource layers (soils, geology, riparian zone, watersheds, geomorphology, natural hazards, and monitoring sites) will be completed and several will be prepared for USGS review.

Publications, Fiscal Years 1989-90:

Frick, E.A., 1989, Development of a data-management system for environmental and resource assessment in the Lake Tahoe Basin, California and Nevada: Environmental Science Research Institute, Users Conference, Palm Springs, Calif., May 1989, Poster-Session Display.

Smith, J.L., 1989, Raster processing of data from a Digital Elevation Model to determine slope and aspect attributes for inclusion into ARC/INFO: Environmental Science Research Institute, Users Conference, Palm Springs, Calif., May 1989, Poster-Session Display.

Stream Monitoring in the Lake Tahoe Basin (*Project 147*)



Location: Lake Tahoe Basin, California and Nevada.

Project Chief: Timothy G. Rowe.

Period of Project: Continuous since 1987.

Cooperating Agency: Tahoe Regional Planning Agency.

Problem: Deteriorating water quality in Lake Tahoe prompted the initiation of environmental programs in the basin. A monitoring network of streams tributary to Lake Tahoe that would provide water-quality data with emphasis on nutrient loading from tributary streams, is needed to document the local and regional effectiveness of environmental programs and to assure compliance with the State water-quality management plan.

Objectives: The objectives of this study are to (1) provide a long-term data base of streamflow and of sediment and nutrient loadings from major tributary streams to Lake Tahoe, (2) determine the sources of streamflow and of sediment and nutrient loads, (3) describe the mechanisms by which sediment and nutrient loads are transported to and by streams, (4) develop methods of estimating total streamflow and nutrient and sediment loads transported by streams to Lake Tahoe, and (5) support assessment of the effects of land use and development in the Lake Tahoe Basin on the measured tributary loads.

Approach: The existing network of sites will be expanded to better define the nutrient and sediment input to Lake Tahoe from tributary streams. The additional stations will be added to the Lake Tahoe Interagency Monitoring Program network.

Progress and Significant Results, Fiscal Years 1989-90: Sampling began in 1988 at four stations at approximately monthly intervals and resulting data were stored in the NWIS data bases. The stream-monitoring network continued to provide data needed to develop estimates of annual streamflow and loads of sediment and nutrients contributed to Lake Tahoe by Nevada tributaries. Continuous-record streamflow gages were operated and maintained; water samples were collected and analyzed for concentrations of suspended sediment, iron, and nitrogen and phosphorous species. The network was expanded to 5 sites in 1989 and then to 13 sites in 1990 to include data collection for continuous-record streamflow and instantaneous measurements of nutrient and sediment. Data collected during 1988 and 1989 were included in the annual water-data reports and 1990 data were compiled for the next annual data report.

Plans for Fiscal Year 1991: Network operation will continue and a report will be prepared comparing different methods for calculating nutrient and sediment loads.

Publications, Fiscal Years 1989-90:

Pupacko, Alex, La Camera, R.J., Riek, M.M., and Swartwood, J.R., 1989, Water resources data, Nevada, water year 1988: U.S. Geological Survey Water-Data Report NV-88-1, 271 p.

Pupacko, Alex, Van Gordon, L.C., Swartwood, J.R., and Collins, R.P., 1990, Water resources data, Nevada, water year 1989: U.S. Geological Survey Water-Data Report NV-89-1, 342 p.

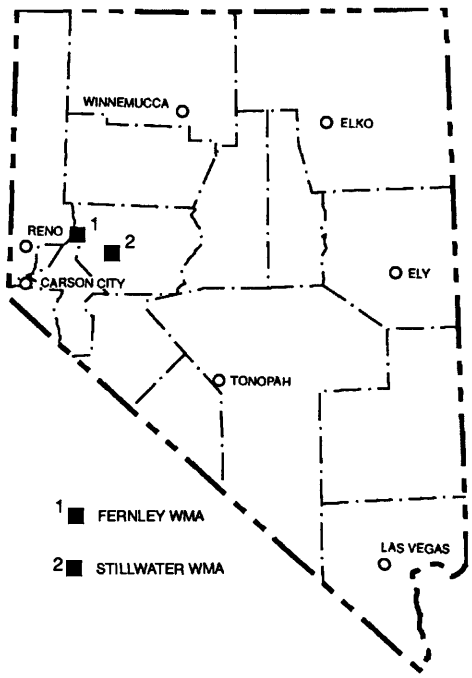
Detailed Study of Irrigation Drainage in and near the Stillwater Wildlife Management Area (*Project 148*)

Location: Churchill and Lyon Counties, Nevada.

Project Chief: Michael S. Lico.

Period of Project: 1987-91.

Cooperating Agencies: U.S. Bureau of Reclamation, and U.S. Fish and Wildlife Service (Department of the Interior program).



Problem: The Stillwater Wildlife Management Area (SWMA) is the largest wetland in Nevada and is maintained mostly by irrigation-return flow draining from fields in the Fallon area. Elevated concentrations of potentially toxic trace elements have been found in this drain water. The geochemical processes controlling the mobilization, transport, and fate of these trace elements need to be determined.

Objectives: The objectives of this study were to (1) determine for selected areas the occurrence, distribution, and geochemical processes responsible for mobilization and transport of toxic constituents to SWMA and Fernley Wildlife Management Area (FWMA); and (2) collect baseline water-quality and bottom-material data in areas where none existed.

Approach: Results of quarterly water-quality sampling at monitored sites were used to identify areas that contributed trace elements to SWMA and FWMA. Continuous monitoring of input drains provided data from areas that contribute relatively large loads of trace and toxic materials. Water levels in wells were measured to determine ground-water flow directions, and additional wells were installed along ground-water flow paths for detailed sampling. Ground-water seepage on lake bottoms was measured, and bottom sediments and cores characterized. Geochemical models were used to evaluate sediment-water interactions.

Progress and Significant Results, Fiscal Years 1989-90: Reconnaissance sampling of surface-water sites continued. Water-quality sampling wells were augured at Stillwater and Fernley WMA's, and core and bottom-material samples were collected and analyzed for trace elements. Optical petrography and X-ray diffraction were used to determine the mineralogy of the sediment samples. Continuous-recording monitors were installed to collect data on pH, temperature, dissolved oxygen, and specific conductance at a drain in the FWMA, and at five sites in the SWMA. Water-quality monitors and stream gages were removed in December 1989. Study results were presented at the Nevada Water Conference, March 1989; the USGS Water-Quality Symposium, November 1989; and at the Nevada Water Conference, February 1990. Report writing commenced, and two reports--an interpretive and a data report--were prepared and placed in review.

Plans for Fiscal Year 1991: The report-review process will be completed, and the reports will be prepared for publication after USGS approval.

Publications, Fiscal Years 1989-90:

Hoffman, R.J., 1989, Preliminary report of potentially toxic trace elements and pesticides in water, sediment, and biota in and near the Stillwater Wildlife Management Area, Churchill County, Nevada, 1986-87, Department of the Interior Irrigation Drainage Program, *in* Howard, A.Q., ed., Selenium and agricultural drainage--Implications for San Francisco Bay and the California environment: Fourth Selenium Symposium, Berkeley, Calif., March 1987, Proceedings, p. 163-167.

Hoffman, R.J., Hallock, R.J., Rowe, T.G., Lico, M.S., Burge, H.L., and Thompson, S.P., 1990, Reconnaissance investigation of water quality, bottom sediment, and biota associated with irrigation drainage in and near Stillwater Wildlife Management area, Churchill County, Nevada, 1986-87: U.S. Geological Survey Water-Resources Investigations Report 89-4105, 150 p.

Lico, M.S., 1989, Geochemistry of ground water at and near Fernley Wildlife Management Area, Lyon County, Nevada [abs.], *in* Pederson, G.L., and Smith, M.M., compilers, U.S. Geological Survey Second National Symposium on Water Quality--Abstracts of the Technical Sessions, Orlando, Florida, November 12-17, 1989: U.S. Geological Survey Open-File Report 89-409, p. 52.

Lico, M.S., Rowe, T.G., and Hoffman, R.J., 1989, U.S. Geological Survey study of irrigation drainage at wildlife management areas in Churchill, Lyon, and Pershing Counties, Nevada [abs.], *in* Foglesong, M.T., Bunch, R.L., and Myers, C.W., compilers, Water resources for expanding State needs: Annual Conference, Nevada Water Resources Association, Carson City, Nev., March 1989, Program Information and Selected Abstracts, unpaginated.

Rowe, T.G., 1990, Mercury and selenium concentrations in surface water, bottom sediment, and biota, Stillwater Wildlife Management Area and vicinity, Churchill County, Nevada [abs.], *in* Pederson, G.L., and Smith, M.M., compilers, U.S. Geological Survey Second National Symposium on Water Quality---Abstracts of the Technical Sessions, Orlando, Florida, November 12-17, 1989: U.S. Geological Survey Open-File Report 89-409, p. 80.

Rowe, T.G., and Hoffman, R.J., 1990, Wildlife kills in the Carson Sink, western Nevada, winter of 1986-87, *in* Carr, J.E., Chase, E.B., Paulson, R.W., and Moody, D.W., compilers, National water summary 1987--Hydrologic events and water supply and use: U.S. Geological Survey Water-Supply Paper 2350, p. 37-40.

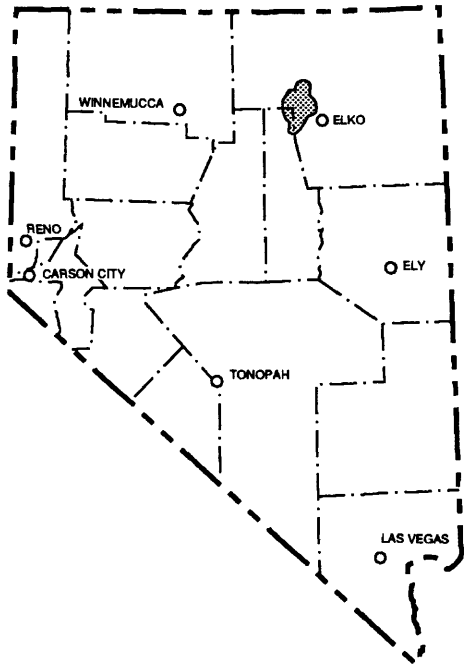
Effects of Ground-Water Withdrawals in the Maggie Creek Area (*Project 149*)

Location: Elko and Eureka Counties, Nevada.

Project Chief: Russell W. Plume.

Period of Project: 1988-91.

Cooperating Agency: Nevada Division of Water Resources.



Problem: The Maggie Creek area, including the town of Carlin, is in an area of rapidly developing mining operations. In 1985, water consumption for mining and milling operations was less than 800 acre-feet per year. An estimated 5,650 acre-feet will have been used in 1988 and this will increase to more than 9,000 acre-feet in 1989. Mining and milling activities are expected to continue at 1989 levels for 10-20 years. Specific concerns are: (1) potential for reduction of flow at Carlin Springs, the main water source for the town; (2) potential for induced leakage from the channels of Maggie Creek and the Humboldt River, which could affect downstream water users; and (3) uncertainty regarding the long-term response of the ground-water system in the area to sustained larger withdrawals.

Objectives: The objectives of the Maggie Creek study are to (1) document hydrologic conditions, including ground-water levels, water quality, surface flows, pumpage, and any response to pumping; (2) update ground-water budgets; (3) evaluate the lower part of the basin to determine hydrologic characteristics, geometric boundaries, and interaction of the aquifers; (4) develop a conceptual model of the flow system in the lower part of the basin that is compatible with available geologic, hydrologic, geochemical, and geophysical information; (5) evaluate probable effects of pumping during the anticipated life of the mining operation; and (6) determine areas that, on the basis of geologic and hydrologic information, appear to have potential as artificial-recharge sites.

Approach: The project was initiated in late 1988 with a literature search and establishment of eight sites for measuring streamflow on Maggie Creek. Hydrologic, geologic, and geophysical data will be collected and analyzed. A summary report of study findings will be prepared.

Progress and Significant Results, Fiscal Years 1989-90: Water levels were measured at all wells in the newly established observation network. Streamflow gains and losses were measured on Maggie Creek and the Humboldt River. Wells and springs were sampled and measured. Observation wells were drilled in areas of sparse data, and streamflow gages were installed on Maggie and Marys Creeks. Data analysis was started and the results were documented.

Plans for Fiscal Year 1991: Data analysis will continue and report writing will begin.

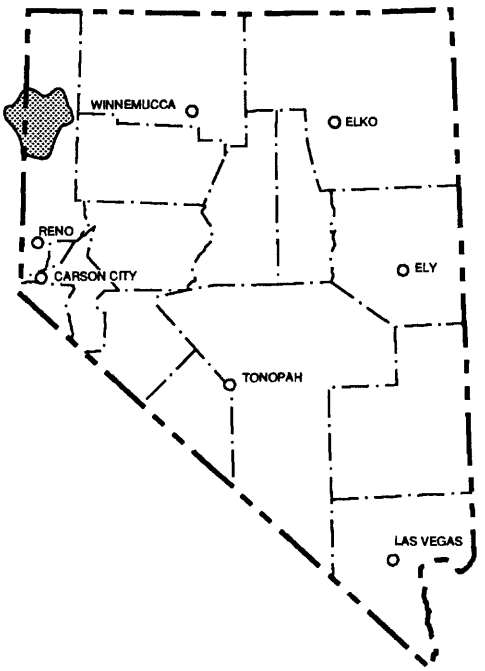
Ground-Water Appraisal of Smoke Creek Desert (*Project 150*)

Location: Washoe County, Nevada, and Lassen County, California.

Project Chief: Douglas K. Maurer.

Period of Project: 1988-91.

Cooperating Agencies: California Department of Water Resources, and Regional Water Planning and Advisory Board--Reno-Sparks and Washoe County.



Problem: Smoke Creek Desert is under consideration as a potential source of water for the rapidly growing population of Reno, Sparks, and surrounding areas. An estimated 13,000 acre-feet of water recharges the basin, but estimates of the amount and type of discharge are significantly less well defined. Much of the discharge may be by evapotranspiration from a large playa in the center of the basin--water that could be put to other uses. A more detailed assessment of the amount and quality of water available is needed.

Objectives: This study will collect data that will be used to (1) reappraise the water budget, (2) define the boundaries and hydrologic properties of the principal aquifers, (3) determine the general quality of surface and ground water, and (4) develop a conceptual model of the hydrologic system to aid in understanding the occurrence and movement of ground water in Smoke Creek Desert.

Approach: Hydrologic and geologic data are insufficient to support interpretive studies because Smoke Creek Desert is undeveloped. The emphasis of this study is on collection of data that relate to recharge, discharge, water quality, and basin and aquifer geometry. Wells and springs will be inventoried and a ground-water monitoring network established. Precipitation gages will be installed and a streamflow network will be established. A site for measurement of evapotranspiration from the playa will be selected. Surface- and ground-water samples will be collected for chemical analysis. Geophysical techniques will be used to determine aquifer geometry.

Progress and Significant Results, Fiscal Years 1989-90: A ground-water data-collection network was developed and quarterly measurements of depth to water or pressure head, and flow rate, specific conductance, and temperature were made; very little change was noted. A continuous-recording gage and three crest-stage gages were installed at major streams, and seepage measurements were made along Smoke Creek. Two high-altitude precipitation gages were installed in FY 1989 and operated during FY 1990. Magnetic and seismic geophysical surveys were made along a bedrock-to-bedrock transect across the center of the basin; a maximum thickness of about 2,000 feet was estimated for unconsolidated sediments. Water-quality samples were collected and analyzed for concentrations of major ions, trace elements, oxygen and deuterium isotopes, and radon activity; drinking-water standards for pH, chloride, sulfate, and total dissolved solids were exceeded at 10 sites near the playa.

Plans for Fiscal Year 1991: Data collection will continue and instruments to measure evapotranspiration rates will be installed and operated. Landsat imagery will be used to produce a map of phreatophyte distribution. A report summarizing the data and interpreting the results and a report on evapotranspiration will be written.

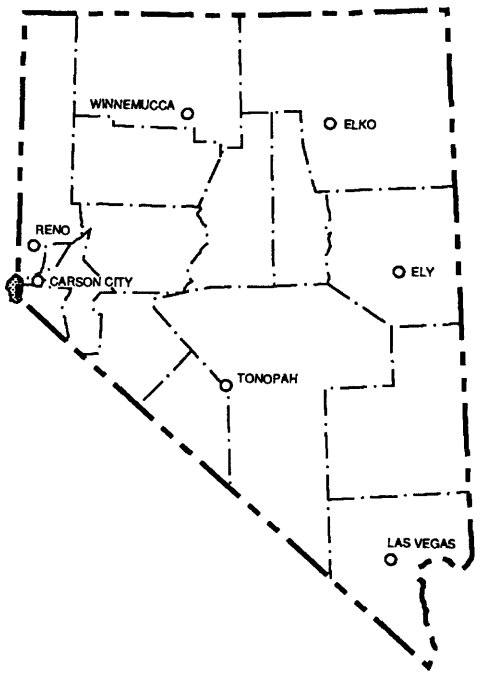
Ground-Water Quality Monitoring, Lake Tahoe Basin (*Project 151*)

Location: Lake Tahoe, California and Nevada.

Project Chief: Carl E. Thodal.

Period of Project: 1988-92.

Cooperating Agency: Tahoe Regional Planning Agency.



Problem: The clarity of water in Lake Tahoe has been decreasing during the last two decades as a result of increasing phytoplankton productivity attributed to nutrient loading. Nutrient monitoring networks in the basin had been developed to determine nutrient loads from tributary streams and atmospheric deposition. Results from previous investigations suggest that nitrate nitrogen and soluble phosphorus are transported into Lake Tahoe by ground water, either as base flow in tributary streams or as direct seepage into the lake. A well-designed ground-water monitoring network is needed to determine the role of ground water in the nutrient budget of Lake Tahoe.

Objectives: The objectives of the 4-year investigation are to (1) compile and evaluate historical ground-water flow and water-quality data available for the Lake Tahoe Basin; (2) determine data needed to estimate loads and define sources of nutrients transported to the lake by ground water; and (3) design and begin operation of a network of wells in the basin to monitor ground-water levels and quality, with an emphasis on nutrients.

Approach: All available data on ground-water levels and water quality will be compiled, and historical sampling sites will be inventoried and field checked during the first year of the study. Additional wells will be sampled to augment the available data base. The monitoring network will be designed and implemented, on the basis of an evaluation of the historical data, during the second year of the study. Data on nutrient loads, water levels, on-site measurements, and chemical analyses of constituents will be collected to determine the sources and chemical evolution of ground water. Existing data and new data will be evaluated to determine which drainages may potentially contribute significant nutrient loads to the lake and to determine areas where additional data needs are the greatest.

Progress and Significant Results, Fiscal Years 1989-90: Data on historical ground-water levels and water-quality were compiled. A network of 30 wells was established and sampled for nutrient analysis and for major and selected trace constituents. Four wells that were determined to have significant amounts of dissolved nitrate-nitrogen were sampled for the nitrogen isotopic-ratio analysis.

Plans for Fiscal Year 1991: Field measurements and water samples will be collected quarterly to characterize seasonal variability. A report presenting design and operational results of the ground-water monitoring network will be drafted.

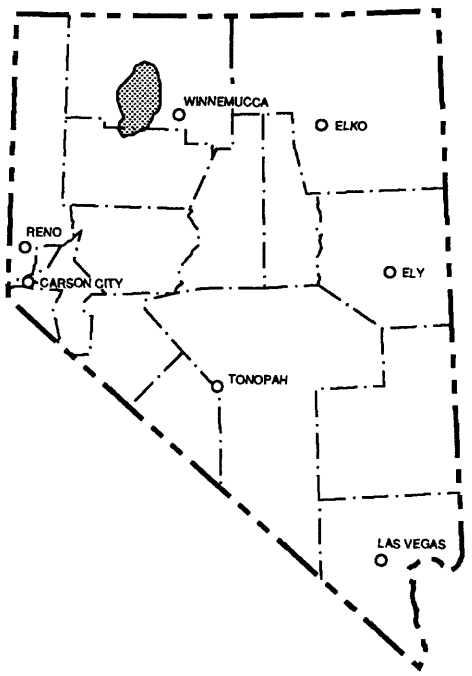
Ground-Water Conditions, Desert Valley (*Project 152*)

Location: Northwest Nevada.

Project Chief: David L. Berger.

Period of Project: 1989-93.

Cooperating Agency: Nevada Division of Water Resources.



Problem: A ground-water overdraft has been created in northern Desert Valley due to the dewatering of an open-pit mine. Prior to dewatering of the mine, annual ground-water withdrawals for irrigation in the Valley were approximately equal to the estimated average annual recharge. Current hydrologic conditions need to be documented before effects of increased ground-water withdrawals can be evaluated. The ground-water budget of the area needs to be reevaluated with respect to new information collected since 1962, then revised if necessary.

Objectives: The investigation will provide hydrologic data and interpretation needed to (1) document 1990 hydrologic conditions, (2) determine hydrologic changes that have occurred since the predevelopment conditions of 1962, (3) reevaluate the ground-water budget based on hydrologic information available since 1962, and (4) evaluate the potential for long-term hydrologic effects of current ground-water withdrawals.

Approach: Available hydrologic data will be compiled, and wells, springs, and streams will be inventoried. Water-quality samples will be collected and ground-water withdrawal records will be compiled. Predevelopment hydrologic conditions will be estimated by using the 1962 data and then compared to current conditions. The water budget will be reevaluated and revised on the basis of results from evapotranspiration studies, geophysical studies made to determine the potential for subsurface flow, evaluation of the potential for recharge in sand dune areas, and determination of ground-water interaction with the Quinn River. Long-term effects of ground-water withdrawals will be evaluated by developing a digital model to simulate current and potential ground-water conditions.

Progress and Significant Results, Fiscal Years 1989-90: Three rounds of ground-water level measurements were made at 50 wells throughout Desert Valley. Two precipitation-storage gages in the sand dunes area and one rain gage near the Jackson Mountains were installed. Two crest-stage gages were installed, and three discharge measurements were made at each of six surface-water sites during spring runoff. Water-quality data were collected and analyzed at 13 ground-water sites and 3 surface-water sites during base-flow conditions. Observation wells were installed in areas that had few or no ground-water-level data. A gravity base station, developed from the Winnemucca base, was created in Desert Valley. Numerous gravity measurements were made to supplement existing data for developing profiles and maps showing depth to bedrock. Phreatophytes were mapped using color prints of Landsat data and ground-truth calibration. A conceptual ground-water flow model was developed, and initial estimates of recharge, subsurface inflow, and hydraulic properties of the basin aquifer were made.

Plans for Fiscal Year 1991: Monitoring and measurement of ground-water levels and storage, rain, and crest-stage gages will continue. Miscellaneous discharge measurements, geophysical surveys across alluvial gaps, and phreatophyte mapping will continue. Depth-to-bedrock maps and profiles will be completed. Two observation wells will be drilled and installed in alluvial gaps to determine whether there is subsurface inflow to the basin. A percolation model will be constructed to estimate potential recharge of the sand dunes area and data sets will be developed for use in the ground-water flow model. The ground-water flow model will be tested, modified, and calibrated. A report of the results will be drafted.

Interim National Water-Information System, Water-Quality Subsystem Maintenance (*Project 153*)

Location: Nationwide.

Project Chief: Kerry T. Garcia.

Period of Project: Continuous since 1988.

Cooperating Agency: None (U.S. Geological Survey program).

Problem: The new National Water-Information System (NWIS) must be designed and implemented, and the existing NWIS Water-Quality Subsystems must be maintained and managed. The development of a new NWIS requires the effective and efficient management of numerous large numbers of personnel in many locations.

Objectives: Data-base management for the Water-Quality Subsystem will be provided and contributions made for planning and designing the new NWIS. The manager will direct the maintenance of computer software, and provide user assistance and training related to the analysis, storage, and retrieval of water-quality data. The manager also will serve as a resource person for the existing NWIS software to expedite the design, development, and implementation of the new NWIS.

Approach: The data-base manager will assure computer-software compatibility with new revisions of the PRIME minicomputer operating system by testing all software functions, making necessary modifications to software, and reporting operating system problems to the Distributed Information Systems (DIS) staff. Malfunctions in the computer software will be identified and repaired, using various software debugging techniques and modifications to software code. Revisions of the computer software will be prepared as part of NWIS releases. User support and training will be provided for computer-processing techniques in a distributed environment using minicomputers. Activities with other NWIS data-base managers will be coordinated.

Progress and Significant Results, Fiscal Years 1989-90: Several information transfer and training workshops were conducted and attended. Software updates were tested and water-quality data-base managers were assisted in resolving their data-base problems in various Districts.

Plans for Fiscal Year 1991: Assistance will continue to be provided to water-quality data-base managers in the Districts, software updates will be tested, training will be provided for users, and information and ideas will be contributed to the development of NWIS-II.

Foreign Hydrology (*Project 155*)

Location: Foreign countries.

Project Chief: Craig L. Westenburg.

Period of Project: 1989-91.

Cooperating Agency: U.S. Department of Defense.

Problem: Military operations involving troop deployments depend on local water resources for water supplies. In many undeveloped or politically inaccessible parts of the world, water-resources information is scarce or not readily available. U.S. military planners need a comprehensive, automated water-resources data base from which areal or point-source information can be rapidly retrieved in support of logistical decisions by field commanders.

Objectives: The investigation will evaluate water resources in selected areas of foreign countries with respect to their suitability as sources of military water supplies. An automated Geographic-Information System (GIS) data base will be constructed using available water-resources and related data, and interpretations will be made after analyzing the available data and information.

Approach: Selected foreign study areas will be assigned through USGS Headquarters by the Terrain Analysis Center of the U.S. Army Corps of Engineers, which will provide pertinent documents and materials. Additional literature and data searches will be made as needed. All pertinent hydrologic and related information will be compiled, reviewed, and analyzed. Relevant data and interpretations will be entered into the GIS.

Progress and Significant Results, Fiscal Years 1989-90: Foreign study areas were assigned to the Carson City and Las Vegas project personnel. Two map sheets showing parts of the selected areas were initially assigned to the Carson City office and three map sheets showing parts of another area were assigned to the Las Vegas office. The Army supplied overlays for each map sheet and source documents for updating the overlays. Terrain Analysis Center personnel completed two project reviews. Overlays, data-base forms, and data tables for two map sheets were completed and sent to the Terrain Analysis Center; work on the remaining three map sheets was started.

Plans for Fiscal Year 1991: Overlays, data-base forms, and data tables for the three remaining map sheets will be completed.

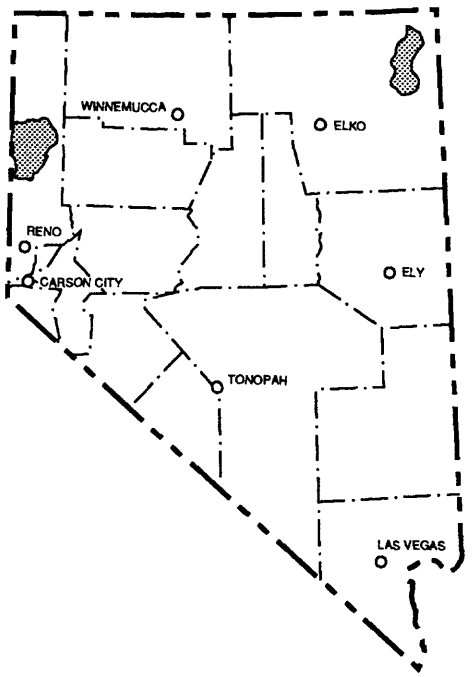
Evapotranspiration Variability in Native Vegetation (*Project 156*)

Location: Northeastern and northwestern Nevada.

Project Chief: Michael J. Johnson.

Period of Project: 1989-92.

Cooperating Agency: Elko County, and the Regional Water Planning and Advisory Board--Reno-Sparks and Washoe County.



Problem: The major discharge component of groundwater basins in Nevada, and in a large part of the western United States, is evapotranspiration (ET). In these basins, ET has not been quantified by making actual measurements, but commonly is estimated on the basis of empirical equations using available meteorological data or assumed ET rates for land cover in the basin. Such ET estimates can greatly affect the accuracy of water budgets upon which water allocations are based. Quantification of ET through direct measurements of water-vapor discharge is believed to hold the greatest promise in improving water-budget estimates. Very little work has been done that physically measures ET from native vegetation in the Great Basin.

Objectives: The study will (1) measure and define the areal variability of ET from native vegetation by monitoring actual water-vapor discharge (latent heat flux); and (2) develop and use ET/land-cover relations, along with satellite imagery, to interpolate point measurements of ET over a selected basin for the purpose of quantifying the total ET component of the water-budget of the basin.

Approach: The Bowen-ratio method will be used to solve the energy-balance equation and obtain the latent heat flux. The eddy-correlation method also will be used. Both are micrometeorological techniques requiring short-term monitoring to obtain water-vapor discharge. In the first year, point measurements of ET will be made and interpolated to determine ET in the Toano Draw-Rock Springs Creek area of northeastern Nevada. Work will also be done in other basins.

Progress and Significant Results, Fiscal Years 1989-90: One Penman weather station, one radiation station, two Bowen-ratio systems, and two eddy-correlation systems were installed in the Toano Draw area. The two Bowen-ratio systems were placed over native sage and rangeland grasses during the growing season. The eddy-correlation systems were correlated to the Bowen sites and used to obtain periodic measurements from a variety of vegetation assemblages. Landsat imagery to identify plant assemblages and to distribute point measurements of ET was enhanced and classified. A total of 57 spectral clusters were identified, grouped into 27 classes, and verified.

Plans for Fiscal Year 1991: Processing of field data from Toano Draw will be completed. ET/land-cover relations, used in conjunction with vegetation-assemblage maps to interpolate point measurements of ET over the study area, will be developed to quantify the total ET component in the water budget. A map-report will be prepared to show generalized zones of ET and to describe the total ET component of the water budget for the growing season. Micrometeorological equipment will be installed in the Smoke Creek Desert basin, data will be collected, Landsat imagery will be obtained and correlated to spectral units of vegetation, and a map-report will be prepared.

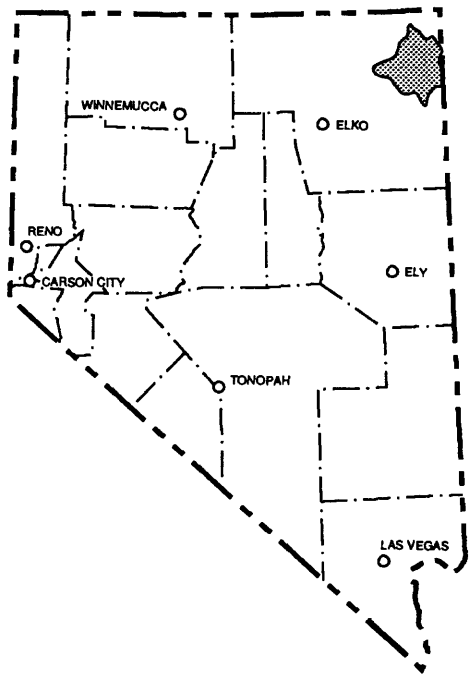
Water Availability, Thousand Springs Valley (*Project 157*)

Location: Northeastern Nevada.

Project Chief: Kathryn C. Kilroy.

Period of Project: 1989-91.

Cooperating Agency: Elko County.



Problem: A proposed power generation facility to be constructed in the Toano Draw area of Thousand Springs Valley would require an estimated 32,000 acre-feet of ground water annually. A withdrawal of this magnitude could greatly stress the hydrologic system. A reconnaissance study in the 1960's determined that only an estimated 35,000 acre-feet of runoff from mountainous areas is potentially available for ground-water recharge. However, estimates of water-budget components and ground-water movement are largely uncertain. A recent environmental-impact study in the area indicated that the ground-water resources are very sensitive to subsurface inflow and outflow, evapotranspiration, and precipitation recharge, all of which are poorly understood in the basin.

Objectives: The study will (1) increase the hydrologic data base needed to provide insight into hydrologic processes, (2) develop an improved conceptual model of ground-water movement, and (3) describe water-quality characteristics of surface-water and ground-water resources in the basin.

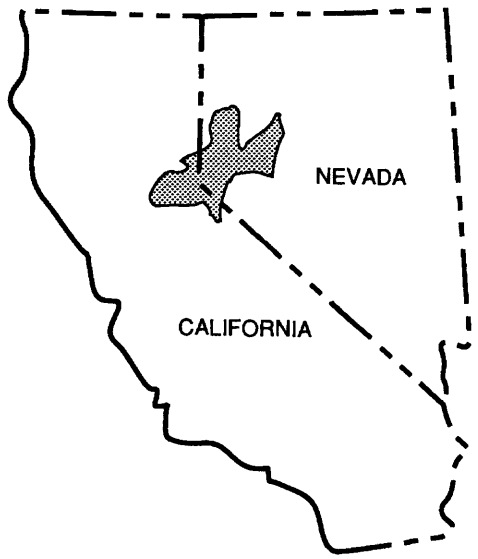
Approach: Available literature will be assembled and searches for geophysical, geologic, hydrologic, and geochemical data will be made. Operation of the Phase I monitoring networks (which began in 1985 under project 131) for ground-water levels, streamflow, and water quality will be continued. A comprehensive well and spring inventory will be made. Measurements will be made of instantaneous stream discharge at ungaged sites, and for water-quality parameters at both ground-water and surface-water sites. The hydraulic properties of major rock units will be analyzed to determine basin hydrostratigraphy. Precipitation, streamflow characteristics, and channel morphology will be analyzed to determine rainfall-runoff relations. Maps and graphs of water-quality data will be plotted to determine variations in space and time. Evapotranspiration data will be collected and analyzed to determine vegetative use. Ground-water flow directions and paths will be determined from observed water levels, geochemistry, and geologic and geophysical interpretations of geohydrologic structure.

Progress and Significant Results, Fiscal Years 1989-90: The literature and data-base searches were completed. All data collection in the field was completed, and all field data were plotted on maps and graphs for future analysis. Sections of the final report were written.

Plans for Fiscal Year 1991: Report writing will be completed and the draft placed in review. Not all project objectives will be met; the cooperator reduced funding because plans to construct the power facility were cancelled.

Paired-Basin Climate Change (*Project 158*)

Location: Sierra Nevada, California and Nevada.



Project Chief: Alex Pupacko.

Period of Project: 1990-93.

Cooperating Agency: None (U.S. Geological Survey program).

Problem: Changes in the current climatic regime could significantly affect the type, amount, and occurrence of precipitation and runoff in the Carson, American, and Truckee River basins and result in far-reaching changes in hydrologic processes and water management and use.

Objectives: The project will define the effects of possible climate change on the surface-water resources of the Carson, American, and Truckee River basins and develop analytical tools for interpreting those changes. The project complements a parallel investigation by the U.S. Bureau of Reclamation to study the possible effects of climate change on water supply and demand, system management, and operating criteria.

Approach: Current climate and future climate scenarios will be defined and developed, a data base to support watershed modeling of the three basins will be developed, and watershed processes for current and future climate scenarios will be modeled.

Progress and Significant Results, Fiscal Year 1990: A work plan was developed and presented to the Geological Survey and Bureau of Reclamation steering committee. Work groups were formed to foster communication between the Survey and the Bureau in development of climate scenarios, remote-sensing techniques, a Geographic-Information System (GIS), and computer resources.

Plans for Fiscal Year 1991: A data base and GIS will be developed for the study area, climate scenarios will be developed, a stochastic analysis of streamflow will be prepared, and watershed models will be developed.

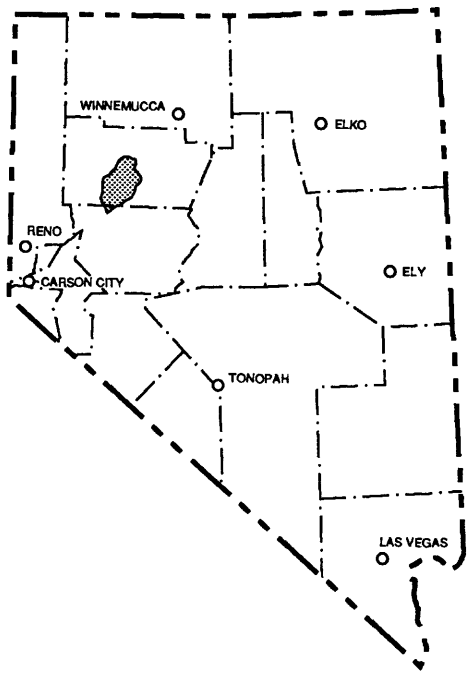
Reconnaissance Study of Irrigation Drainage in the Humboldt Wildlife Management Area (*Project 159*)

Location: Pershing and Humboldt Counties, Nevada.

Project Chief: Ralph L. Seiler.

Period of Project: 1990-92.

Cooperating Agency: U.S. Bureau of Reclamation, and U.S. Fish and Wildlife Service (Department of the Interior Program).



Problem: During the past several years concern has been increasing about the quality of irrigation drainage and its effect on human health, fish, and wildlife. The Humboldt Wildlife Management Area (HWMA) is an important feeding and resting area for migratory birds that use the Pacific flyway. It is maintained mostly by irrigation-return flow from fields in the Lovelock area. Elevated concentrations of potentially toxic trace elements have been found in the drain water and in birds using the HWMA.

Objectives: Determine if irrigation drainage flowing into the area has caused or has potential to cause significant harmful effects on human health, fish, and wildlife, or to impair water use in the HWMA.

Approach: Reconnaissance sampling of surface and ground water at sites near HWMA will be done during the pre-, mid-, and post-irrigation seasons. Water samples for inorganic chemical analysis will be collected all three times; water samples for organic chemical analysis will be collected only once, during the mid-irrigation season. Bottom sediment samples for inorganic and organic chemical analyses will be collected once, during the post-irrigation season. Data will be analyzed to determine what effect irrigation-return flows have on water quality in the HWMA.

Progress and Significant Results, Fiscal Year 1990: The detailed work plan was completed and approved. Pre- and mid-irrigation season water-quality samples were collected at 11 sites. Chemical analyses of water samples showed high concentrations of dissolved solids, arsenic, boron, and lithium compared with the background stations. Concentrations of selenium were less than or equal to 2 micrograms per liter for all the surface-water sites. No carbamate pesticides were detected in surface-water samples collected in July 1990, but 2,4-D was detected in one surface-water sample. An annotated outline of the report was prepared.

Plans for Fiscal Year 1991: Sample collection will be completed, data analyzed, and results compiled in a report.

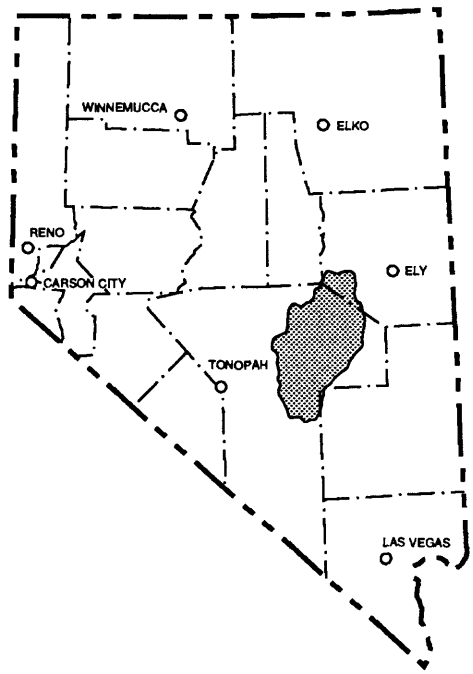
Effect of Regional Ground-Water Flow on Oil Migration (*Project 160*)

Location: Great Basin
(initial study site: Railroad Valley area, Nevada)

Project Chief: Donald H. Schaefer.

Period of Project: 1990-93.

Cooperating Agency: None (U.S. Geological Survey program).



Problem: Recent studies indicate that regional flow of ground water may be a driving force of oil migration in certain areas. A conceptual model of a water-driven, oil-migration system describes ground water descending from the recharge area, leaching soluble oil near deeply buried source rocks, and transporting it through regional aquifers. The oil is deposited in a trap at the discharge end of the flow system.

Objectives: The study will determine if there is a relation between regional ground-water flow and the occurrence and movement of oil in the Great Basin. The overall study area for this project is the Great Basin region of eastern Nevada and western Utah; however, much of the initial work will be concentrated in the Railroad Valley area, east-central Nevada. An understanding of the movement of oil in and adjacent to Railroad Valley, as related to regional ground-water flow, could provide information usable in other areas of the Great Basin. A conceptual model of the Railroad Valley ground-water flow system will be developed based on the observations and analyses made during this study.

Approach: A literature search will be made and existing data compiled, with an emphasis on Railroad Valley. The large amount of existing oil-well data and considerable oil exploration in this valley make it a good location to develop and test conceptual models. Any correlations with occurrence of oil and regional ground-water flow will be determined. On the basis of these results, a recommendation regarding further study will be made. Plans include sampling, cross-sectional modeling, and possible test drilling; a final report will be prepared.

Progress and Significant Results, Fiscal Year 1990: All data for existing oil and gas wells in Nevada were collected and compiled. A cross-sectional model crossing the Railroad Valley ground-water flow system was constructed and preliminary model runs were made.

Plans for Fiscal Year 1991: A comprehensive study plan will be prepared. Selected wells and springs will be measured and sampled. Water samples from wells and springs will be analyzed for organic carbon compounds that indicate contact with oil. Ground-water age dating will be done to determine rates of flow in some of the systems. Ground-water flow within Railroad Valley will be related to the location of oil fields in the Valley by using cross-sectional transport models.

Publications, Fiscal Year 1990:

Dettinger, M.D., Schaefer, D.H., and Thomas, J.M., 1990, Tertiary-age extensional patterns as a geologic framework for interpreting regional ground-water flow in the eastern Great Basin, Nevada and Utah, *in* Flanigan, D.M.H., Garside, L.J., and Hansen, Mike, eds., Oil fields and geology of the Pine Valley, Eureka County area, Nevada: Reno, Nev., Nevada Petroleum Society Inc., 1990 Fieldtrip Guidebook, 74 p.

Thomas, J.M., Schaefer, D.H., and Dettinger, M.D., 1990, Use of geochemical data to trace ground-water flow, which could affect oil migration, in carbonate-rock aquifers of the eastern Great Basin, Nevada and Utah [abs.], *in* Flanigan, D.M.H., Garside, L.J., and Hansen, Mike, eds., Oil fields and geology of the Pine Valley, Eureka County area, Nevada: Reno, Nev., Nevada Petroleum Society Inc., 1990 Fieldtrip Guidebook, 74 p.

Surface-Water Runoff Monitoring, Yucca Mountain Area (*Project 161*)

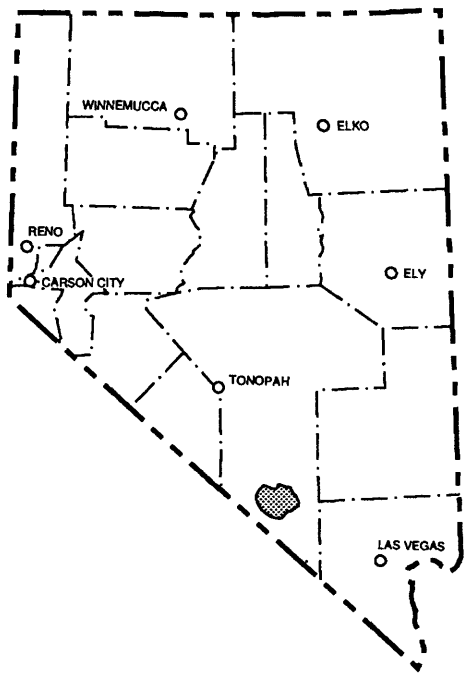
Location: Yucca Mountain area, southern Nevada.

Project Chief: David A. Beck.

Period of Project: Continuous since 1989.

Cooperating Agency: U.S. Department of Energy.

Problem: Yucca Mountain is being studied as a proposed repository for high-level radioactive waste. Streamflow data are needed to help determine the relation between precipitation and runoff and between runoff and infiltration in the area.



Objectives: The study will (1) use streamflow data to describe the runoff characteristics of the area and assess the response of runoff to precipitation, and (2) provide basic data and interpretation of surface-water runoff to investigations that evaluate the amounts and processes of infiltration to the unsaturated zone and ground-water recharge at Yucca Mountain and surrounding areas.

Approach: Streamflow data from a dense network of recording and nonrecording gages on Yucca Mountain washes and a regional network peripheral to Yucca Mountain will be collected and analyzed.

Progress and Significant Results, Fiscal Years 1989-90: A final version of the study plan was submitted to the Department of Energy for review. Continuous-recording stream gages, peak-flow gages, and precipitation gages were operated and maintained. Detailed plans for the installation of stream gages in upper Fortymile Wash, Yucca Mountain washes, and Amargosa Valley areas were developed. Construction, testing, calibration, and installation of equipment were completed at selected sites for the collection of samples of runoff for chemical and isotopic analyses. Surface-water records for 1983-90 were compiled and checked. Moderate runoff and localized flooding in the Las Vegas Valley, Amargosa Valley, Mercury Valley, Moapa Valley, Jackass Flats, and other miscellaneous sites in southern Nevada were investigated and documented.

Plans for Fiscal Year 1991: Data will be compiled and summarized in reports. Reconnaissance will begin for potential gaging sites in upper Fortymile Wash and in washes on Yucca Mountain. Installation and operation of stream gages at selected sites in Upper Fortymile Wash, Yucca Mountain, and Amargosa Valley will begin, and the operation of the existing continuous-recording stream gages, peak-flow gages, and precipitation gages will continue.

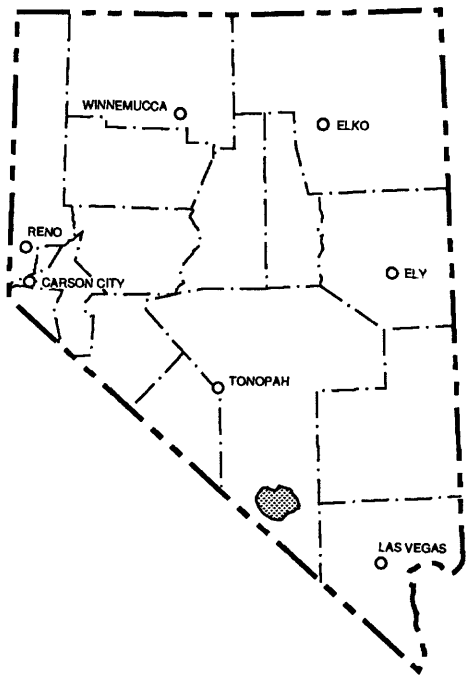
Transport of Debris by Severe Runoff, Yucca Mountain Area (*Project 162*)

Location: Yucca Mountain area, southern Nevada.

Project Chief: Patrick A. Glancy.

Period of Project: 1989-95.

Cooperating Agency: U.S. Department of Energy.



Problem: Flooding and associated sediment movement constitute significant hazards in arid and semiarid regions, yet the infrequent nature of precipitation has yielded a meager data base on which to predict site-specific frequency of flooding or debris-transport processes. Yucca Mountain is being considered as a repository for high-level radioactive waste; therefore, debris movement caused by intensive runoff may present a significant hazard to surface facilities. Thus, methods of prediction of debris-associated hazards are needed for rational placement and design of surface facilities at the proposed nuclear repository. Additionally, predictions of long-term denudation rates are required for assessment of the Yucca Mountain site as a potential repository for high-level radioactive-waste.

Objectives: The study will (1) expand the debris-transport data base in southern Nevada and adjacent parts of California, Arizona, and Utah; and (2) improve predictive techniques to estimate debris transport at Yucca Mountain by developing both qualitative assessments and quantitative measures of the magnitude and frequency of intensive runoff and associated debris movement.

Approach: The data-collection program will investigate debris transport within a 200-mile radius of Yucca Mountain. Estimates and indirect measurements of peak flow at ungaged sites will be made. Debris-transport events will be documented to determine effects, or potential effects, of erosion, transport, and deposition and the conditions and processes that determine them. Specifically, documentation will (1) map and analyze areas of erosion, transportation, and deposition using aerial photographs and other remote-sensing products, or topographic maps; (2) describe deposits to determine the mode of transport (debris flow, hyperconcentrated flow, or streamflow); (3) describe rock types to determine debris provenance; (4) collect and analyze samples of deposits; (5) describe vegetation that may have interacted with the flows; and (6) document the meteorologic events that produced the runoff. From this data base, predictive capability for site-specific conditions at Yucca Mountain will be developed.

Progress and Significant Results, Fiscal Years 1989-90: Flooding and debris transport during August 1989 and the summer of 1990 were documented to the extent possible. Quality-assurance procedures for documenting debris transport were prepared and approved, and a study plan was submitted to DOE.

Plans for Fiscal Year 1991: Field work will continue and the 1990 summer storms and associated debris transport will be documented. Monitoring of debris transport by severe runoff will continue within about a 200-mile radius of Yucca Mountain. Recent, historical, and prehistoric debris deposits at Yucca Mountain will be described.

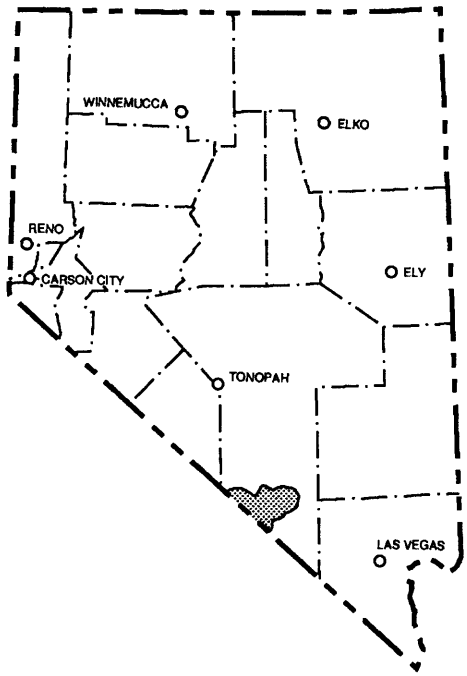
Ground-Water Monitoring Program, Yucca Mountain Area (*Project 163*)

Location: Yucca Mountain area, southern Nevada.

Project Chief: Richard J. La Camera.

Period of Project: Continuous since 1989.

Cooperating Agency: U.S. Department of Energy.



Problem: Yucca Mountain is being considered as a possible repository of high-level nuclear waste. A variety of hydrologic, geologic, geochemical, and other investigations are needed to determine the suitability of that site for storage of such waste. Any adverse effects on water resources in the area due to construction or operation of a proposed repository must be identified. In order to identify any such adverse effects, the quantity and quality of water resources in the area require systematic monitoring. Available data and current monitoring efforts are inadequate to satisfactorily provide for an early detection of possible adverse effects on water resources.

Objectives: The study will monitor and characterize water resources at and near Yucca Mountain with respect to quantity and quality in order to (1) document baseline water-resource conditions; (2) detect changes in those conditions due to ongoing site investigations, other activities in the region, or natural variability; and (3) provide a basis for further hydrologic analyses needed to determine changes due to waste-storage related activities.

Approach: Three major components will be studied: (1) water quantity, (2) water quality, and (3) water use. The design of a water quantity and quality monitoring network program will include a literature survey and data compilation, measurements of discharge at selected springs and ephemeral streams, measurements of water levels at selected wells, and characterization of the chemical quality of ground and surface waters with respect to drinking-water standards and the presence of inorganic, organic, and radioactive contaminants. The data base will be used to document baseline conditions, detect changing conditions, and evaluate effects of site investigations. Data from existing data-collection efforts will be used and supplemented to provide uniform monitoring. When possible, data will be collected before, during, and after investigative and waste-storage activities.

Progress and Significant Results, Fiscal Years 1989-90: Preliminary networks of springs and wells were designed for the collection of spring-discharge, water-level, and water-quality data in the Amargosa Desert, Ash Meadows, and Death Valley areas. Spring discharge was measured at selected springs and water levels were measured at selected wells and at Devils Hole. Water samples were collected for analyses of major inorganic ions, trace metals, nutrients, radionuclides, radon-222, organic carbon, volatile organic compounds, and pesticides.

Plans for Fiscal Year 1991: Installation of the monitoring network will be completed and the scheduled sampling will begin.

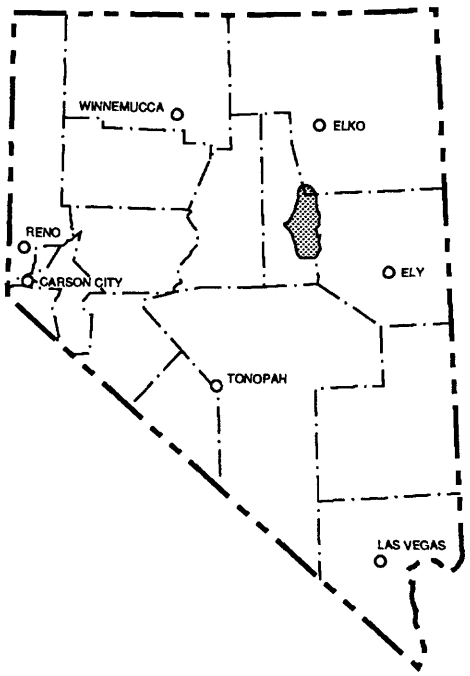
Estimating Ground-Water Withdrawals, Diamond Valley (*Project 164*)

Location: East-central Nevada.

Project Chief: Freddy E. Arteaga.

Period of Project: 1990-91.

Cooperating Agency: Nevada Division of Water Resources.



Problem: Withdrawals of ground water in Diamond Valley have caused water-level declines of 50 feet or more in some parts of the Valley. Pumpage data are sparse; however, pumpage currently is estimated to be equivalent to consumptive water use for irrigation, estimated as 3 feet per year for each acre of alfalfa in production. Data from well-efficiency tests and power consumption are needed to refine pumpage estimates.

Objectives: The project will apply techniques for estimating ground-water withdrawals for irrigation during the growing season by developing relations among reported well-efficiency test data, actual flow measurements, and electricity consumption.

Approach: Existing well data from the Ground-Water Site Inventory (GWSI) files will be assembled and updated and well locations field checked. The annual discharge of irrigation wells in Diamond Valley will be determined from well-efficiency tests on selected wells. Available records on electricity consumption and pump-efficiency tests will be assembled. Relations that could be used to estimate annual withdrawals on the basis of electricity consumption and infrequent discharge measurements will be developed.

Progress and Significant Results, Fiscal Year 1990: Existing well data from the GWSI data base were assembled. All well locations were field checked, location sketches were prepared, site photographs were taken, and documentation of electric and utility-meter numbers was initiated. The ultrasonic flowmeter was tested. Because of imposed constraints, actual flow measurements could not be made and well efficiencies could not be determined. In consultation with the cooperator, the objectives and the approach were modified to consist of compilation of data on irrigated acreage, pumpage, and well tests.

Plans for Fiscal Year 1991: Future work to refine estimates of pumpage will include: (1) conducting well-efficiency tests to augment the existing test data and comparing and defining the spatial and temporal trends; (2) applying nonintrusive, ultrasonic-flow measuring technology throughout the valley to measure well-discharge rates; and (3) converting the data on well electricity consumption to volume of water pumped.

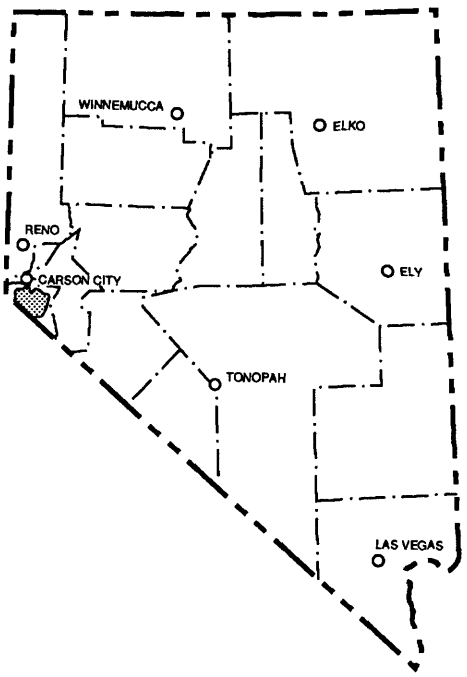
Artificial-Recharge Evaluation, Douglas County (*Project 165*)

Location: West-central Nevada.

Project Chief: Douglas K. Maurer.

Period of Project: 1990-91.

Cooperating Agency: Douglas County.



Problem: Rapid population growth in Carson Valley, west-central Nevada, is producing changes from agricultural to urban land use, accompanied by changes in the distribution and use of water. Artificial recharge to the ground-water aquifers of the valley would provide dependable, off-channel storage for urban water use.

Objectives: The project will evaluate and summarize available information pertaining to artificial recharge for the Douglas County part of Carson Valley. Specifically, the study will (1) develop criteria to determine the relative potential for developing artificial recharge sites in areas throughout the valley, (2) provide information needed to evaluate artificial recharge as a way to provide additional off-channel storage of surface water, and (3) delineate areas with potential for artificial recharge.

Approach: Existing literature will be reviewed to obtain criteria for assessing the potential for artificial recharge. Data from USGS files and data bases; files of State, County, and other Federal agencies; and published reports will be compiled and reviewed and will be used to delineate areas with high potential for recharge.

Progress and Significant Results, Fiscal Year 1990: The literature search was completed, and the data compilation was nearly completed. The preliminary criteria for site evaluation were determined. Maps of depth-to-water, specific yield, hydraulic conductivity, and geology were completed, and the text of the report started. A map-report was selected as the format for the publication.

Plans for Fiscal Year 1991: A Geographic-Information System (GIS) will be used to combine maps and attributes to obtain a final map showing areas with high potential for artificial recharge. The report will be completed and submitted for review.

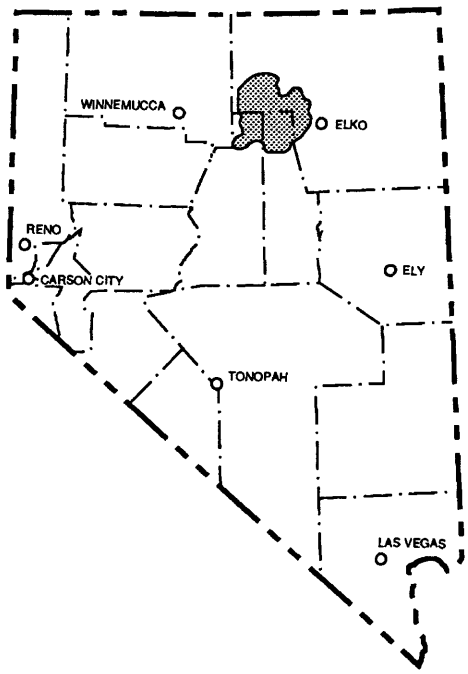
Carlin Gold-Belt Hydrology (*Project 166*)

Location: Northeastern Nevada.

Project Chief: Russell W. Plume.

Period of Project: 1990-91.

Cooperating Agency: Nevada Division of Water Resources.



Problem: Demands for ground water to process ore are increasing rapidly along the Carlin trend, an area in northeastern Nevada, where several large, open-pit gold mines are in different stages of operation and development. In addition, some of the open pits will extend below the water table, requiring the withdrawal of large volumes of water. The mining life of the area is anticipated to be 10-20 years. Thus, potential long-term effects on the hydrologic environment include water-level declines over large areas, changes in streamflow of the Humboldt River and its tributaries, and changes in the quality of ground and surface water. However, these potential effects cannot be assessed unless background hydrologic conditions are documented. Hydrologic data needed to document these conditions generally are not available for most of the area. The problem is further complicated by a severe drought, now in its fourth year, that has affected water resources in the area. Because of the lack of hydrologic data, future changes in water resources would be difficult to assess in terms of cause (drought or mining) and potential long-term effects. Thus, there is a need to document and monitor hydrologic conditions and develop a better understanding of the regional and basin-level hydrogeologic framework along the Carlin trend.

Objectives: A reconnaissance of hydrologic conditions in basins along or adjacent to the Carlin trend north of the Humboldt River will begin in the summer of 1990 and a long-term, hydrologic-monitoring network to provide data for evaluating effects of mining on areal water resources will be recommended. Specific objectives of the reconnaissance include: (1) obtain available data from various sources; (2) measure streamflow of the Humboldt River and its tributaries to identify gaining and losing reaches of the streams and suitable stream-gaging sites; (3) install four recording streamflow gages; (4) measure water levels in wells; (5) sample wells, springs, and streams at selected sites for water quality; and (6) recommend a hydrologic-monitoring network. The reconnaissance will be completed early in fiscal year 1991 and the study will be expanded to develop a better understanding of the hydrogeologic framework of the region.

Approach: Existing hydrologic data will be obtained and evaluated, including (1) data collected as a part of the lower Maggie Creek project and (2) streamflow data for existing gages on the Humboldt River and its tributaries. A reconnaissance of areal water resources will be made. Streamflow measurements will be made and water-quality samples will be collected at 10-15 sites on the Humboldt River and its tributaries between Carlin and Battle Mountain. Ground-water levels will be measured and water-quality samples collected from about 30 wells and springs in Rock Creek basin, Boulder Flat, Willow Creek Valley, and the upper Maggie Creek area. Locations for four additional streamflow gages will be selected on the Humboldt River and its tributaries.

Progress and Significant Results, Fiscal Year 1990: Streamflow was measured and water-quality samples were collected at 12 sites on the Humboldt River and its tributaries from Carlin to Battle Mountain. Ground-water levels were measured at about 80 wells; and water-quality samples were collected from 22 wells and springs in the basins of Boulder, Rock, Willow, and upper Maggie Creeks. The locations for four streamflow gages were selected.

Plans for Fiscal Year 1991: Four streamflow gages were installed in January 1991, and a network for monitoring hydrologic conditions in the study area will be developed. Meetings will be held with State agencies and mining companies to evaluate progress and accomplishments in the project to date and to plan for continuing data collection and work necessary for developing a better understanding of the hydrogeologic framework.

WATER-RELATED PUBLICATIONS, NEVADA DISTRICT, FISCAL YEARS 1989-90

Note: This list also includes reports approved for publication during fiscal years 1989-90 but published in 1991.

Andraski, B.J., 1989, Physical properties of trench backfill at a simulated burial site for low-level radioactive waste near Beatty, NV [abs.]: 80th Annual Meeting, American Society of Agronomy, Anaheim, Calif., December 1988, Program of Agronomy Abstracts, v. 80, p. 178.

-----1989, Water movement and trench stability at a simulated arid burial site for low-level radioactive waste near Beatty, Nevada: American Nuclear Society and Geological Society of America, Nuclear waste isolation in the unsaturated zone--Focus '89, Las Vegas, Nev., September 1989, Proceedings, p. 166-173.

-----1990, Rubber-balloon and drive-core sampling for determining bulk density of an alluvial desert soil [abs.]: Agronomy Abstracts, 1990 Annual Meetings, San Antonio, Texas, October 1990, p. 208.

-----1990, Soil-water movement at a simulated burial site for low-level radioactive waste near Beatty, Nevada--First year results [abs.], *in* Nevada decision point--Which water course to the future?: Annual Conference, Nevada Water Resources Association, Las Vegas, Nev., February 1990, Program Information and Abstracts, unpaginated.

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Most **maps** (Hydrologic Investigations Atlases, Hydrologic Unit Maps, topographic maps, and other maps pertaining to Nevada) are available from:

- U.S. Geological Survey, Map Distribution Section, Federal Center, Box 25286, Denver, CO 80255; telephone (303) 236-7477.

Circular 900, titled "**Guide to Obtaining U.S. Geological Survey Information**," is a free publication designed to help the public utilize U.S. Geological Survey resources. A copy of Circular 900 may be obtained at the Public Inquires Offices listed above, or ordered from the Books and Open-File Reports Section (which also is listed above).

Certain reports, including (1) those having an alpha-numeric designation such as "PB-89 167 399" at the end of the citation, (2) annual U.S. Geological Survey **Water-Data Reports** (which contain all data collected and stored in the U.S. Geological Survey National Water Data Storage and Retrieval System, by state), and (3) most Water-Resources Investigations Reports released before 1982, are available from:

- National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, VA 22161; telephone (703) 487-4650.

The National Water Data Exchange (NAWDEX) was established to assist users of water information in identifying, locating, and acquiring needed data. NAWDEX maintains two data bases: a Water-Data Sources Directory that identifies organizations that collect data, their location, type, and availability of information; and a Master Water-Data Index that identifies and describes water data. These are available from:

- U.S. Geological Survey, National Water Data Exchange, 421 National Center, 12201 Sunrise Valley Drive, Reston, VA 22092; telephone (703) 648-5677.

New reports are announced monthly in "**New Publications of the Geological Survey**," subscriptions to which are available upon request from:

- U.S. Geological Survey, 582 National Center, 12201 Sunrise Valley Drive, Reston, VA 22092.

Topographic, orthophotoquad, land-use, and land-cover maps, and geographic-name and geodesic-control lists pertaining to Nevada are available from:

- Earth Sciences Information Center, U.S. Geological Survey, 345 Middlefield Road, Menlo Park, CA 94025; telephone (415) 329-4309 for custom products, or (415) 329-4390 for published materials.

Reports and maps produced by the **Nevada District** are available for inspection in the Carson City and Las Vegas offices; those pertaining to the Elko area also are available in that office:

- U.S. Geological Survey, Water Resources Division, Room 224, Federal Building, 705 North Plaza Street, Carson City, NV 89701; telephone (702) 887-7600;

- U.S. Geological Survey, Water Resources Division, 1500 E. Tropicana, Suite 201, Las Vegas, NV 89119; telephone (702) 295-1770;

- U.S. Geological Survey, Water Resources Division, 275 Third Street, Elko, NV 89801; telephone (702) 738-5322.

Additional information about Nevada District activities may be obtained from:

- M. Teresa Foglesong, Public Information Assistant, U.S. Geological Survey, Room 224, Federal Building, 705 North Plaza Street, Carson City, NV 89701; telephone (702) 887-7649.