Summary of Water-Resources Activities of the U.S. Geological Survey in Colorado—Fiscal Years 1992-93

U.S. GEOLOGICAL SURVEY

Open-File Report 94-383

Denver, Colorado
1994

U.S. DEPARTMENT OF THE INTERIOR

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U.S. GEOLOGICAL SURVEY

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FIGURE

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Table 1. Water-resources data-collection stations in operation during fiscal year 1993, by station classification 8

CONVERSION FACTORS

Multiply	By	To obtain
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
foot (ft)	0.3048	meter
inch (in.)	25.4	millimeter
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer

Degree Celsius (°C) may be converted to degree Fahrenheit (°F) by using the following equation:

$$°F = 9/5\ (°C) + 32.$$

Degree Fahrenheit (°F) may be converted to degree Celsius (°C) by using the following equation:

$$°C = 5/9\ (°F-32).$$

Sea level: In this report "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)—a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.

SUMMARY OF WATER-RESOURCES ACTIVITIES OF THE U.S. GEOLOGICAL SURVEY IN COLORADO—FISCAL YEARS 1992–93

INTRODUCTION

Water-resources activities of the U.S. Geological Survey in Colorado consist of collecting water-resources data and doing interpretive hydrologic investigations. The water-resources data and the results of the investigations are published or released by either the U.S. Geological Survey or by cooperating agencies. Water-resources investigations in Colorado for the 1992–93 fiscal years (October 1, 1991, to September 30, 1993) are described in this report.

The U.S. Geological Survey's investigations of the water resources of Colorado are under the direction of David J. Lystrom, District Chief. The Colorado District office is located on the second floor of Building 53, Denver Federal Center, Denver, Colorado. The Colorado District has two Subdistrict offices, the Western Slope Subdistrict office in Grand Junction and the Pueblo Subdistrict office in Pueblo; three field headquarters—Lakewood (located in Building 82 on the Federal Center), Meeker, and Durango; and a project office at the Rocky Mountain Arsenal, Commerce City (fig. 1). Requests for information should be addressed as follows:

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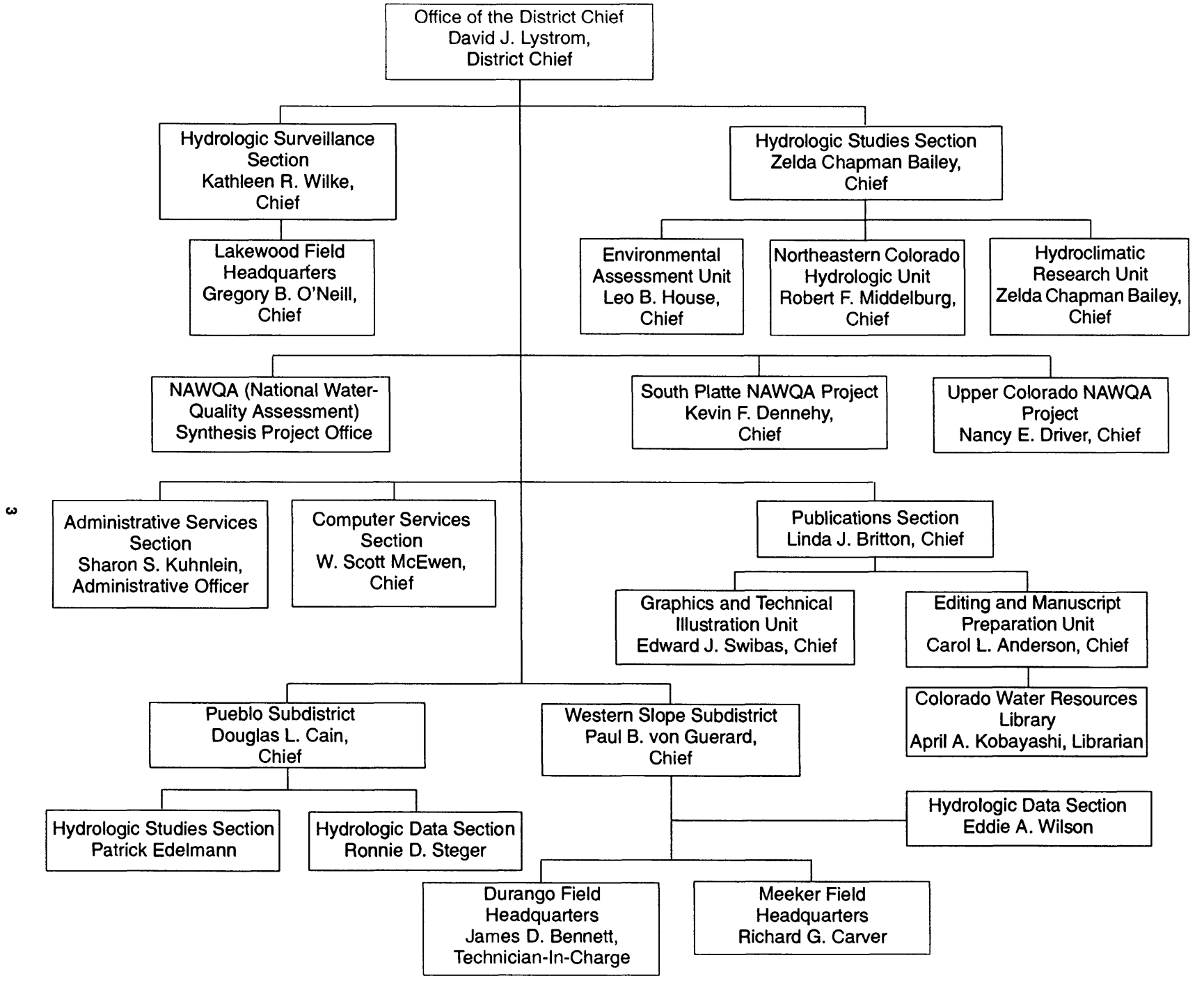


Figure 1. Organizational chart of the Colorado District.

MISSION OF THE U.S. GEOLOGICAL SURVEY

The U.S. Geological Survey was established by an act of Congress on March 3, 1879, to answer the need for a permanent government agency at the Federal level to conduct, on a continuing, systematic, and scientific basis, investigations of the "geological structure, mineral resources, and products of the national domain." Although a number of laws and executive orders have expanded and modified the scope of the U.S. Geological Survey's responsibilities during its 115-year history, the U.S. Geological Survey has remained principally a scientific and technical investigation agency as contrasted with a developmental or regulatory one. Today the U.S. Geological Survey is mandated to assess onshore and offshore energy and mineral resources; to provide information for society to mitigate the effect of floods, earthquakes, landslides, volcanoes, and droughts; to monitor the Nation's ground- and surface-water supplies; to study the effect of man on the Nation's water resources; and to provide mapped information on the Nation's landscape and land use. The U.S. Geological Survey is the principal source of scientific and technical expertise in the earth sciences within the U.S. Department of the Interior and the Federal government. The U.S. Geological Survey's activities span a wide range of earth-science research and services in the fields of geology, hydrology, and cartography and represent the continuing pursuit of the long-standing scientific missions of the U.S. Geological Survey.[1]

MISSION OF THE WATER RESOURCES DIVISION

The mission of the Water Resources Division, which supports the mission of the U.S. Geological Survey and the U.S. Department of the Interior, is to develop and disseminate scientific knowledge and understanding of the Nation's water resources. The activities carried out by the Water Resources Division fall into three broad categories: (1) resource assessment; (2) research; and (3) coordinating the activities and cataloging the products of numerous other entities involved in water research, data acquisition, or information transfer.

Resource Assessment. Resource assessment is conducted by individual Water Resources Division District offices in each State, territory, possession, and the Commonwealth of Puerto Rico. These assessments consist of:

- Collecting data on the quantity, quality, and use of surface water (rivers, streams, lakes, reservoirs, estuaries, and glaciers); the quantity, quality, and use of ground water (including water in the unsaturated zone); and the quality of precipitation.
- Storing and disseminating these data.
- Interpreting these data and publishing the results of these interpretations. This involves the inference of hydrologic causes, effect, and probabilities; and the extension, over space and time, of information contained directly in the data.
- Developing and applying new methods of hydrologic data collection, analysis, and interpretation.
- Conducting areally focused interpretive investigations and appraisals at national, regional, State, or local scales. These include characterizations of ground and surface waters, and of precipitation chemistry, evaluation of natural hydrologic hazards, and studies of other water-related topics. Frequently these investigations involve the development, testing, and application of mathematical models capable of providing insight into hydrologic consequences of management actions, development plans, or natural phenomena. These investigations are carried out through specific Federal programs or in cooperation with State and local governments or other Federal agencies. Results are published in technical journals or in State, local, U.S. Geological Survey, or other Federal agency publications.

[1]Source: Adapted (and updated December 1984) from U.S. Geological Survey Yearbook for Fiscal Year 1983.

- Reporting to the Nation, on a regular basis, on the overall status of the water resource, and on hydrologic events and water-resource issues.

Research. Research is conducted in three National Research Program offices indicated in Reston, Virginia; Denver, Colorado; and Menlo Park, California; and in District offices by research hydrologists. The research, which includes a wide variety of scientific disciplines—geochemistry, ecology, geomorphology and sediment transport, water chemistry, ground-water hydrology, surface-water hydrology, climate change, acid precipitation, and effects of toxic chemicals and hazardous waste—is intended to:

- Improve the overall understanding of the pathways, rates of movement, chemical processes, and biological processes in the hydrologic cycle.
- Improve the overall understanding of the hydraulic, chemical, and biological factors, both natural and anthropogenic, which affect the resource.
- Provide new strategies of data collection, analysis, and interpretation, in the light of new knowledge and evolving scientific capabilities.
- Improve methods of predicting the response of hydrologic systems to stresses, whether hydraulic or chemical, and whether of natural or human origin.

Coordinating the Activities and Cataloging the Products of Other Entities Involved in Water Research, Data Acquisition, or Information Transfer. This function has four major components:

- The coordination of water-data acquisition activities of Federal agencies (as mandated by OMB Circular A–67).
- The acquisition of water-use data and development of State and national water-use data bases in cooperation with State governments.
- The operation of Water Information Exchanges and Centers which provide all interested parties with indexing and access to many sources of water data and information.
- The administration of extramural water-resources research, technology, development, academic training, and information-transfer programs mandated by the Water Resources Research Act of 1984 (Public Law 98–242). The Act mandates research oriented to the environmental values associated with the resource. The research promoted by the Act involves many disciplines and activities other than those required in the assessment, research, and coordinating functions of the Water Resources Division.[2]

MISSION AND VISION OF THE COLORADO DISTRICT

Our mission is to provide the hydrologic information and interpretations that are needed to understand, manage, and use the Nation's water resources.[3]

Our vision is to be a progressive, well-respected, scientific organization dedicated to providing relevant, high-quality hydrologic information and interpretations that are timely and exceed the needs of our customers. We will attain this vision by creating a challenging and rewarding work environment that encourages teamwork, provides opportunities for personal and professional growth, respects the dignity of all employees, and fosters full development of their talents.[3]

[2]Source: Mission statement by the Chief Hydrologist, September 18, 1984.

[3]Source: Colorado District Total Quality Management Quality Council, July 1993.

COOPERATING AGENCIES

In Colorado, some of the water-resources data-collection activities and interpretive hydrologic investigations are done in cooperation with Federal, State, and local agencies. Those agencies cooperating with the U.S. Geological Survey during fiscal years 1992–93 were as follows:

Arkansas River Compact Administration
Bent County Board of County Commissioners
Boulder County Public Works Department
Centennial Water and Sanitation District
Cherokee Water and Sanitation District
Cities of Littleton-Englewood, Bi-City Wastewater Treatment Plant
City and County of Denver, Board of Water Commissioners
City of Aspen
City of Aurora
City of Boulder
City of Colorado Springs
  Department of Public Works
  Department of Utilities, Wastewater Division
City of Englewood
City of Fort Collins, Water and Wastewater Department
City of Glendale
City of Glenwood Springs
City of Lakewood
City of Lamar
City of Las Animas
City of Longmont
City of Loveland
City of Pueblo, Department of Public Works
City of Rocky Ford
City of Steamboat Springs, Public Works Department
City of Thornton
City of Westminster
Colorado Department of Public Health and Environment
Colorado Department of Transportation
Colorado Department of Natural Resources
  Division of Water Resources, Office of the State Engineer
  Division of Wildlife
  Division of Minerals and Geology
  Mined Land Reclamation Division
  Oil and Gas Conservation Commission
Colorado River Water Conservation District
Colorado Water Conservation Board
Delta County Board of County Commissioners
Eagle County Board of County Commissioners
East Cherry Creek Valley Water and Sanitation District
East Grand County Water Quality Board
Evergreen Metropolitan District
Fountain Valley Authority
Fremont Sanitation District
Garfield County, Building, Sanitation, and Planning Department
Jefferson County Board of County Commissioners
Lower Fountain Water Quality Management Association
Metro Wastewater Reclamation District
Moffat County

Northern Colorado Water Conservancy District
Pueblo Board of Water Works
Pueblo County Board of County Commissioners
Pueblo West Metropolitan District
Rio Blanco County Board of County Commissioners
Rio Grande Water Conservation District
Routt County
St. Charles Mesa Water District
Southeastern Colorado Water Conservancy District
Southern Ute Tribal Council
Southwestern Colorado Water Conservancy District
Town of Breckenridge
TRANS Mountain Hydro Corp., Federal Energy Regulatory Commission Licensee
Trinchera Water Conservancy District
Uncompahgre Valley Water Users Association
Upper Arkansas Area Council of Governments
Upper Arkansas Water Conservancy District
Upper Eagle Regional Water Authority
Upper Yampa Water Conservancy District
Urban Drainage and Flood Control District
U.S. Department of Defense
  Department of the Air Force
    Construction Engineering Research Lab
    Air Force Academy
    Human Systems Division
  Department of the Army
    Aberdeen Proving Ground
    Aeronautical Systems Center (Material Command)
    Corps of Engineers
      Albuquerque District
      Omaha District
   Fort Carson
    Pueblo Depot Activity
    Program Manager, Rocky Mountain Arsenal
U.S. Department of Energy
U.S. Department of the Interior
  Bureau of Land Management
  Bureau of Reclamation
  Fish and Wildlife Service
  National Park Service/Environmental Restoration
  Office of the Secretary
U.S. Environmental Protection Agency
Ute Mountain Ute Indian Tribe
Vail Valley Consolidated Water District
Willows Water District
Yellow Jacket Water Conservancy District

COLLECTION OF WATER-RESOURCES DATA

Hydrologic-data stations are maintained at selected locations throughout Colorado and constitute a water-resources-data network for obtaining records on streamflow stage and discharge, lake elevation and storage, the quality of surface and ground water, ground-water levels, well and spring discharge, and meteorological data (table 1). Every year, new stations are added and other stations are terminated; thus, the U.S. Geological Survey has a current and a historical file of hydrologic data. Most water-resources data are stored in the U.S. Geological Survey's National Water Information System (NWIS) data base and are available on request to water planners and others involved in making decisions affecting Colorado's water resources. These data can be retrieved in machine-readable form or in the form of computer-printed tables, statistical summaries, and computer plots. Local assistance in the acquisition of services or products from NWIS can be obtained by contacting the District Chief, Denver, Colorado.

Table 1. Water-resources data-collection stations in operation during fiscal year 1993, by station classification

[The number and type of stations located in each county are shown on plate 1 (in pocket)]

Station Classification	Number of stations
Surface water:	
Streamflow:	
Continuous (daily) record	330
Seasonal (daily) record	8
Peakflow, crest-stage record	55
Real-time stage and discharge	128
Lakes and reservoirs:	
Stage and contents	27
Real-time stage and contents	10
Water quality:	
Periodic chemical quality	91
Daily quality monitoring	44
Ground water:	
Periodic water levels	1,450
Daily water levels	14
Chemical quality	18
Meteorological:	
Precipitation quantity or air temperature or both	25
Periodic precipitation quality	1
Real-time precipitation and air temperature	9

Surface-Water Data

Surface-water stage (water level), discharge (streamflow), and water-quality data are collected for general hydrologic purposes, such as assessment of water resources, areal analysis, determination of long-term trends, research and special studies, or for management and operational purposes. Data-collection platforms (DCP's), used for the transmission of satellite-telemetered data, have been installed at 147 sites throughout the State. Satellite-telemetry acquisition of the information is essential to many agencies for operating reservoirs, predicting river stage and flood conditions, and optimizing the use of water resources. DCP information is transmitted to the Geostationary Operational Environmental Satellite (GOES) and received at the U.S. Geological Survey Local Readout Ground Station (LRGS) located in Denver, where it is processed and made available to other agencies.

Continuous water-quality monitoring for water temperature, pH, dissolved oxygen, specific conductance, or turbidity was done at 44 sites. Instruments measured the parameters of interest periodically during the day, enabling the information to be summarized for the day, such as the daily maximum, minimum, and mean values.

Periodic water-quality data (major ions, nutrients, trace elements, pesticides, or radiochemicals) were obtained at 91 of the surface-water stations listed in table 1. Seven of these stations were part of a U.S. Geological Survey nationwide network known as National Stream Quality Accounting Network (NASQAN)), and two of these stations are part of the nationwide Hydrologic Benchmark Network (HBN) that provides data used in the evaluation of trends in stream quality. Information from water-quality stations is used to monitor the quality of surface water in Colorado. The frequency of sample collection can vary from daily for some of the physical data to annually for pesticide or radiochemical data.

A variety of water-quality data is collected at miscellaneous sites that are part of interpretive hydrologic studies. This information also is available from the files of the U.S. Geological Survey.

Ground-Water Data

Water levels in wells are key characteristics for monitoring ground-water trends; however, they must be integrated with other observations and ground-water investigations to have the most relevance and usefulness. A network of 1,450 observation wells is maintained in eastern Colorado and the San Luis Basin for monitoring fluctuations in water levels. Other wells, known as "project wells," are used for specific (generally short-term) investigations; although these wells are not part of the observation-well networks, data obtained from them also are available.

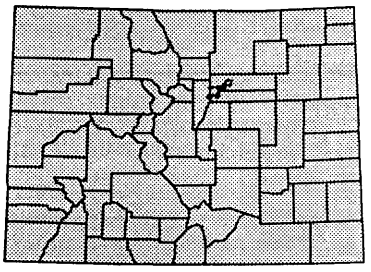
Water-quality data were collected at 18 wells during 1993. These data, as well as data from project wells, are available from the files of the U.S. Geological Survey.

Meteorological Data

Precipitation quantity or air temperature or both are collected at 25 stations in Colorado. One station, located in Bent County, is part of the nationwide National Trends Network program (NTN) to monitor long-term precipitation-quality changes. Information from the precipitation stations is available to users on request.

INTERPRETIVE HYDROLOGIC INVESTIGATIONS

Fifty interpretive hydrologic investigations were done during fiscal years 1992–93 in cooperation with 70 Federal, State, and local agencies. Hydrologic investigations were done that will provide information needed to answer hydrologic questions specific to the State's four major river basins (Missouri, Arkansas, Rio Grande, and Colorado), as well as questions addressing nationwide, multistate, and statewide hydrologic problems. A summary of each investigation, including problem, objectives, approach, progress, and plans for fiscal years 1992–93, follows.



PROJECT TITLE: STATEWIDE WATER-USE INVENTORY

PROJECT NUMBER: CO–78–007

STUDY LOCATION: Statewide

COOPERATING AGENCIES: Colorado Department of Natural Resources, Division of Water Resources, Office of the State Engineer

PROJECT CHIEF AND OFFICE: Russell G. Dash, Subdistrict Office, Pueblo

PROJECT DURATION: November 1977 to September 1999

PROBLEM: Water-use data in Colorado are not complete and detailed enough for planning purposes and implementation of a State water plan. Sources of water supplies, water use, and the volume of water consumed or available for multiple use require documentation so State and local managers and planners may be better informed to make decisions for development of the State's water resources.

OBJECTIVE: Maintain a computerized water-use data base that can be accessed by a variety of users. Develop methods and guidelines for more complete and accurate estimation of water use.

APPROACH: Obtain water-use data by contacting users, accessing pre-existing data bases, and developing estimation techniques.

PROGRESS: Estimates of State water use during 1990 were completed and transmitted to the National Water-Use Information Program data base. Data retrievals were made for the Rio Grande National Water-Quality Assessment program (NAWQA) and for the Nebraska District. The draft of a report, "Irrigation water use during 1989–90 for the Fort Lyon Canal, southeastern Colorado," was written.

PLANS FOR FY 93: An effort to provide the general public with basic information on how water resources are used in Colorado will continue. An evaluation of the 1990 data-collection program in Colorado will determine the water-use categories that will need to be inventoried for the 1995 national assessment of water use.

PROJECT TITLE: EVALUATION OF THE HYDROLOGIC BENCHMARK NETWORK

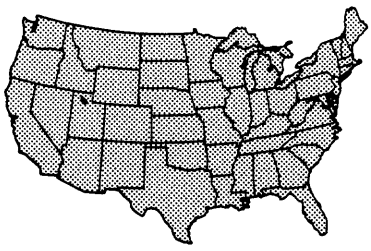
PROJECT NUMBER: CO–80–131

STUDY LOCATION: Nationwide

COOPERATING AGENCIES: None—U.S. Geological Survey funds only

PROJECT CHIEF AND OFFICE: John T. Turk, District Office, Denver

PROJECT DURATION: November 1979 to September 1994



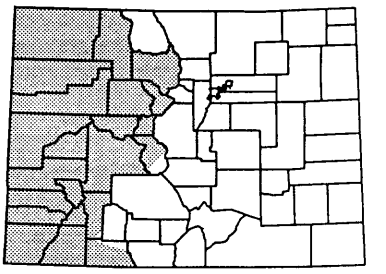
PROBLEM: The purpose of the Hydrologic Benchmark Network (HBN) is to detect trends in the chemistry and hydrology of pristine, headwater hydrologic systems unaffected by local, anthropogenic disturbances. However, because many of these sites contain roads, dwellings, mines, logged areas, or other disturbances, they may not be truly pristine. Whether these apparent disturbances significantly affect stream chemistry is not known.

OBJECTIVE: This study will determine whether the past and present HBN sites are appropriate to meet the goals of the HBN program. The study will also determine what types of new sites are needed to improve the program.

APPROACH: Each past or present HBN site is to be visited by a review team. The watershed sub-basins will be sampled for major ion chemistry to determine whether the watershed chemistry is heterogeneous. Disturbances will be documented and sampling downstream from disturbances will be used to determine their importance. Information from land managers on watershed history and management will be cataloged. A publication will be prepared documenting the status of past and present sites.

PROGRESS: Most of the stations in the HBN have been visited and synoptic sampling completed. Several stations have been selected to be deleted from the network because of incompatibility with network objectives.

PLANS FOR FY 93: Field evaluations of HBN will be completed, and a report will be written.



PROJECT TITLE: REGIONAL AQUIFER SYSTEM ANALYSIS OF THE UPPER COLORADO RIVER BASIN IN COLORADO

PROJECT NUMBER: CO–81–158

STUDY LOCATION: The Upper Colorado River Basin in western Colorado

COOPERATING AGENCIES: None—U.S Geological Survey funds only

PROJECT CHIEF AND OFFICE: Emanuel Weiss, District Office, Denver

PROJECT DURATION: July 1981 to September 1992

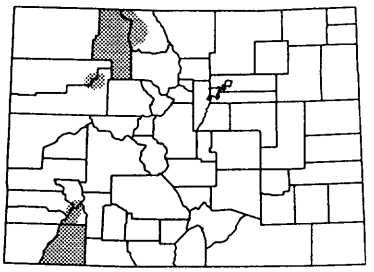
PROBLEM: Water demands are increasing in the Upper Colorado River Basin. Ground-water reservoirs may contain large supplies, but they have not been investigated. Effective water management cannot proceed until all water supplies have been appraised.

OBJECTIVE: To locate major aquifer systems, to estimate the volume of ground water in storage, to determine the quality of available ground water, and to estimate the hydrologic impacts of major withdrawals and injection.

APPROACH: Hydrologic and geochemical data will be compiled from existing well logs and field inventory of wells and springs. Simulation models will be prepared and used to estimate the effects of withdrawals from, and injection into, various aquifer systems.

PROGRESS: Project was completed in FY 92 and final reports were written.

PLANS FOR FY 93: None. Project complete.



PROJECT TITLE: EFFECTS OF ENERGY-PRODUCTION EMISSIONS ON COLORADO LAKES

PROJECT NUMBER: CO–80–165

STUDY LOCATION: Rio Blanco, Garfield, LaPlata, and Routt Counties

COOPERATING AGENCIES: Colorado Department of Public Health and Environment

PROJECT CHIEF AND OFFICE: John T. Turk, District Office, Denver

PROJECT DURATION: November 1979 to September 1999

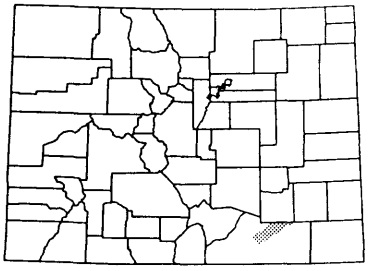
PROBLEM: Current and proposed production of energy in Colorado and surrounding States will release acidic gases and other constituents that can affect the chemistry of precipitation and of poorly buffered lakes and streams. The water resources of the Flat Tops, Mt. Zirkel, and Weminuche Wilderness Areas in western Colorado are located downwind from areas of possible oil-shale development and coal-burning powerplants. The unreactive bedrock of the area, combined with the orographic effect on precipitation, may cause the area to be particularly susceptible to adverse effects of energy production. Data on precipitation and lake quality do not exist to define predevelopment conditions or relative sensitivity of waters to input of additional chemical constituents.

OBJECTIVE: Delineate the areas in Colorado most susceptible to the effect of acid rain. Determine which lakes, within susceptible areas, have the least buffering capacity and the smallest nutrient-loading rate. Select lakes, representative of other lakes within the susceptible areas, for more detailed study. Determine baseline chemical quality of precipitation.

APPROACH: Select areas most susceptible to acidification based on the following: downwind location from acidic-gas sources, unreactive bedrock geology, and large snowpack accumulation. Measure relative buffering capacity of the lakes by alkalinity-titration curves. Install and operate precipitation gages and weather stations to collect samples for analysis of wet- and dry-deposition quality and data on wind direction and speed. Conduct long-term monitoring of index lakes.

PROGRESS: The chemistry of atmospheric deposition and lakes has been monitored and used to demonstrate the rapid response of high-elevation lakes to changes in the chemistry of atmospheric deposition.

PLANS FOR FY 93: Monitoring of lakes and wetfall will continue. Stable sulfur isotopes have been added to routine monitoring of major ions.



PROJECT TITLE: ASSESSMENT OF WATER RESOURCES AND RELATED EFFECTS RESULTING FROM MILITARY TRAINING IN THE PINON CANYON AREA, COLORADO

PROJECT NUMBER: CO–83–172

STUDY LOCATION: Southeastern Colorado, including tributaries of the Purgatoire and Apishapa Rivers in Las Animas County

COOPERATING AGENCY: U.S. Department of the Army, Fort Carson

PROJECT CHIEF AND OFFICE: Paul von Guerard, Subdistrict Office, Pueblo

PROJECT DURATION: October 1982 to September 1992

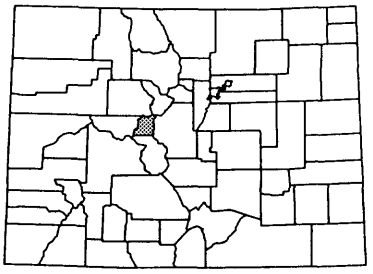
PROBLEM: Beginning in 1985, a 400-square-mile area will be acquired in the Pinon Canyon area by the U.S. Department of the Army and used for military training beginning in 1985. Conversion of land use from grazing may alter streamflow and water quality. These changes could not be quantified in the Environmental Impact Statement (EIS) for the acquisition but are a concern to downstream water users in Colorado and Kansas. The Authorizing Act for the acquisition directs the Army to establish a system of hydrologic monitoring to collect baseline data and record changes in the quantity and quality of water flowing from the land acquired.

OBJECTIVE: Assess the quantity and quality of surface- and ground-water resources in the area. Determine the effect of military training on the water resources of the area.

APPROACH: Surface-water flow will be monitored at 10 stations. Two are existing and eight will be installed in FY 83. Specific conductance will be monitored continuously at all stations. Sediment samples will be collected by automatic samplers at seven stations. Water-quality samples will be collected of baseflow and storm runoff. Historic sediment yield will be determined by surveying sediment accumulation in 40–50 small reservoirs. These will be resurveyed to determine sediment yield following training. Existing wells will be inventoried and 50 will be sampled. Water levels will be measured monthly in 10 wells.

PROGRESS: Precipitation volume and intensity were measured April through September at 19 sites in the Taylor and Lockwood Arroyo drainage basins. The final interpretive report was published. Compilation of precipitation data for 19 sites in the Taylor and Lockwood arroyo drainage basins was begun.

PLANS FOR FY 93: Compilation of precipitation data and operation of the seasonal precipitation data-collection network will continue and precipitation data for 1987–92 will be published.



PROJECT TITLE: MECHANISMS OF STREAM RECOVERY FROM METAL CONTAMINATION

PROJECT NUMBER: CO–86–217

STUDY LOCATION: Arkansas River near Leadville, Colorado

COOPERATING AGENCIES: None—U.S. Geological Survey funds only

PROJECT CHIEF AND OFFICE: Briant Kimball, District Office, Salt Lake City, Utah

PROJECT DURATION: February 1986 to September 1996

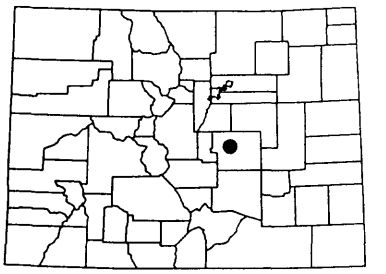
PROBLEM: Past mining of ore deposits in the Leadville area has yielded economic amounts of gold, silver, copper, lead, zinc, iron, and bismuth. Water flowing through abandoned tailings and from draining adits in the Leadville area contributes large amounts of cadmium, copper, iron, lead, manganese, nickel, and zinc to the Arkansas River. Reactive solute-transport processes within the river channel are not well quantified. An interdisciplinary study of controls on trace-element concentrations in streams of the Leadville area will allow a better understanding of the transport and removal mechanism controlling trace-element concentrations in streams.

OBJECTIVE: Characterize the within-stream chemical processes that control the transport and distribution of trace elements in streams of the Leadville area. Characterize the chemistry of sediment and sediment coatings that are active in controlling the dissolved concentrations of trace elements. Quantify the time and length scales for chemical and hydrologic processes that affect the trace metals. Determine the chemical equilibrium and kinetic controls on trace-element concentrations, and quantify those controls in a reactive solute-transport model that is based on instream experimental data from St. Kevin Gulch. Quantify suspended-sediment concentration and particle-size distribution at various streamflow regimes.

APPROACH: Define the transition from natural conditions to areas of active chemical precipitation and, finally, areas dominated by natural weathering and sediment transport. Determine concentration, mineralogy, and particle-size distribution of suspended and bed sediment. After size separation into clay, silt, and sand, organic and metallic coatings on the sediment will be analyzed by extraction procedures to determine their chemistry. Combined with X-ray diffraction and scanning electron microscopy, the chemical analyses will be used to determine the mineral and organic phases that control heavy-metal concentrations. These results will be tested by an instream transport experiment. Stable isotope distributions may also prove useful in evaluating diagenetic changes.

PROGRESS: Three papers have been published on solute-transport simulations of St. Kevin Gulch, evaluation of colloidal iron in the Arkansas River, and mechanisms of water exchange between stream and substream environments. Metal concentrations in acid mine drainage are affected by a combination of hydrologic and biogeochemical processes. These processes affect metal transport by causing attenuation or mobilization, depending on local geochemical conditions. A substantial part of the metal load leaving the Leadville mining district in the Arkansas River is carried by colloidal-size hydrous iron oxides. The colloids persist downstream and can affect aquatic organisms. Water exchange between the stream and substream zones can affect instream concentrations of metals on a spatial scale of a few meters. This contributes to the understanding of how hydrologic processes affect instream chemical concentrations.

PLANS FOR FY 93: A summary water-supply paper will be completed. Several journal papers also are in preparation. As the State of Colorado makes plans to demonstrate remediation of mine spoils in St. Kevin Gulch, monitoring and experiments in St. Kevin Gulch will be completed before remediation begins in late 1993.



PROJECT TITLE: U.S. AIR FORCE ACADEMY INSTALLATION RESTORATION PROGRAM STUDY

PROJECT NUMBER: CO–88–226

STUDY LOCATION: U.S. Department of the Air Force, Colorado Springs, Colorado

COOPERATING AGENCIES: U.S. Department of the Air Force

PROJECT CHIEF AND OFFICE: Earl W. Cassidy, Colorado District Office, Denver

PROJECT DURATION: October 1987 to September 1994

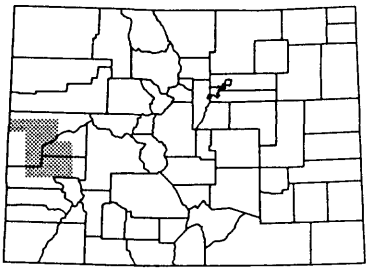
PROBLEM: In accordance with the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) and Superfund Amendment Reauthorization Act (SARA), all Federally owned installations and property must comply with all Federal and State environmental laws and regulations. As a consequence, the U.S. Department of the Air Force initiated the Installation Restoration Program (IRP) to identify sites on Air Force installations that may not be in compliance with the existing environmental laws and to remediate those sites.

OBJECTIVE: The objectives of the U.S. Geological Survey remedial investigation (RI) at the U.S. Air Force Academy are to assess water, sediment, and soil of potential hazardous-waste disposal or spill sites and to determine if these media are contaminated to an extent that exceeds the standards of the U.S. Environmental Protection Agency (EPA) or Colorado Department of Public Health and Environment.

APPROACH: In 1987, 11 potentially contaminated sites were identified by the IRP at the U.S. Air Force Academy. Monitoring wells were installed and ground-water, surface-water, sediment, and soil samples were collected and analyzed. Evaluation of analytical data indicated that 5 of the 11 sites were contaminated at levels that exceeded EPA or Colorado Department of Public Health and Environment standards. In 1991, additional monitoring wells were installed at these five sites and more samples collected to better characterize the types of contaminants and the extent and movement of the contamination. An additional IRP site also was identified and sampled during 1991. Human health and environmental risk assessment will be completed for the six sites following EPA guidelines to determine if risks to human health or the environment exist. In 1992, a hydrologic investigation was planned to define ground-water movement and ground-water and surface-water interaction near the six sites. Five more potential IRP sites were investigated for contamination during 1992.

PROGRESS: A draft remedial investigation report for five sites was submitted to the U.S. Air Force Academy for review. This report summarized (1987–92) findings of contamination in soil, water, and surface-water sediment for five of the IRP sites and includes a risk assessment and review of a hydrologic investigation. The hydrologic investigation was initiated, and gain and loss studies were completed along streams near the five IRP sites.

PLANS FOR FY 93: Initiate the field investigations and complete preliminary site assessments for the five new potential IRP sites by sampling ground-water, surface-water, soil, and surface-water sediment. Complete the hydrologic investigation field work and incorporate findings into a final remedial investigation report for four sites.



PROJECT TITLE: DETAILED INVESTIGATION OF THE IRRIGATION DRAINAGE IN THE LOWER GUNNISON RIVER BASIN, UNCOMPAHGRE RIVER BASIN, AND IN THE GRAND VALLEY, WEST-CENTRAL COLORADO

PROJECT NUMBER: CO–88–231

STUDY LOCATION: West-central Colorado

COOPERATING AGENCIES: U.S. Department of the Interior, Office of the Secretary

PROJECT CHIEF AND OFFICE: David L. Butler, Subdistrict Office, Grand Junction

PROJECT DURATION: March 1991 to December 1993

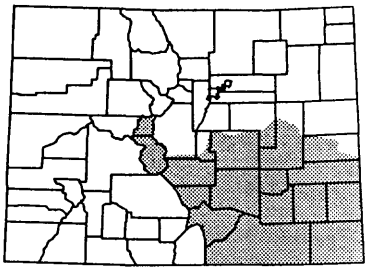
PROBLEM: The U.S. Department of the Interior (DOI) initiated more than 20 studies in the Western United States to identify irrigation-induced water-quality problems that may be caused by irrigation projects constructed or managed by DOI. One such study was the Uncompahgre project, which included parts of the lower Gunnison River, the Uncompahgre River, and Sweitzer Lake. Results of that study indicate that irrigation from the Uncompahgre project area may be contributing dissolved solids, sulfate, nitrate, selenium, boron, and uranium to the Gunnison and Uncompahgre Rivers. The U.S. Fish and Wildlife Service reported significant concentrations of selenium in biota from Sweitzer Lake and the Escalante State Wildlife Area. Based on the results of the reconnaissance study, the Irrigation Drainage Task Group decided that further study of the Uncompahgre project area was needed to provide basic technical information for future planning and management. The Grand Valley area was added to the detailed study because of known or suspected effects on water quality of the Colorado River.

OBJECTIVE: There are two general objectives for detailed irrigation-drainage studies: (1) Determine the geographical extent and severity of existing and potential irrigation-induced water-quality problems, and (2) provide the scientific understanding needed for development of reasonable alternatives to mitigate or resolve identified problems.

APPROACH: Water samples were collected from the Gunnison, Uncompahgre, and Colorado Rivers and from many tributary streams, washes, and ditches within the irrigated areas of the Uncompahgre Valley and the Grand Valley. Water and bottom sediment were sampled at selected wetland sites. Hydrogeologic investigations were done to determine processes affecting selenium concentrations in irrigation drainwater. Water samples were analyzed for selenium, major ions, dissolved solids, nitrate, and selected trace elements. Selected samples were analyzed for hydrogen and oxygen isotopes, and a few water, sediment, and core samples were analyzed for chemical forms of selenium. Mineralogic data and historical ground-water data also were collected. Other data-collection activities included soil and alfalfa sampling by the Geologic Division of the U.S. Geological Survey and biological sampling by the U.S. Fish and Wildlife Service.

PROGRESS: An open-file data report was written and processed through colleague review, and the first draft of the ground-water-resources-investigations interpretative report was partially written. Additional funding was received for collection of surface-water samples for monitoring dissolved solids and selenium and for initiating experiments on the oxidation of selenium by nitrate.

PLANS FOR FY 93: Publish the data report and complete the interpretative report. The interpretative report may be published late in the year. Complete laboratory experiments on nitrate oxidation of selenium in the samples of Mancos Shale collected last summer.



PROJECT TITLE: EVALUATION OF WATER QUALITY IN THE ARKANSAS RIVER BASIN OF COLORADO.

PROJECT NUMBER: CO–88–232

STUDY LOCATION: Arkansas River Basin, southeastern Colorado

COOPERATING AGENCIES: City of Aurora; City of Colorado Springs, Department of Utilities; City of Lamar; City of Las Animas; City of Pueblo, Department of Public Works; City of Rocky Ford; Fremont Sanitation District; Pueblo Board of Water Works; Pueblo County; Pueblo West Metropolitan District; St. Charles Mesa Water District; Southeastern Colorado Water Conservancy District; Upper Arkansas Area Council of Governments; Upper Arkansas Water Conservancy District; U.S. Bureau of Reclamation

PROJECT CHIEF AND OFFICE: Roderick F. Ortiz, Subdistrict Office, Pueblo

PROJECT DURATION: March 1990 to September 1995

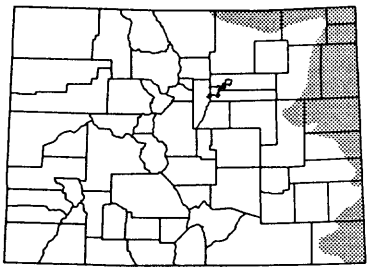
PROBLEM: Available water-quality data indicate that the use of water in parts of the basin is impaired as the result of poor water quality. Current water-quality networks lack a consistent, basinwide set of water-quality data that are needed for making sound decisions for present and future planning and management of the basin's water resources, including the effects of water uses, land uses, tributary inflows, wastewater discharges, climate, and geology on water quality. Better information is needed to establish appropriate water-quality standards and to evaluate trends in water quality.

OBJECTIVE: Evaluate downstream and seasonal variations in water quality throughout the basin. Assess variations in water quality during different flow periods. Assess impacts on water quality that may occur as the result of water uses, land uses, tributary inflows, point- and nonpoint-source discharges, and natural climatic and geologic conditions affecting water quality of the Arkansas River.

APPROACH: The water quality of the Arkansas River will be evaluated using existing and newly collected data. The water-quality monitoring network consists of collecting water-quality data for 3 years at 20 main-stem sites, 32 tributary sites, and 9 transmountain diversions. Water samples will be collected at critical flows and hydrologic conditions during each year. These data will provide the necessary information to meet the study objectives. Data will be evaluated geophysically and statistically as data are collected and analyzed.

PROGRESS: All aspects of scheduled water-quality data-collection activities have been completed. Data review and preliminary data analysis have been completed. Report activities are progressing. Significant work has been done on the data report.

PLANS FOR FY 93: The open-file data report will be completed this fiscal year. The report will include water-quality data from 60 sites sampled over a 3-year period. Work will continue on the interpretive report for the project. A draft report will be produced by the third quarter.



PROJECT TITLE: HIGH PLAINS WATER-LEVEL NETWORK

PROJECT NUMBER: CO–88–233

STUDY LOCATION: High Plains of eastern Colorado

COOPERATING AGENCIES: Colorado Department of Natural Resources, Division of Water Resources, Office of the State Engineer

PROJECT CHIEF AND OFFICE: Edward R. Banta, District Office, Denver

PROJECT DURATION: May 1988 to September 1993

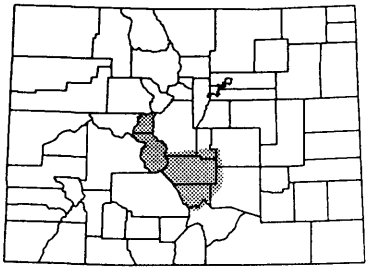
PROBLEM: The High Plains aquifer is the principal source of water for much of eastern Colorado. Historical pumpage has caused substantial water-level declines in some areas. Since the end of Phase I of the High Plains Regional Aquifer Systems Analysis (RASA) study in 1983, the number of water-level measurements has declined, no interpretation of the data has been made, and no information about the seasonal variation has been collected.

OBJECTIVE: Enhance the water-level network of the High Plains. Identify the seasonal variation of water levels. Determine areas of water-level change.

APPROACH: Personnel from the Office of the State Engineer and local ground-water management districts will measure water levels in about 700 wells in the High Plains annually. U.S. Geological Survey personnel will measure water levels in about 20 additional wells. U.S. Geological Survey personnel will screen the data for consistency and possible errors and enter the data into the U.S. Geological Survey Ground-Water Site Inventory (GWSI) system. Wells where measurements are questionable will have follow-up measurements made by the U.S. Geological Survey. Continuous recorders will be operated to monitor the seasonal variation in water levels.

PROGRESS: The State Engineer's Office and local ground-water management districts made measurements in about 680 wells. The U.S. Geological Survey made measurements in 14 wells. All measurements were checked against previous water levels measured in the same wells. Follow-up measurements were made in 16 wells. Water levels and remarks for the measured wells were entered into GWSI. Five continuous water-level recorders were operated throughout the year. The Colorado State Engineer's Office published a data report containing tabulated water-level measurements for the High Plains area and hydrographs for four of the five continuously monitored wells.

PLANS FOR FY 93: Repeat water-level measurements in the same wells where measurements were made in FY 92. Measurements will be made by the State, ground-water management districts, and U.S. Geological Survey personnel. Remeasure water levels where reported levels appear to be anomalous. Continue operation of five continuous recorders. Enter data into GWSI. Provide State with data for analysis and publication.



PROJECT TITLE: PROBABILITY ANALYSIS OF DAILY FLOODFLOWS INTO PUEBLO RESERVOIR DURING APRIL AND MAY

PROJECT NUMBER: CO–89–234

STUDY LOCATION: Arkansas River Basin upstream from Pueblo Reservoir

COOPERATING AGENCIES: Southeastern Colorado Water Conservancy District

PROJECT CHIEF AND OFFICE: Gerhard Kuhn, District Office, Denver

PROJECT DURATION: October 1988 to June 1992

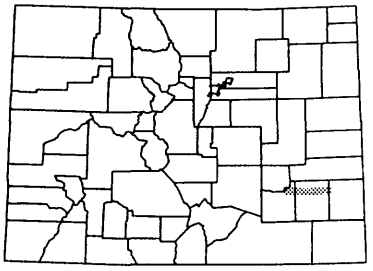
PROBLEM: Pueblo Reservoir, located 10 miles west of Pueblo, Colorado, is one of the principal features of the Fryingpan-Arkansas project, a water-development project of the U.S. Bureau of Reclamation. Part of the storage space in Pueblo Reservoir consists of a 66,000 acre-foot joint-use pool that can be used to regulate imported and native waters for municipal, industrial, and irrigation users during the period November 15 through April 14. During the original design of Pueblo Dam, the U.S. Army Corps of Engineers designated April 15 as the date each year by which the joint-use pool must be vacated for additional flood-control storage. The possibility of using water stored in the joint-use pool even a short time beyond April 15, typically the beginning of the growing season, is very important to the economic interests of water users and to the wise management of water resources. In addition, the long-term yield of the joint-use pool would be increased if the April 15 date were extended during some years when hydrologic and climatic conditions were favorable.

OBJECTIVE: Assess the daily probability of floodflows into Pueblo Reservoir during April and May on the basis of historic streamflow data. Develop a method for evaluation of the risks of allowing extended storage in the joint-use pool in Pueblo Reservoir based on real-time data during April and May of each year.

APPROACH: (1) Evaluate the Precipitation-Runoff Modeling System, the National Weather Service River Forecast System (NWSRFS) model, or other appropriate models for applicability to the study and select the most appropriate model; (2) develop basin characteristics needed to operate the hydrologic model by using a Geographic Information System; (3) develop a data base of historic streamflow and climatologic data; (4) calibrate and verify the hydrologic model with independent data sets; and (5) couple the calibrated model with Extended Streamflow Prediction (ESP) procedure to provide probabilistic estimates of future daily flood volumes and peak discharges on the Arkansas River at Pueblo Reservoir.

PROGRESS: Calibration of the NWSRFS model was completed downstream to Pueblo Reservoir. The ESP procedure also was fully implemented for the Arkansas River Basin upstream from Pueblo Reservoir. A frequency analysis indicated that inflow volume to Pueblo Reservoir from April 15 through May 14 at a 0.01 exceedence probability is about 168,000 acre-feet. Assuming this inflow volume, the joint-use pool could be used for some conservation storage until about May 9. Hence, the study results indicate that the original evacuation date of April 15 could be extended during most years. A draft of the final report was completed.

PLANS FOR FY 93: Publish the final report.



PROJECT TITLE: CONJUNCTIVE WATER USE AND CANAL-SEEPAGE LOSSES IN AN EXTENSIVE IRRIGATION SYSTEM, SOUTHEASTERN COLORADO.

PROJECT NUMBER: CO–89–238

STUDY LOCATION: Southeastern Colorado, Arkansas River between La Junta and Lamar, Colorado

COOPERATING AGENCIES: Bent County Board of County Commissioners

PROJECT CHIEF AND OFFICE: Russell G. Dash, Subdistrict Office, Pueblo

PROJECT DURATION: August 1988 to October 1993

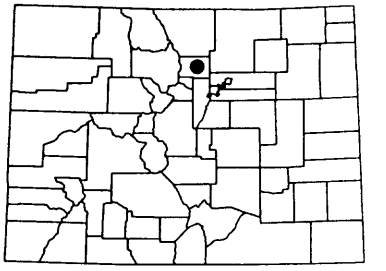
PROBLEM: Land overlying the alluvium of the Arkansas River has been one of the most extensively irrigated areas in Colorado. Although the U.S. Geological Survey conducted extensive hydrologic studies of the area during the 1960's and early 1970's, many of the earlier estimates of water use may no longer be valid because of continued changes in the sources and patterns of water use. Quantification of present-day water use for the lands under irrigation by the Fort Lyon Canal, the largest canal system in southeastern Colorado, would enable better management of water resources in the area.

OBJECTIVE: Estimate the quantity of surface-water use, ground-water use, canal-seepage losses, and areal crop consumptive use for an extensive irrigation system in southeastern Colorado.

APPROACH: Surface-water use will be estimated from analysis of diversion records for the canal and storage reservoirs that comprise the irrigation system. Ground-water use will be estimated from analysis of power-delivery records and power-consumption coefficients determined at irrigation wells distributed throughout the irrigation system. Canal-seepage losses will be estimated by analysis of instantaneous discharge measurements and flow volumes at gaging stations along the canal during non-irrigation periods. Areal crop consumptive use will be estimated for the irrigation system using the Blaney-Criddle technique.

PROGRESS: A draft report which was written for the Fort Lyon Canal system describes four components of irrigation water use. The draft of the report "Irrigation water use for the Fort Lyon Canal, southeastern Colorado, 1989–90" is being reviewed.

PLANS FOR FY 93: Prepare final report for publication.



PROJECT TITLE: ALLUVIAL-AQUIFER SURFACE-WATER INTERACTIONS IN RIPARIAN ECOSYSTEMS.

PROJECT NUMBER: CO–89–242

STUDY LOCATION: Cottonwood Grove Open Space, along Boulder Creek near Boulder, Colorado

COOPERATING AGENCIES: City of Boulder, Colorado

PROJECT CHIEF AND OFFICE: Robert A. Kimbrough, District Office, Denver

PROJECT DURATION: June 1989 to September 1992

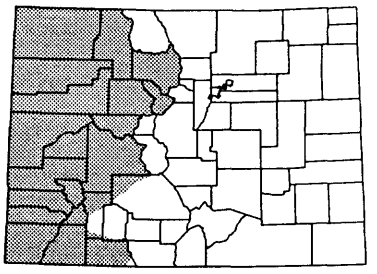
PROBLEM: Riparian vegetation, primarily cottonwoods, are not reproducing along Boulder Creek near the City of Boulder, Colorado. Flows in Boulder Creek have been altered from historic levels; thus, surface-water recharge to adjacent alluvial aquifers may have changed. Before the effect of human-induced changes on riparian vegetation can be determined, the baseline hydrologic conditions need to be understood.

OBJECTIVE: Establish the relation between alluvial aquifer and surface water for a relatively undisturbed riparian study area. Describe alluvial aquifer fluctuations in areas of riparian vegetation.

APPROACH: Transects of wells have been completed in the alluvial aquifer underlying selected riparian vegetation groups. A streamflow-gaging station has been established to monitor flow in Boulder Creek. Alluvial-aquifer hydrographs will be constructed using water-level measurements.

PROGRESS: Project completed and a draft report was written.

PLANS FOR FY 93: Publish final report.



PROJECT TITLE: HYDROGEOLOGIC CHARACTERISTICS OF BEDROCK AQUIFERS IN WESTERN COLORADO

PROJECT NUMBER: CO–90–243

STUDY LOCATION: Colorado west of the Continental Divide

COOPERATING AGENCY: Colorado Water Conservation Board

PROJECT CHIEF AND OFFICE: Edward R. Banta, District Office, Denver

PROJECT DURATION: FY 1990 through FY 1992

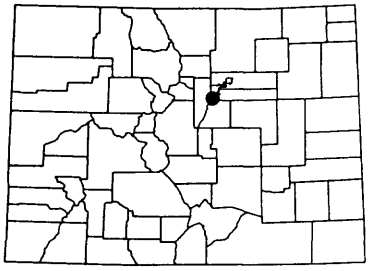
PROBLEM: The ground-water resources west of the Continental Divide in Colorado have been underutilized because of the general abundance of surface water and lack of knowledge of the aquifer systems. Great potential exists for development of the resource, however, and Federal and State agencies are faced with many concerns relative to assessing, administering, and managing those ground-water resources. Developers, administrators, and managers have had to deal with highly disorganized and scattered sources of basic data for wells and published and unpublished interpretive information. An organized method for identifying sources of data and information concerning the ground-water resources of western Colorado is lacking.

OBJECTIVE: The project will be directed toward identifying, referencing, and indexing existing basic-data files, basic-data reports, interpretive reports, and maps that may be useful in understanding the geohydrology of the aquifers of western Colorado. To fulfill this goal, this project will result in a report and a computerized bibliography system designed to direct readers or users who need information in an efficient way.

APPROACH: Two principal components of this project are planned. The first component is the preparation of a report that will be an indexed bibliography of about 1,000 to 2,000 publications related to the geohydrology of western Colorado. The second component of the project is the preparation of a computerized bibliography system. The computerized system will be an automated, expandable version of the bibliography report. References will be entered into the system with a basic level of detail to allow for generalized retrieval of references, and a subset of these will be described in greater detail to allow retrievals using more specific search strategies. Retrievals of reference information from the computerized system will be done using a commercially available data-base management system and FORTRAN programs.

PROGRESS: The computerized bibliography system was completed and the report was completed and published. The project was completed except for delivery of the computerized bibliography system to the cooperating agency.

PLANS FOR FY 93: Deliver computerized bibliography system to cooperating agency.



PROJECT TITLE: THE EFFECTS OF LEACHATE FROM SEWAGE-SLUDGE-DISPOSAL AREAS ON GROUND-WATER QUALITY

PROJECT NUMBER: CO–90–245

STUDY LOCATION: Parts of Senac Creek and Coal Creek Basins, Arapahoe County, Colorado

COOPERATING AGENCY: Metro Wastewater Reclamation District

PROJECT CHIEF AND OFFICE: Ken Lull, Colorado District Office, Denver

PROJECT DURATION: October 1989 to September 1994

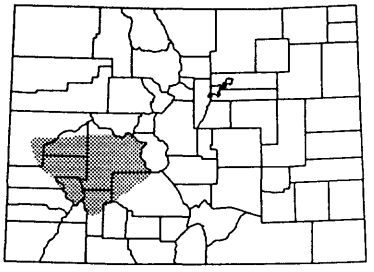
PROBLEM: From 1969 to 1986, the Metropolitan Denver Sewage Disposal District disposed of about 233,000 dry tons of sewage sludge by burial or incorporation into soil at a 1,280-acre site about 15 miles southeast of Denver, Colorado. Movement of leachate from the sewage sludge in the soil could degrade the quality of water in the alluvial aquifer and the surface-water runoff. A new nearby reservoir could recharge the ground water, move the contaminants, and alter streamflow patterns.

OBJECTIVE: Determine the movement of nitrite in the alluvial ground water outside of the disposal site. Identify long-term distribution and trends of water quality within the disposal site. Map the general distribution of organic compounds in soil and ground water within the disposal site. Determine the hydrologic effects of Aurora Reservoir on the alluvial and bedrock aquifers.

APPROACH: Ground water will be sampled three times per year from 15 wells at the boundary and outside the disposal site and once per year from 15 wells inside the disposal site. Maps will be used to show changes in nitrate concentrations with time and estimate the rate of nitrate movement in the alluvial aquifer. Surface water levels will be recorded and surface water will be sampled at the gage and automatic sampling site on Senac Creek. Ground-water and soil samples for organic analyses will be obtained from 12 wells and 7 soil sites. Ground-water levels in the alluvial and bedrock aquifers will be monitored.

PROGRESS: Water levels in the observation wells indicated seasonal variation. Aurora Dam continued to stop the flow of alluvial ground water in Senac Creek Valley at the southern boundary of the study area. The alluvial well nearest Aurora Reservoir contained water only after infiltration of heavy rainfall or snowmelt. The bedrock aquifer was not affected by infiltration of water from Aurora Reservoir. The water level in the bedrock well indicated little change during the year. The source of large nitrite plus nitrate concentrations in parts of the alluvial aquifer downstream of the sludge disposal area probably is sewage-sludge residue in the disposal area.

PLANS FOR FY 93: Water samples will be collected from Senac Creek, if possible. Water levels will be measured monthly at the observation wells and water-level recorders will record hourly water levels in two wells. Water samples will be collected from wells outside and on the boundary of the disposal area.



PROJECT TITLE: ASSESSMENT OF EFFECTS OF POTENTIAL CLIMATE CHANGE ON THE HYDROLOGY OF THE GUNNISON RIVER BASIN

PROJECT NUMBER: CO–90–246

STUDY LOCATION: Gunnison River Basin, Colorado

COOPERATING AGENCIES: None—U.S. Geological Survey funds only

PROJECT CHIEF AND OFFICE: Randolph S. Parker, District Office, Denver

PROJECT DURATION: October 1990 through September 1994

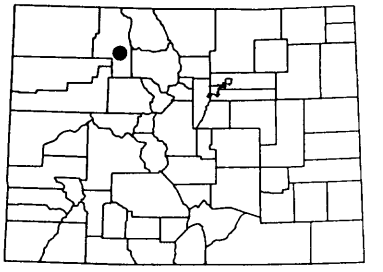
PROBLEM: Changes in climate resulting from increasing concentrations of atmospheric carbon dioxide and other trace gases may alter various hydrologic processes in the drainage basins of the Rocky Mountains. Changes in these processes may affect snowpack accumulation and melt, evapotranspiration, streamflow, and recharge to aquifers. The Gunnison River Basin is a large contributor of water in the Colorado River system and has similar attributes to many basins in the Rocky Mountain region. An effort is needed to improve the understanding of the sensitivity of the Rocky Mountain region's water resources to the potential effects of climate change.

OBJECTIVE: Evaluate the hydrologic response to reasonable scenarios of climate variations. Determine the influence of this hydrologic response to water management and water use and to assess long-term climate change using available studies and data. Specific objectives will be defined during the first year.

APPROACH: The primary task of the first year will be to develop a work plan and to define work elements. The following five broad categories of work are being considered: (1) Identify research needs in critical components of the hydrologic cycle for mountain environments; (2) develop model capabilities; (3) identify components and critical issues of water management; (4) evaluate the hydrologic response to reasonable scenarios of climate variation; and (5) develop Geographic Information System (GIS) to catalog physical characteristics of the basin and the irrigation and reservoir system.

PROGRESS: Atmospheric and watershed models have been linked in order to distribute precipitation and runoff in a mountain environment and to transfer model parameters to additional basins.

PLANS FOR FY 93: Additional analysis of watershed model parameters associated with air temperature and solar radiation is needed to provide better mechanisms to transfer model results to additional drainage basins. Analysis will continue on the sensitivity of the water resource to a series of climate scenarios. A model to characterize the hydraulics of a stream reach will be linked to the watershed model to evaluate the sensitivity of instream processes to changes in climate.



PROJECT TITLE: WATER-QUALITY AND SEDIMENT CHARACTERISTICS OF THE UPPER YAMPA RIVER AND STAGECOACH RESERVOIR, NORTHWESTERN COLORADO.

PROJECT NUMBER: CO–90–247

STUDY LOCATION: Stagecoach Reservoir on the Yampa River approximately 18 miles south of Steamboat Springs, Colorado

COOPERATING AGENCIES: Upper Yampa Water Conservancy District

PROJECT CHIEF AND OFFICE: Robert L. Tobin (Retired), Field Headquarters, Meeker

PROJECT DURATION: October 1989 through September 1993

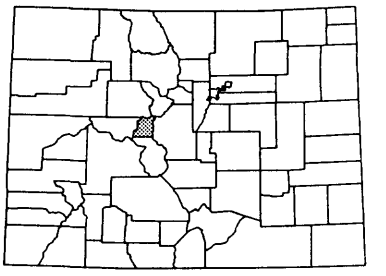
PROBLEM: Recent impoundment of the Yampa River by Stagecoach Reservoir in 1989 will alter, locally, the water-quality and sediment characteristics at the Yampa River. Temporal and spatial variations in water quality are expected within the 33,740 acre-foot reservoir during periods when water temperature gradients during summer control vertical mixing of water. Management of the reservoir for permit requirements, recreation, fishery habitats, and water supplies require the collection and interpretation of physical, chemical, and biological data from river sites upstream and downstream from the reservoir and from several sites within the reservoir.

OBJECTIVE: Compile, evaluate, interpret, and report data on the physical, chemical, and biological processes in Stagecoach Reservoir and from stream sites upstream and downstream from the reservoir. Estimate sediment loads in the Yampa River and provide estimates of sediment retention and volume displacement in the reservoir.

APPROACH: Two or three sampling sites will be established in Stagecoach Reservoir to define the lateral and vertical distribution of physical, chemical, and biological characteristics. Vertical changes in temperature, pH, dissolved oxygen, specific conductance, and water transparency will be measured monthly at each site April through October and, if possible, once under ice in winter. Water samples for laboratory analyses of nutrients, major ions, trace constituents, bacteria, algae identification and biomass, and suspended solids will be collected at near surface and bottom depths. Reservoir data will be compared with similar data from the Yampa River.

PROGRESS: Data collection and laboratory analysis were completed and a draft report was written.

PLANS FOR FY 93: Publish final report.



PROJECT TITLE: UPPER ARKANSAS RIVER METAL LOADS

PROJECT NUMBER: CO–90–248

STUDY LOCATION: Lake County, Colorado

COOPERATING AGENCIES: Multiple agencies

PROJECT CHIEF AND OFFICE: Katherine Walton-Day, District Office, Denver

PROJECT DURATION: June 1990 through September 1993

PROBLEM: Metal-rich water is discharged from abandoned mines in the Leadville, Colorado, area. These mines are point sources of metal loading to the headwaters of the Arkansas River. Nonpoint sources of metals from diffuse inflows draining alluvial accumulations of tailings and slag material might contribute metals to the Arkansas River. Remedial action in the mined areas might eliminate point-source contamination, but nonpoint sources may contribute metals to the Arkansas River indefinitely, and this nonpoint source has not been quantified. Loads of major ions can often be predicted by regressing solute load against daily values of streamflow. Application of this approach to the calculation of metal loads presents major difficulties due to the temporal variability of metal concentrations and the reactive transport of metals. Determination of metal loads requires a method that incorporates this variability and reactivity of metals, yet no method has been developed that incorporates these factors to determine metal loads.

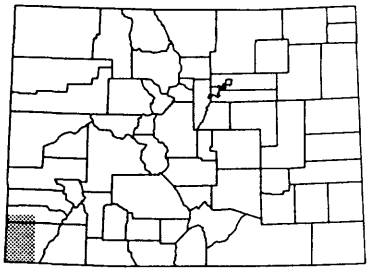
OBJECTIVE: Develop a method for accurate determination of metal loads in the upper Arkansas River.

APPROACH: Development of the method to accurately determine metal loads will incorporate data from a network of streamflow gages where continuous record of streamflow, pH, conductivity, and temperature will be obtained. Water samples will be collected weekly and more frequently during runoff events by Leadville-based observers at the streamflow gages. Samples will be analyzed for concentrations of major ions and selected trace metals. Multiple-regression analysis will be used to relate instantaneous metals loads to variables such as streamflow, pH, and specific conductance.

PROGRESS: Water-quality sampling was completed. Two diel experiments were done in conjunction with the upper Arkansas surface-water toxics project (CO 217). The Bureau of Land Management (BLM) provided additional funds to conduct an assessment of contamination on a parcel of land located approximately 6 miles downstream from Leadville.

Chemical analysis of water-quality samples is in progress and data-base construction and validation are in progress.

PLANS FOR FY 93: Complete water-quality analysis and data-base construction. Initiate data interpretation. Outline and begin data and interpretive reports.



PROJECT TITLE: U.S. DEPARTMENT OF THE INTERIOR IRRIGATION DRAINAGE RECONNAISSANCE INVESTIGATION OF THE DOLORES PROJECT, SOUTHWESTERN COLORADO.

PROJECT NUMBER: CO–90–250

STUDY LOCATION: Southwest Colorado, southeast Utah

COOPERATING AGENCIES: U.S. Department of the Interior, Office of the Secretary

PROJECT CHIEF AND OFFICE: David L. Butler, Subdistrict Office, Grand Junction

PROJECT DURATION: April 1990 through March 1992

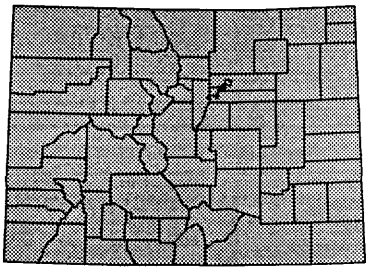
PROBLEM: The Department of Interior (DOI) has conducted a series of studies that were initiated in 1986 to determine if irrigation from projects with Federal involvement have caused or have the potential to cause harmful effects on human health, fish and wildlife, or could adversely affect the suitability of water for beneficial uses. The Dolores project, located in southwestern Colorado, was selected for a reconnaissance investigation in 1990 by the DOI Irrigation Drainage Program because the project may impact water quality of the San Juan River. There were indications that occasional elevated concentrations of selenium and other trace elements have occurred in the San Juan River downstream from the project area. Long-term irrigation in the Montezuma Valley has adversely impacted water quality in the McElmo Creek Basin. Biological information collected by the Bureau of Reclamation and U.S. Fish and Wildlife Service indicated that the Dolores project may be transporting mercury from the Dolores River Basin into the irrigated areas.

OBJECTIVE: Determine if water from the Dolores project area is contributing selenium, other trace elements, and pesticides to water, bottom sediment, and biota in watersheds draining irrigated land. Impacts from long-time irrigation in the Montezuma Valley and impacts from new lands brought recently into irrigation will be addressed. A second objective is gathering background information that may be used to determine future impacts of irrigation drainage from previously non-irrigated land.

APPROACH: The U.S. Geological Survey has responsibility for collection of water and bottom-sediment samples for the DOI studies. Water-quality data will be collected at 21 stream and canal sites, 1 well, and 3 reservoirs. The sampling program is designed to collect data in areas presently irrigated or will be irrigated once all features of the Dolores project are completed. Sites located outside the Dolores project will be used as background sites. Samples will be collected three times in 1990: (1) Pre-irrigation season (March–April); (2) irrigation season (July); and (3) post-irrigation season (November). Samples will be analyzed for major ions, dissolved solids, nitrate, and 14 trace elements, including arsenic, mercury, and selenium. At 14 sites, water samples will be collected in July for analysis of herbicides (2/4-D, picloram) and organophosphate insecticides. Bottom-sediment samples will be collected at 18 sites in November for analysis of trace elements (Geologic Division laboratory) and for organochlorine pesticides and PCB's. Results for water and bottom-sediment samples will be reviewed in conjunction with the biological data collected by the U.S. Fish and Wildlife Service to determine problem areas or potential problem areas associated with irrigation drainage from the Dolores project area.

PROGRESS: The first draft of the report was completed, and the report is through colleague reviews, including reviews by the DOI Irrigation Task Group.

PLANS FOR FY 93: Complete revisions to the report and prepare approval-ready copy. Publish the report.



PROJECT TITLE: EVALUATION OF POTENTIAL BRIDGE SCOUR IN COLORADO

PROJECT NUMBER: CO–90–251

STUDY LOCATION: Statewide

COOPERATING AGENCIES: Colorado Department of Transportation

PROJECT CHIEF AND OFFICE: Jerry E. Vaill, Subdistrict Office, Grand Junction

PROJECT DURATION: July 1990 through September 1993

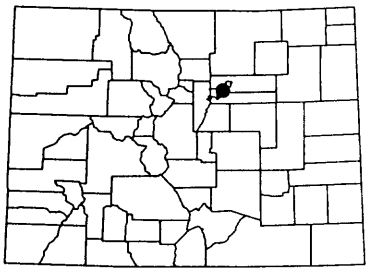
PROBLEM: The Federal Highway Administration has established a requirement that all State highway agencies evaluate bridges on the Federal Aid system for susceptibility of scour-related failures. In the State of Colorado, there are about 1,600 State-owned bridges that cross waterways. With such a large number of bridges that need to be evaluated as to their vulnerability to damage or failure from scour and the limited resources to repair or replace them, a need exists for a procedure to evaluate and identify bridges that are scour susceptible.

OBJECTIVE: Develop a procedure to evaluate the potential for scour at bridges in Colorado and identify those structures that are most susceptible to scour. Provide hydraulic information so that the Colorado Department of Transportation (CDOT) may develop and implement scour counter-measures.

APPROACH: Perform field assessments of bridges from a list provided by CDOT as susceptible to scour. Rank sites according to procedure developed by the U.S. Geological Survey and select sites considered most susceptible to scour for hydraulic evaluation. Measure scour at a limited number of sites.

PROGRESS: Field assessments (Level 1) have been completed at about 375 sites. Water-surface profiles and scour computations were completed for the Q100 and Q500 flood events at 220 bridge sites. These computations constitute a Level 2 analysis as defined by the Federal Highway Administration publication, HEC–18. Thirty scour measurements have been obtained at six sites. Work has been completed on three bridge sites to compare results of the Level 2 analysis to scour predicted by BRI-STARS, a mobile-bed sediment-transport model.

PLANS FOR FY 93: Complete data and water-resources investigations reports. Level 1 assessments and Level 2 analyses will be completed for 90 bridge sites. Direct and indirect measurements of scour will be done for 10–15 sites as hydrologic events occur. Comparison of predicted scour by BRI-STARS to Level 2 analysis will be done at two sites. A report on the results of the analyses will be written.



PROJECT TITLE: HYDROLOGIC MONITORING AND EVALUATION, ROCKY MOUNTAIN ARSENAL

PROJECT NUMBER: CO–90–252

STUDY LOCATION: Rocky Mountain Arsenal and vicinity, Adams County, Colorado

COOPERATING AGENCIES: U.S. Department of the Army, Program Manager, Rocky Mountain Arsenal

PROJECT CHIEF AND OFFICE: Robert F. Middelburg, District Office, Denver

PROJECT DURATION: August 1990 through September 1999

PROBLEM: Because of increased activities, the Program Manager, Rocky Mountain Arsenal (PMRMA), an organization within the U.S. Army Material Command at the Arsenal, needs assistance in managing and evaluating the ground-water and surface-water elements of the Comprehensive Monitoring Program (CMP). The water-management program at RMA requires a comprehensive data-collection network for proper implementation and evaluation. In addition, the effects on water resources from offsite activities and planned development on Arsenal cleanup activities may require supplemental information and evaluation.

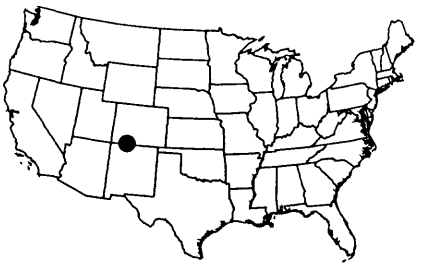
OBJECTIVE: The objectives of this project are to: (1) Provide guidance, review, and technical assistance for ground-water investigations that are designed to evaluate the effect of offsite activities and onsite remedial actions on ground-water flow, ground-water quality, contaminant migration, and the ground- and surface-water relationship; (2) evaluate the current ground-water and surface-water monitoring elements of the CMP and assist with the development of a long-term monitoring strategy to meet the needs of the RMA contamination cleanup and water-management programs; (3) provide technical assistance to PMRMA staff as needed; (4) design and operate surface-water and ground-water monitoring programs as needed to meet the objectives of the CMP; and (5) develop and undertake hydrologic investigations associated with chemical transport in surface and ground water.

APPROACH: The U.S. Geological Survey has established a project office located at RMA for the purpose of conducting hydrologic monitoring of the surface-water and ground-water systems associated with RMA. A complex network of 28 gaging stations utilizing satellite telemetry is operated to monitor the surface-water system which include streams, lakes, reservoirs, and wetlands. A ground-water monitoring program is being implemented to measure water levels in 1,400 wells on a quarterly basis and to sample between 300 to 1,000 wells annually for chemical quality. Hydrologic information collected is processed and published in an annual hydrologic data report to the PMRMA.

Hydrologists assigned to the project will conduct scientific investigations to evaluate the quality and design of the ground-water monitoring network, data evaluation and interpretation using Geographic Information System (GIS), quality of analytical results conducted by RMA contract laboratories, and evaluate hydrologic processes that are critical to the remediation and cleanup activities at RMA. The staff will provide technical expertise for managing hydrologic-related activities conducted by other agencies at RMA.

PROGRESS: A regional ground-water model using GIS was developed. Twenty-eight surface-water gaging stations are being operated with data telemetered to central processor using data-collection platforms (DCP's) and satellite telemetry. Eighteen-hundred ground-water wells have been evaluated for use in a ground-water water-quality monitoring network.

PLANS FOR FY 93: A ground-water monitoring network will be operated. A real-time hydrologic monitoring program using GIS will be operated.



PROJECT TITLE: ASSESSMENT OF METHANE CONCENTRATIONS IN THE SHALLOW GROUND WATER OF THE ANIMAS RIVER VALLEY IN THE NORTH-CENTRAL SAN JUAN VALLEY

PROJECT NUMBER: CO–91–253

STUDY LOCATION: Animas River Valley between Durango, Colorado, and Aztec, New Mexico

COOPERATING AGENCIES: Colorado Department of Natural Resources, Oil and Gas Conservation Commission; Southern Ute Tribal Council, La Plata County

PROJECT CHIEF AND OFFICE: Daniel T. Chafin, District Office, Denver

PROJECT DURATION: June 1990 to September 1992

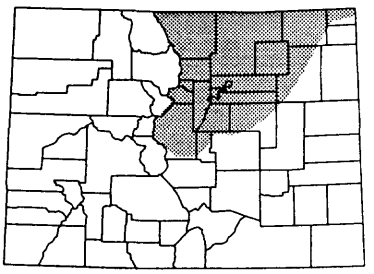
PROBLEM: Water from household wells in some areas of the Animas River Valley contains elevated concentrations of methane. The methane in shallow ground water may have originated from degradation of organic material near the land surface or it may have moved upward along natural pathways from deep underground reservoirs of natural gas, and coalbed gas also may have created pathways for upward movement of methane. The source of the methane and the mechanisms for methane movement to the ground water, and within the ground water, must be better understood before proper remedial and preventative procedures can be established.

OBJECTIVE: Map the occurrence of methane in shallow ground water. Assess the current chemical quality of potable ground water and evaluate the potential for contamination with other deeper formation waters. Attempt to differentiate between areas of increased methane concentrations that result from leaking oil and gas wells and areas of gas concentrations that result from upward movement through geologic units and fractures. Formulate a generalized qualitative description of present and predevelopment ground-water flow between the Fruitland Formation, the shallow aquifers, and surface water.

APPROACH: Sample household wells to determine concentrations of methane and other water-quality constituents at selected sites. Compare areas of elevated methane concentrations to mapped geologic features and the distribution of oil and gas wells to assess possible relations. Collect samples from selected household wells and gas wells for isotopic analyses of methane to determine sources of ground-water methane.

PROGRESS: A report on methods of analysis and data was published. A report on interpretive results of the investigation is near completion.

PLANS FOR FY 93: Publish final report.



PROJECT TITLE: WATER-QUALITY ASSESSMENT OF THE SOUTH PLATTE BASIN, COLORADO, WYOMING, AND NEBRASKA

PROJECT NUMBER: CO–91–255

STUDY LOCATION: South Platte River Basin

COOPERATING AGENCIES: None—U.S. Geological Survey funds only

PROJECT CHIEF AND OFFICE: Kevin F. Dennehy, District Office, Denver

PROJECT DURATION: October 1990 to September 1996

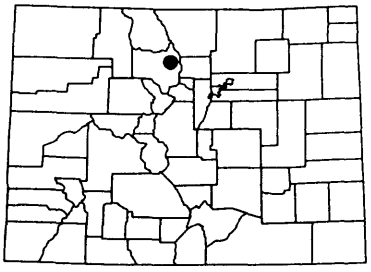
PROBLEM: Many national water-quality concerns arise from the recognition of recurring local and regional problems related to managing and protecting water quality. In order to address these complex concerns and related issues, the U.S. Geological Survey has undertaken a National Water-Quality Assessment program (NAWQA). National and regional assessments of ground- and surface-water quality will be conducted in a nationally consistent manner. By including study units that cover a large part of the United States, the program ensures that many critical water-resources and water-quality concerns or issues will be addressed. The South Platte River Basin is one of the initial 20 national study units begun in 1990.

OBJECTIVES: (1) To define existing water-quality conditions within the South Platte River Basin; (2) to determine magnitude and direction of temporal changes that have or could occur within the basin; (3) to identify current or potential water-quality problems; and (4) to develop understanding of the cause and effect relations and water-quality processes that are responsible for the present water-quality conditions in the basin.

APPROACH: This long-term investigation will be divided into various phases. The first phase of the project will concentrate on developing a work plan. A liaison committee will be formed that is made up of various Federal, State, and local agencies that have interests in the water-quality assessment of the South Platte Basin. The committee will be informed of the U.S. Geological Survey program, coordination of potential field and interpretive work of respective agencies will be addressed, and water-quality issues of concern to each agency will be identified and discussed. The next phase of the study will be the retrospective analysis of available hydrological, chemical, and biological information and the interpretation and reporting of the results. The third phase is the intensive data-collection and interpretation phase, that will continue for 3 years. The final phase will be directed to completion of reports. Hydrologic, biologic, and water-quality information pertinent to fulfilling the study objectives will be collected through the use of fixed-station monitoring, synoptic surveys, and reach-intensive investigations. Ground-water quality will be examined by doing regional sampling for a wide array of water-quality constituents, targeted sampling in selected locations for specific groups of water-quality constituents, and by long-term sampling of selected wells. The final phase will be directed to completion of reports.

PROGRESS: Project staffing was completed, and field reconnaissance of potential sampling sites was conducted. A synoptic survey of nitrate, triazines, and dissolved oxygen were performed concurrently with the field reconnaissance. An occurrence survey of bed sediment and tissue samples at 16 sites across the basin representing differing environmental strata was completed. Work continued on the retrospective analysis of existing nutrient, pesticide, and sediment data.

PLANS FOR FY 93: The retrospective analysis of available data for nutrients, sediments, and pesticides was completed and published. A bibliographic report containing references on water-related studies in the South Platte River Basin was published. Basic-fixed and modified-intensive surface-water stations were selected and sampling begun. Existing wells were selected and new wells installed to be used in land-use and transect ground-water studies. Intensive ecological surveys at fixed stations were begun.



PROJECT TITLE: PROCESSES CONTROLLING WEATHERING

PROJECT NUMBER: CO–91–256

STUDY LOCATION: Rocky Mountain National Park

COOPERATING AGENCIES: None—U.S. Geological Survey funds only

PROJECT CHIEF AND OFFICE: John T. Turk, District Office, Denver

PROJECT DURATION: October 1990 to September 1999

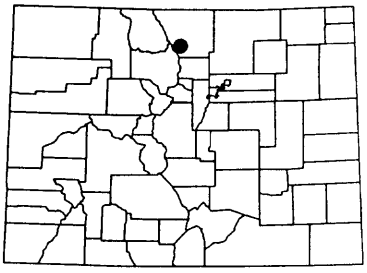
PROBLEM: Lack of understanding of weathering and biogeochemical budgets seriously affects calculation of a carbon dioxide (CO_2) budget. The amount of atmospheric CO_2 converted to bicarbonate (HCO_3^-) we measure as transported from a watershed is twice the amount if feldspar weathering rather than carbonate weathering is the controlling process. The common assumption is that feldspar weathering is the controlling process because feldspars are the most common, weatherable mineral in the granitic bedrock of the Rocky Mountains; however, recent work indicates that carbonate weathering may be the controlling process. Also, the effect of climate change on chemical weathering depends on which of these is the controlling process.

OBJECTIVE: Determine the processes controlling weathering.

APPROACH: Use stable strontium isotopes as a tracer of the minerals being weathered. Confirmation of these results will be done with stable and radioactive carbon isotopes.

PROGRESS: Synoptic and time-series water samples have been collected. Strontium isotope ratios have been determined for most major minerals, surface water, and snowfall.

PLANS FOR FY 93: Continue sampling.



PROJECT TITLE: PROCESSES CONTROLLING ENERGY BALANCE AND CHEMISTRY OF SNOWPACKS

PROJECT NUMBER: CO–91–257

STUDY LOCATION: Rocky Mountain National Park

COOPERATING AGENCIES: None—U.S. Geological Survey funds only

PROJECT CHIEF AND OFFICE: Donald H. Campbell, District Office, Denver

PROJECT DURATION: October 1990 to September 1999

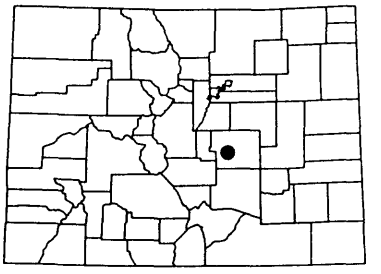
PROBLEM: Lack of understanding of the energy balance and chemistry of snowpacks affects our ability to predict runoff generation, the chemistry of runoff, and sediment transport and storage in response to climate change. Also, the effect of changing albedo on climate as a result of various snowmelt characteristics is affected.

OBJECTIVE: Determine in detail the metamorphosis of Rocky Mountain snowpacks, which are colder than most of the better studied snowpacks, and to model the interaction of energy, snowpack accumulation and melt, and runoff generation. This modeling will include the water and solutes that are transported through the watershed.

APPROACH: Use a point energy and mass-balance model.

PROGRESS: Spatial variability of snowpack depth, water equivalent, and chemistry were characterized at the time of maximum snow accumulation during water years 1991 and 1992. Physical and chemical changes in the snowpack were measured at two sites throughout the snowmelt period. Aerial photographs of snow-covered areas were collected from April through August 1992, and images were processed in cooperation with the U.S. Forest Service. Topographic surveys of Andrews Glacier were conducted in the spring and fall of 1991 and 1992. Stream-water chemistry was monitored on Icy Brook and Andrews Creek from April through October to evaluate effects of snowmelt on the streams. Preliminary results based on 1991 data were presented at the 1991 Fall Meeting of the American Geophysical Union.

PLANS FOR FY 93: Data collection will continue. An image-processing system will enhance aerial photography data. Spatial and temporal variability of 1991 and 1992 snow data will be examined to design more efficient monitoring strategies. Interpretive reports will be written.



PROJECT TITLE: HYDROGEOLOGY, RECHARGE, AND DISCHARGE AT AQUIFER BOUNDARIES, AND WATER QUALITY OF THE FOUNTAIN CREEK ALLUVIAL AQUIFER BETWEEN COLORADO SPRINGS AND WIDEFIELD IN SOUTH-WESTERN EL PASO COUNTY, COLORADO

PROJECT NUMBER: CO–91–259

STUDY LOCATION: Colorado Springs, Colorado

COOPERATING AGENCIES: City of Colorado Springs, Department of Utilities, Wastewater Division

PROJECT CHIEF AND OFFICE: Kenneth R. Watts, Subdistrict Office, Pueblo

PROJECT DURATION: January 1991 to September 1994

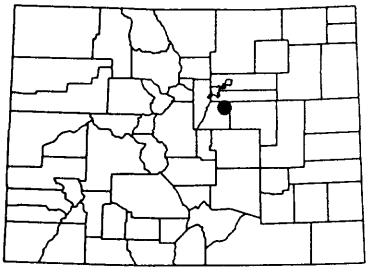
PROBLEM: Concentrations of nitrate in the Fountain Creek alluvial aquifer, locally, are near the regulatory limit of 10 milligrams per liter. Because the alluvial aquifer is hydraulically connected with Fountain Creek, which receives effluent from the Colorado Springs Wastewater Treatment Plant, the quality of effluent from the treatment plant may adversely affect water quality in the alluvial aquifer. However, the potential effects on water quality in the aquifer cannot be predicted without additional knowledge of the hydraulic conditions at the aquifer boundaries and knowledge of the water quality of boundary recharge to the alluvial aquifer.

OBJECTIVE: The objectives are to: (1) Define the geometry and hydrologic boundaries of the aquifer; (2) identify reaches of Fountain Creek that are hydraulically connected to the aquifer; (3) quantify boundary flux, including flow between the stream and aquifer; (4) define selected chemical characteristics of boundary flux; and (5) define long-term trends in nitrogen concentrations in the alluvial aquifer.

APPROACH: Test drilling and seismic refraction will be used to refine the geometric configuration of the bedrock surface. Monitoring wells will be installed to measure potentiometric levels and for collection of water samples. Water levels will be measured monthly at about 30 wells and semi-annually at about 30 additional wells. Continuous recorders will be installed in about 10 wells adjacent to Fountain Creek. Gain-loss measurements will be used to estimate stream-aquifer flux. Samples for chemical analyses will be collected quarterly from about 28 wells. Water-quality data from eight wells that have been sampled quarterly since 1978 to 1981 will be analyzed to define long-term trends in nitrogen concentrations in the alluvial aquifer.

PROGRESS: Field-data-collection activities were completed. Drafts of two interpretive reports were completed. The map report has been revised, subsequent to colleague review, and submitted for Director's approval. The interpretive report describing hydrogeochemistry has been revised, subsequent to supervisory review, and periodic sampling of selected wells will continue as part of an ongoing data-collection program.

PLANS FOR FY 93: Reports will be processed and released to the public after receiving the Director's approval.



PROJECT TITLE: THE EFFECTS OF LAND APPLICATION OF SEWAGE SLUDGE ON THE UNSATURATED AND SATURATED ZONES OF DRY-LAND WHEAT FARMLAND NEAR DEER TRAIL, COLORADO

PROJECT NUMBER: CO–91–260

STUDY LOCATION: Deer Trail, Colorado

COOPERATING AGENCIES: Metro Wastewater Reclamation District

PROJECT CHIEF AND OFFICE: Kenneth J. Lull, District Office, Denver

PROJECT DURATION: October 1990 to September 1999

PROBLEM: The Metropolitan Wastewater Reclamation District (MWRD) applies sewage sludge on farmland in northeastern Colorado where soils benefit from the additional nitrogen and organic matter provided by the sludge. However, application of sludge in excess of agronomic rates may degrade the chemical quality of shallow ground water or surface water. Data collected during a cooperative study between the U.S. Geological Survey and MWRD from 1985 to 1991 indicated that commercial fertilizers used during the past 20 years and sewage sludge applied during 1985–90 on farmland 2 miles east of Platteville, Colorado, probably have caused nitrate concentrations in ground water to increase above the regulated drinking water limit of 10 milligrams per liter. Thus, the effects of land application of sewage sludge on newly acquired land near Deer Trail, Colorado, should be monitored to ensure that sludge application is not a significant factor in water-quality degradation when used in normal dry-land wheat farming practices.

The expansion of MWRD sewage-sludge-disposal activities onto other land in northeastern Colorado provides an opportunity to evaluate the potential for water-quality degradation near all MWRD disposal sites, and to instrument and monitor sites that are found to be sensitive to the effects of sewage-sludge application.

OBJECTIVE: (1) To develop a study plan that will describe proposed monitoring facilities, sampling intervals, analyzed constituents, and data-interpretation and publication procedures to be used; (2) evaluate the effects of land application of sewage sludge on ground-water quality in the shallow aquifer and to evaluate the potential for transportation of constituents off-site either in ground water or as surface-water runoff; and (3) develop an unsaturated study to determine the chemical processes and rate of transport of nutrients and other constituents through the vadose zone.

APPROACH:

1. During the first year of study, a detailed site characterization and reconnaissance will be conducted. Evaluations of climate, geohydrology, depth to water, soil classification, structure, and profile will be required. Background water-quality samples will be taken from existing wells and surface-water bodies throughout the property. Additionally, 10 water-quality monitoring wells were drilled during FY 93 in order to further establish background constituents levels and will continue to be monitored.

2. Water-quality samples collected from four existing wells and nine newly installed wells will document nitrogen concentrations at several locations throughout the property at or near the top of the saturated zone. Additional drilling during FY 94 and FY 95 will allow for sampling at varied depths within the alluvial aquifer, sampling from the bedrock aquifer, and mapping of vertical and lateral distribution of nitrogen concentrations within the saturated zone. Rate of movement, if any, off of the application area will be determined through analysis of water-quality samples. Changes in distribution between samplings will indicate the direction of movement. Water-quality sampling during the first 3 years will be conducted quarterly for major constituents and bi-annually for bacteria.

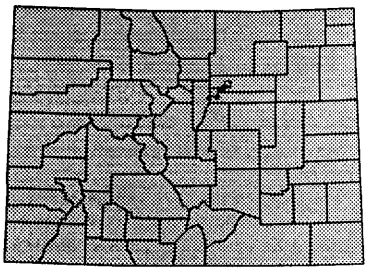
Water-level recorders will be installed in three to five observation wells within the sludge application area so that the amount of recharge to the alluvial aquifer within specific drainages can be better estimated. A series of rain gages will be installed to estimate the amount of precipitation within the study site. Evapotranspiration will be estimated using the Blaney-Criddle method and data on crop type and length of growing season.

All water-quality samples will be analyzed by the MWRD laboratory. Equipment blanks and replicate samples will be submitted at random along with normal samples for quality control purposes.

3. Unsaturated hydraulic conductivity will be determined at selected locations throughout the study area using 36 suction lysimeters installed at varied depths. The unsaturated study site will consist of four test plots configured with nine randomly assigned suction lysimeters each. Samples for major constituents to include nutrients, metals, anions, cations, and bacteria will be taken on a monthly basis throughout the annual sampling period or after significant precipitation events.

PROGRESS: A list of the locations where sewage sludge is applied by MWRD in Colorado was plotted on a map, and data for the potential sites were assembled. The observation wells and other installations installed by the U.S. Geological Survey were removed from the Platteville site.

PLANS FOR FY 93: The proposed new study site will be chosen by U.S. Geological Survey and MWRD. A proposal will be completed, observation wells and other installations will be installed, and data collected will begin.



PROJECT TITLE: SOURCES OF SULFATE IN HIGH-ELEVATION SURFACE WATERS

PROJECT NUMBER: CO–91–261

STUDY LOCATION: Statewide

COOPERATING AGENCIES: Routt County

PROJECT CHIEF AND OFFICE: John T. Turk, Colorado District, Denver

PROJECT DURATION: March 1991 to September 1993

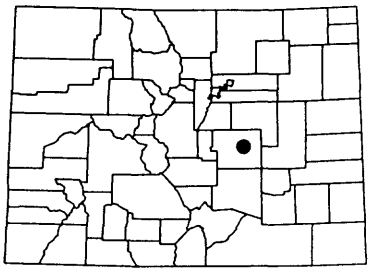
PROBLEM: Long-term changes in the concentration of sulfate in lakes and streams may be caused by anthropogenic sources such as "acid rain" or by changes in the natural watershed processes such as chemical weathering of sulfur minerals and bacterial reduction of sulfate to sulfide. Thus, to effectively monitor for changes in sulfate concentration attributable to changing anthropogenic sources, it is necessary to be able to separate the contribution of the individual sources. To determine unambiguously whether such changes are due to changes in atmospheric deposition of sulfate, it will be necessary to separate the fractional change due to atmospheric deposition from that due to changes in watershed processes.

OBJECTIVE: (1) Determine the isotopic ratio of Sulfur-34 to Sulfur-32 in atmospheric deposition and selected low-alkalinity lakes and streams in Colorado; (2) determine the geographic and temporal variance of this isotopic ratio; and (3) select surface waters best suited to serve as effective monitoring sites for changes in sulfate loading.

APPROACH: The proposed study will make use of the fact that most of the water supplied to low-alkalinity lakes and streams in Colorado is derived from the melting snowpack. At elevations above about 10,000–11,000 feet, where most of the low-alkalinity lakes and streams occur, snow accumulates from October through May. Integrated samples of snowpack will be obtained about three times each winter for 2 years at about 20–30 sites statewide.

PROGRESS: Second synoptic snowpack samples has been completed. Pollution source in the Yampa River drainage seems to have a large effect on snowpack chemistry.

PLANS FOR FY 93: Identify pollution source.



PROJECT TITLE: ASSESSMENT OF URBAN-RUNOFF WATER QUALITY IN THE CITY OF COLORADO SPRINGS, COLORADO

PROJECT NUMBER: CO–92–263

STUDY LOCATION: Colorado Springs

COOPERATING AGENCIES: City of Colorado Springs

PROJECT CHIEF AND OFFICE: Paul von Guerard

PROJECT DURATION: October 1992 to September 1994

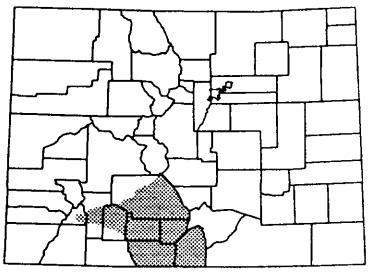
PROBLEM: The U.S. Environmental Protection Agency (EPA), under Section 319 of the Water Quality Act of 1987, requires that States "assess the nature and extent of nonpoint sources of pollution." As part of this assessment, the City of Colorado Springs is required to characterize the quantity and quality of storm discharge and estimate storm event-mean concentrations and annual pollutant loads for the cumulative discharges of stormwater discharges in the City of Colorado Springs.

OBJECTIVE: The objectives of the study are: (1) Install a wet-weather monitoring network and collect data to characterize stormwater quality for representative land uses; (2) attempt to verify regional regression equations that have been developed to estimate storm-runoff volumes, constituent loads, and event-mean concentrations; (3) assist the City of Colorado Springs in estimating storm event-mean concentrations and annual pollutant loads for cumulative discharge of stormwater discharge points in the area; and (4) assist in design of a monitoring program to evaluate effects of best management practices.

APPROACH: Five to ten sites will be instrumented to measure continuous streamflow and to collect flow-weighted composite water samples. Up to three discrete samples will be collected for certain constituents. Flow-weighted composite samples will be analyzed for up to 140 constituents required by EPA. Estimate event-mean concentrations and constituent loads for 12 pollutants designated by EPA. Verify regional regression equations for the 12 designated pollutants event-mean concentrations, and loads from the Colorado Springs sites will be compared to event-mean concentrations and loads from the regression estimates. Assist the City of Colorado Springs in estimating annual constituent-loads and event-mean concentrations of the cumulative discharges from all identified municipal outfalls.

PROGRESS: All stormwater samples were collected using local data for the purposes of estimating event-mean concentrations and constituent loads for 12 pollutants. An interpretive report summarizing stormwater-quality data and describing the regression models was completed.

PLANS FOR FY 93: The report will be processed and released to the public after receiving the Director's approval.



PROJECT TITLE: RIO GRANDE VALLEY NATIONAL WATER-QUALITY ASSESSMENT—PUEBLO

PROJECT NUMBER: CO–92–264

STUDY LOCATION: Colorado, New Mexico, and Texas

COOPERATING AGENCIES: None—U.S. Geological Survey funds only

PROJECT CHIEF AND OFFICE: Mary Jo Radell, Subdistrict Office, Pueblo

PROJECT DURATION: October 1991 to September 1996

PROBLEM: The Nation's water resources are composed of many interrelated ground- and surface-water systems which respond to natural and human factors in a corresponding set of hydrologic, chemical, and biological characteristics that reflect the water-quality effects of these factors. Many national water-quality concerns arise from the recognition of recurring local and regional problems related to managing and protecting water quality. In order to address these complex concerns and related issues, the U.S. Geological Survey has undertaken a National Water-Quality Assessment program (NAWQA). National and regional assessments of ground- and surface-water quality will be conducted in a nationally consistent manner. By including study units that cover a large parts of the United States, the program ensures that many critical water-resources and water-quality concerns or issues will be addressed. The Rio Grande Valley is one of the initial 20 national study units begun in 1990.

OBJECTIVE: (1) To provide a description of current water-quality conditions for the Rio Grande Valley that can be integrated into a national assessment; (2) define long-term trends (or lack of trends) in water quality; and (3) identify, describe, and explain, to the extent possible, the major natural and human factors that affect observed water-quality conditions and trends.

APPROACH: Water-quality data available from water-resource agencies at all governmental levels will be assembled, screened, and evaluated to the extent possible. These data will be stored in computerized U.S. Geological Survey data bases. Additional water-quality data will be collected specifically for the Rio Grande study unit based on surface- and ground-water networks established after data analysis.

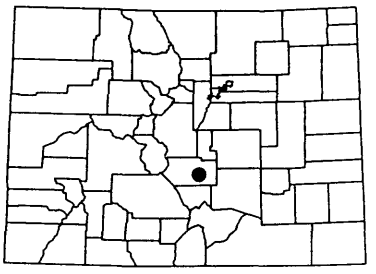
PROGRESS: Water-quality data were acquired and compiled for the Rio Grande study area. Irrigation water-use data for the San Luis Valley were presented at the Liaison Committee meeting in November. Water-quality data analyses were started for the retrospective report. Assistance was provided in designing sampling strategy and locating sites.

Monthly surface-water quality runs at 10 stations—6 in Colorado and 4 in New Mexico. Land-use studies (ground-water quality) completed in Albuquerque and retrospective report completed.

PLANS FOR FY 93: The retrospective report on the nutrients (total N, dissolved NO-3, dissolved NH-4, total P, and dissolved PO-4) sediment and pesticides for the Rio Grande NAWQA will be completed. Surface- and ground-water sampling will begin. Land-use and flow-path studies will be designed; water-quality data will be analyzed and presented at periodic Liaison Committee meetings.

1. Continue with surface-water quality sampling monthly.

2. Ground-water land-use study to be conducted in Las Cruces, New Mexico.



PROJECT TITLE: LINCOLN PARK WATER-QUALITY DEGRADATION STUDY

PROJECT NUMBER: CO–92–265

STUDY LOCATION: Lincoln Park, Colorado

COOPERATING AGENCIES: U.S. Environmental Protection Agency

PROJECT CHIEF AND OFFICE: Edward R. Banta, District Office, Denver

PROJECT DURATION: June 1992 to September 1993

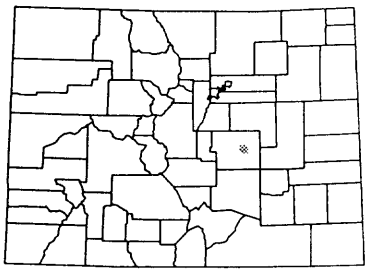
PROBLEM: Liquid-waste constituents from a uranium-ore processing mill located near Lincoln Park have contaminated some wells completed in the alluvial aquifer in Lincoln Park. The mill site has been included by the U.S. Environmental Protection Agency (EPA) as part of the National Priority List of hazardous waste sites. Previous workers at the site postulated that buried paleochannels in the bedrock surface may contain saturated alluvium that has served as a conduit for contaminants. EPA has questions concerning how representative water samples from two existing compliance wells are of quality of water in the alluvial aquifer that underlies Lincoln Park and concerning contamination pathways.

OBJECTIVE: Review and evaluate existing geohydrologic data and interpretive reports (1) to determine if water-quality data from two existing compliance wells and other wells in Lincoln Park indicate that the compliance wells can be considered representative of raffinate-contaminated wells in Lincoln Park; (2) to determine if existing data are suitable for defining paleochannels; and (3) to describe the geohydrologic framework of the alluvial aquifer. Evaluate suitable techniques for collection of additional data. Collect additional data as required to achieve the desired level of understanding of the pathways by which contaminants were transported to, and distributed in, the alluvial aquifer.

APPROACH: Quality-of-water (QW) data from two existing compliance wells and other wells in Lincoln Park will be statistically analyzed to determine if water from the compliance wells is representative of water from raffinate-contaminated wells in Lincoln Park. Surface geophysical data previously collected by the mill owner and any other pertinent data held by EPA or the mill owner will be examined to determine if they can be used to help define the geohydrology of the area; additional surface geophysics and/or drilling of test holes likely will be needed. If a paleochannel is found to contain saturated alluvium, two monitoring wells will be constructed to enable water-level measurements and QW sampling of the aquifer. Samples for QW analyses will be collected from each well and analyzed for principal anions, cations, and raffinate compounds. Any of the project activities may be performed by the mill owner instead of U.S. Geological Survey if consensus is reached among the interested parties.

PROGRESS: Report draft on findings of statistical analyses was written.

PLANS FOR FY 93: Process report to approval and publication.



PROJECT TITLE: HYDROGEOLOGY OF PUEBLO ARMY DEPOT

PROJECT NUMBER: CO–92–266

STUDY LOCATION: East-central Colorado

COOPERATING AGENCIES: U.S. Corps of Engineers

PROJECT CHIEF AND OFFICE: Daniel T. Chafin, District Office, Denver

PROJECT DURATION: October 1992 to April 1994

PROBLEM: Ground-water contamination at the Pueblo Army Depot. A detailed hydrogeologic evaluation is necessary to determine potential contaminant migration pathways and to characterize background ground-water chemistry.

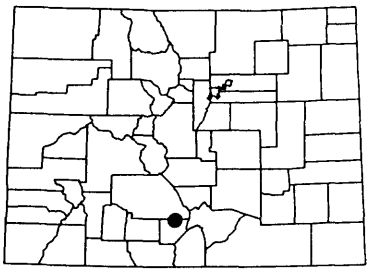
OBJECTIVE: (1) Define the extent, saturated thickness, 1993 potentiometric surface, and the transmissivity of the alluvial aquifer; (2) evaluate regional and local ground-water flow paths; and (3) define the distribution of dissolved solids, nitrate, and selected inorganic and organic contaminants in the alluvial aquifer.

APPROACH:

1. Compile and review available geologic, hydrologic, and water-quality data for the alluvial aquifer.
2. Collect new geologic, hydrologic, and water-quality data in areas where existing data are sparse or outdated. About 15–20 new wells will be drilled and sampled.
3. Prepare maps showing the potentiometric surface, bedrock elevations, saturated thicknesses, and concentrations of selected water-quality constituent.

PROGRESS: New project.

PLANS FOR FY 93: Compile data. Select sites and drill monitoring wells. Survey wells and springs. Sample wells for quality-of-water analyses. Measure water levels. Prepare report.



PROJECT TITLE: SAN LUIS VALLEY PILOT STUDIES

PROJECT NUMBER: CO–92–267

STUDY LOCATION: Closed Basin Division of San Luis Valley

COOPERATING AGENCIES: U.S. Bureau of Reclamation

PROJECT CHIEF AND OFFICE: Kenneth R. Watts, Subdistrict Office, Pueblo

PROJECT DURATION: January 1993 to December 1994

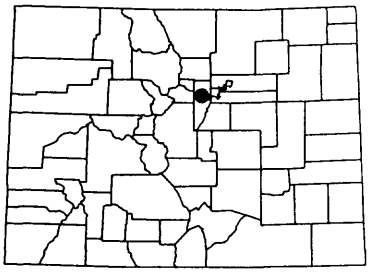
PROBLEM: Variations in concentrations of dissolved solids in ground water produced by salvage wells in the U.S. Bureau of Reclamation's Closed Basin project affect operation of this salvage project. Variations in water quality produced by the wells are believed to be related to the heterogeneity of the unconfined aquifer and underlying confined systems. Available geologic data from driller's logs are not adequate to define spatial variations in lithology, and little data are available to define variations in water quality.

OBJECTIVE: On a pilot-study basis, evaluate methods of better defining spatial variations in lithology and temporal and spatial variations in water quality of the shallow unconfined aquifer and upper part of the underlying confined aquifer. In addition, hydraulic characteristics of the heterogeneous system need to be defined so that contributing zones within the system can be identified. A work plan will be developed for future evaluation of the entire Closed Basin project area.

APPROACH: A pilot-study area will be selected in which water quality and lithology vary. Surface and subsurface geophysical methods will be tested to determine a cost-effective method of evaluating spatial variation of water quality and lithology. Limited test drilling, water-level measurement, and water-quality sampling of a few wells may be needed to verify geophysical interpretations. An aquifer test will be conducted to evaluate methods of determining spatial variation in hydraulic characteristics.

PROGRESS: Field-data collection, consisting of 20,000 feet of electromagnetic profile, six vertical electrical sandings using direct-current resistivity and induced polarization; seven nuclear magnetic resonance soundings were completed. Six small diameter observation wells were installed near a large capacity well and used in an aquifer test. Geophysical logs, electromagnetic and gamma, were measured in two wells. An extension on project completion date was granted until November 30, 1993.

PLANS FOR FY 93: Complete documentation of field-data collection, and prepare a plan of study for future studies using methods evaluated during this study.



PROJECT TITLE: WATER AND SEDIMENT QUALITY IN STANDLEY RESERVOIR, GREAT WESTERN RESERVOIR, AND MOWER RESERVOIR

PROJECT NUMBER: CO–92–268

STUDY LOCATION: Central Colorado

COOPERATING AGENCIES: U.S. Department of Energy

PROJECT CHIEF AND OFFICE: David Johncox, Denver

PROJECT DURATION: October 1992 to September 1994

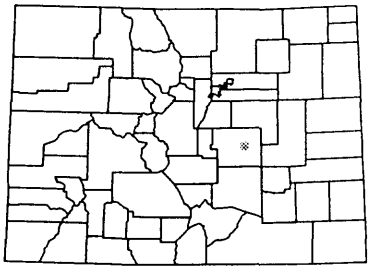
PROBLEM: The Rocky Flats office is trying to evaluate chemical quality in water and sediments of three reservoirs: Standley, Great Western, and Mower. Previous work done in 1983 and 1984 lacks the data-use ability criteria currently required for use at the Rocky Flats office.

OBJECTIVE: The objective of the reservoir sampling program is to verify historical sediment data from sampling done by the Rocky Flats office in 1983–84. The 1983–84 data lacks the data-use ability criteria currently required for use at the Rocky Flats office.

APPROACH: Water samples shall be collected from each reservoir at depths to be determined in the field. Sediment samples include core sample lengths of up to 45 inches or more, where possible, and sediment grab samples collected from each reservoir. Statistical methods to be employed in the interpretive report have not yet been determined as of this writing.

PROGRESS: Field sampling was completed in early FY 93. A summary report containing a detailed documentation of all sampling activities was provided to the contractor.

PLANS FOR FY 93: After results from the laboratory are received, a report containing interpretations of the laboratory data will be published as a U.S. Geological Survey Water-Resources Investigations Report.



PROJECT TITLE: PUEBLO DEPOT ACTIVITY WATER-QUALITY MONITORING, ANALYSIS, AND DATA-BASE MANAGEMENT

PROJECT NUMBER: CO–92–269

STUDY LOCATION: East-central Colorado

COOPERATING AGENCIES: U.S. Corps of Engineers

PROJECT CHIEF AND OFFICE: Ronnie D. Steger

PROJECT DURATION: October 1992 to September 1994

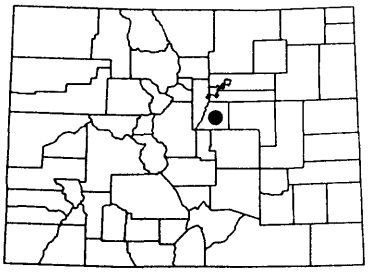
PROBLEM: The Pueblo Depot Activity is a 50-year-old Army base that was served in several capacities. There have been up to 60 surface-management units identified with possible hazardous-waste contamination by various organic and inorganic substances. Specified sampling is required on a timely basis by the Colorado Department of Public Health and Environment to identify changes in patterns and amounts of contamination as problem areas are identified by private contractors. A data-base management system is needed to allow tracking and interpretation of data collected since 1988 by many contractors.

OBJECTIVE: (1) Collect water quality for required constituents samples at specified time intervals following defined protocols; (2) develop and maintain a complete data base of all sites and analyses for use by the cooperator as well as other contractors working on the base; (3) add into the network new sites as they are developed by current and future contractors on the base; and (4) make recommendations for improving the sampling locations, constituents, and protocols.

APPROACH: Water samples for specified constituents will be collected at all the sites included in the scope of work defined by the cooperator. The number of sites will change as the areas of intense study and potential problems are identified by contractors. The frequency of sampling will be dictated by the cooperator and the regulators and the analytical results of the continuing samples. The data base will be loaded and maintained with data as it is collected and will be used to present data to interested parties as requested.

PROGRESS: New project.

PLANS FOR FY 93: Sampling sites will be increased as areas of contamination are identified and monitor wells are completed by on-site contractors.



PROJECT TITLE: EVALUATION OF METHODS FOR ESTIMATING AQUIFER SPECIFIC YIELD IN THE DENVER BASIN, COLORADO

PROJECT NUMBER: CO–93–270

STUDY LOCATION: Central Colorado

COOPERATING AGENCIES: Office of the State Engineer

PROJECT CHIEF AND OFFICE: Stanley G. Robson, District Office, Denver

PROJECT DURATION: October 1992 to September 1993

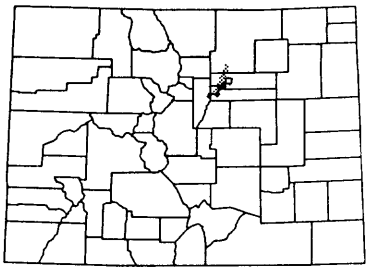
PROBLEM: Determination of specific yield can be costly and time consuming when core drilling and laboratory analyses of core samples are involved. Specific yield could be estimated rapidly and inexpensively if techniques could be developed to use geophysical logs to estimate specific yield.

OBJECTIVE: This study will develop and evaluate techniques for determining specific yield using grain-size data and geophysical logs.

APPROACH: Empirical relations between grain-size characteristics and specific yield and between geophysical log response and specific yield will be developed and evaluated using least-squared linear-regression techniques.

PROGRESS: New project.

PLANS FOR FY 93: Empirical relations between grain-size characteristics and specific yield and between geophysical log response and specific yield will be developed and evaluated using least-squared linear-regression techniques. A report on the results will be published.



PROJECT TITLE: QUANTITY AND QUALITY OF GROUND-WATER DISCHARGE TO THE SOUTH PLATTE RIVER: SEGMENT 15, DENVER TO FORT LUPTON, COLORADO

PROJECT NUMBER: CO–93–271

STUDY LOCATION: Central Colorado

COOPERATING AGENCIES: Metro Wastewater Reclamation District

PROJECT CHIEF AND OFFICE: Peter B. McMahon

PROJECT DURATION: October 1992 to September 1993

PROBLEM: Concentrations of dissolved oxygen (DO) in some parts of the South Platte River between Denver and Fort Lupton (Segment 15) fall below regulatory limits. Effluent discharge has been identified as an important factor in DO depletion, but other processes also contribute to low DO conditions. Initial estimates indicate ground-water discharge to Segment 15 is a significant source of water to the river during low-flow periods. Discharging ground water is depleted in DO and nitrate relative to surface water. Therefore, ground-water discharge to the river may have a significant effect on surface-water quality.

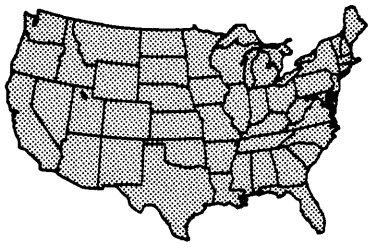
OBJECTIVE: (1) Provide direct measurements of the quantity and quality of ground-water discharge to Segment 15 of the South Platte River, and (2) identify chemical and biological processes in stream-bed sediments that affect the chemistry of ground-water discharging to the river.

APPROACH: Thirty cross-sections along the 26-mile reach of river will be delineated where hydraulic head and water-quality measurements are taken monthly over low-flow period. Field measurements, pH, dissolved oxygen, and specific conductance will be made at each site and a composite sample will be analyzed for nutrients. Wells will be installed at three locations to monitor ground-water discharge to the river. Water levels will be measured and water-quality samples collected monthly. Samples will be analyzed for nutrients and major ions. Seepage runs (discharge measurements) will be made on a monthly basis along a 26-mile reach.

PROGRESS: Begin ground-water discharge measurements at the 30 cross-sections over low-flow period on a monthly basis. Examine hydraulic head and water-quality data collected at cross-section and wells.

PLANS FOR FY 93: Complete data collection, analyze data, and publish results.

PROJECT TITLE: NATIONAL WATER-QUALITY ASSESSMENT PROGRAM—INTERACTION OF FRESH-WATER STREAMS AND AQUIFERS



PROJECT NUMBER: CO–91–275

STUDY LOCATION: Nationwide

COOPERATING AGENCIES: None—U.S. Geological Survey funds only

PROJECT CHIEF AND OFFICE: Lehn Franke, District Office, Denver

PROJECT DURATION: October 1992 to September 1997

PROBLEM: Many of the factors that affect the sources, behavior, and effects of contaminants in water are common to most hydrologic systems, although to widely varying degrees of importance. These common natural and anthropogenic factors, in aggregate, provide a unifying framework for making comparative assessments of water quality among hydrologic systems in different parts of the nation. Quantification of the interaction between surface water and ground water and the water-quality implications of these interactions is an essential part of characterizing the environmental framework in each of the study units that are part of the National Water-Quality Assessment program (NAWQA).

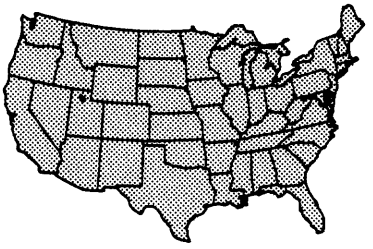
OBJECTIVE: (1) Estimate and compare the contributions of ground water and storm runoff to streamflow under different flow regimes and at different times of the year for selected watersheds studied as part of the NAWQA program and; (2) refine existing hydrograph separation programs to take into account the effects of (a) point withdrawals and point discharges, (b) surface-water storage, and (c) snowmelt.

APPROACH: Hydrograph separation techniques, simple mass-balance models, and rainfall-runoff modeling will be used to approximate the contributions of ground water and storm runoff to streamflow.

PROGRESS: New project.

PLAN FOR FY 93: Apply mass-balance concepts in the South Platte and other selected NAWQA study units. Advise and collaborate with colleagues applying selected rainfall-runoff models to NAWQA study-unit investigations. Continue refinement of the hydrograph separation techniques. Continue characterization of environmental framework in NAWQA study units.

PROJECT TITLE: NATIONAL WATER-QUALITY ASSESSMENT PROGRAM—NATIONAL SYNTHESIS OF NUTRIENTS IN FRESHWATER STREAMS AND AQUIFERS



PROJECT NUMBER: CO–93–276

STUDY LOCATION: Nationwide

COOPERATING AGENCIES: None—U.S. Geological Survey funds only

PROJECT CHIEF AND OFFICE: David K. Mueller, District Office, Denver

PROJECT DURATION: October 1992 to September 1997

PROBLEM: Consistent and comparable water-quality information is needed to provide an improved scientific basis for evaluating the effectiveness of water-quality management programs and for predicting the likely effects of contemplated changes in land and water-management practices.

OBJECTIVE: (1) Compare and contrast the geographic and seasonal distribution of nutrients among the broad range of natural and anthropogenic settings encompassed by National Water-Quality Assessment program (NAWQA) study units; (2) develop and test hypotheses regarding causes of the similarities and differences in relations between nutrient sources and water-quality conditions among different environmental settings; and (3) evaluate the national and regional implications of relations between water quality and specific human activities and natural conditions found in the study units.

APPROACH: The goals of the national synthesis will be accomplished through an analysis of existing data, data collected as part of the NAWQA study-unit investigations, and regional synoptic surveys. Each study-unit investigation consists of four parts: analysis of available data; occurrence and distribution assessment; long-term monitoring; and case studies of sources, transport, and effects on aquatic organisms. The sampling design and analysis of data are guided by a geographic framework at two scales: national and study unit. At both scales, the framework is derived from the geographic distribution of primary natural and anthropogenic features that govern water quality.

PROGRESS: New project.

PLANS FOR FY 93: Complete reports summarizing and contrasting key findings related to nutrients from NAWQA pilot studies, Mid-continent initiative, and other U.S. Geological Survey efforts. Complete national synthesis report comparing and contrasting key findings from an analysis of available information in the first 20 study units focused on nutrients in streams and aquifer computer-enhanced national characterization of agricultural and urban land use in the first 20 NAWQA study units using existing GIRAS, Agricultural Census, and Bureau of the Census population estimates. This information will help to provide a unifying environmental framework for making comparative assessments of water quality among hydrologic systems in different parts of the Nation.

REPORTS PUBLISHED OR APPROVED FOR PUBLICATION, FISCAL YEARS 1992–93

Open-File Data Reports

[Reports available from U.S. Geological Survey, Earth Science Information Center, Open-File Reports Section, Box 25286, Mail Stop 517, Denver Federal Center, Denver, CO 80225, except as indicated]

Banta, E.R., and Lane, T.J., 1992, Bibliography, index, and data sources for ground-water hydrology and geology of Colorado west of the Continental Divide: U.S. Geological Survey Open-File Report 92–79, 214 p.

Dennehy, K.F., and Ortiz-Zayas, J.R., 1993, Bibliography of water-related studies, South Platte River basin—Colorado, Nebraska, and Wyoming: U.S. Geological Survey Open-File Report 93–106, 278 p.

Edelmann, Patrick, Scaplo, J.A., Colalancia, D.A., and Elson, B.B., 1991, Compilation of water-quality data for Pueblo Reservoir and the upper Arkansas River basin, Colorado, 1985–87: U.S. Geological Survey Open-File Report 91–506, 409 p.

Grey, D.W., 1992, Operation of the Sutron 8200 with a USGS minimonitor: WRD Instrument News, December 1992, no. 59, p. 20–22.

Griffith, P.A., comp., 1991, Summary of water-resources activities of the U.S. Geological Survey in Colorado—Fiscal year 1991: U.S. Geological Survey Open-File Report 91–210, 72 p.

Johncox, D.A., 1993, Silver concentrations and selected hydrologic data in the Upper Colorado River Basin, 1991–92: U.S. Geological Survey Open-File Report 93–447, 13 p.

Johncox, D.A., and Gaggiani, N.G., 1991, Selected hydrologic data for farmland treated with sewage sludge near Platteville, Colorado, 1985–91: U.S. Geological Survey Open-File Report 91–529, 120 p.

Robson, S.G., and Banta, E.R., 1993, Data from core analyses, aquifer testing, and geophysical logging of Denver basin bedrock aquifers at Castle Pines, Colorado: U.S. Geological Survey Open-File Report 93–442, 94 p.

Ruddy, B.C., Johncox, D.A., and Mueller, D.K., 1992, Methods of data collection and water-quality data for Standley Lake, Jefferson County, Colorado, 1989–90: U.S. Geological Survey Open-File Report 92–44, 187 p.

Turk, J.T., Campbell, D.H., Ingersoll, G.P., and Clow, D.W., 1992, Initial findings of synoptic snowpack sampling in the Colorado Rocky Mountains: U.S. Geological Survey Open-File Report 92–645, 6 p.

Turk, J.T., Spahr, N.E., and Campbell, D.H., 1993, Planning document of water, energy, and biogeochemical-budget (WEBB) research project, Loch Vale watershed, Rocky Mountain National Park, Colorado: U.S. Geological Survey Open-File Report 92–628, 18 p.

Ugland, R.C., Cochran, B.J., Hiner, M.M., and Steger, R.D., 1992, Water-resources data, Colorado, water year 1991—v. 1, Missouri River basin, Arkansas River basin, and Rio Grande basin: U.S. Geological Survey Water-Data Report CO–91–1, 399 p. [Available only from the U.S. Department of Commerce, National Technical Information Service, Springfield, VA 22161, as PB 92–193085.]

Ugland, R.C., Cochran, B.J., Hiner, M.M., and Steger, R.D., 1993, Water-resources data, Colorado, water year 1992, Missouri River basin, Arkansas River basin, and Rio Grande basin: U.S. Geological Survey Water-Data Report CO–92–1, 331 p. [Available only from the U.S. Department of Commerce, National Technical Information Service, Springfield, VA 22161.]

Ugland, R.C., Cochran, B.J., Hiner, M.M., Wilson, E.A., Bennett, J.D., and Jenkins, R.A., 1992, Water-resources data, Colorado, water year 1991—v. 2, Colorado River basin: U.S. Geological Survey Water-Data Report CO–91–2, 416 p. [Available only from the U.S. Department of Commerce, National Technical Information Service, Springfield, VA 22161, as PB 92–191600.]

Ugland, R.C., Cochran, B.J., Hiner, M.M., Wilson, E.A., Bennett, J.D., and Jenkins, R.A., 1993, Water-resources data, Colorado, water year 1992—v. 2, Colorado River basin: U.S. Geological Survey Water-Data Report CO–92–2, 406 p. [Available only from the U.S. Department of Commerce, National Technical Information Service, Springfield, VA 22161.]

Wetherbee, G.A., Kimball, B.A., and Maura, W.S., 1991, Selected hydrologic data for the upper Arkansas River basin, Colorado, 1986–89: U.S. Geological Survey Open-File Report 91–528, 216 p.

Williams, R.S., Jr., Clark, G.M., and Spahr, N.E., 1993, Climatologic, soil-water, ground-water, geologic, surface-water, and water-quality data for a surface coal mine in northwestern Colorado: U.S. Geological Survey Open-File Report 92–122, 218 p.

Water-Resources Investigations Reports

Banta, E.R., 1992, Colorado—Water-level declines widespread in Colorado High Plains, *in* Dugan, J.T., and Schild, D.E., Water-level changes in the High Plains aquifer; predevelopment to 1990: U.S. Geological Survey Water-Resources Investigations Report 91–4165, p. 31–33.

_____in press, Statistical analysis of uranium-mill raffinate contamination in water wells in Lincoln Park, south-central Colorado: U.S. Geological Survey Water-Resources Investigations Report 93–4211.

Broshears, R.E., Bencala, K.E., Kimball, B.A., and McKnight, D.M., 1993, Trace-dilution experiments and solute-transport simulations for a mountain stream, Saint Kevin Gulch, Colorado: U.S. Geological Survey Water-Resources Investigations Report 92–4081, 18 p.

Broshears, R.E., Kimball, B.A., and Runkel, R.L., 1994, Simulation of reactive transport during a pH modification experiment in a mountain stream affected by acid mine drainage, *in* Morganwalp, D.W., and Aronson, D.A., eds., U.S. Geological Survey Toxic Substances Hydrology Program—Proceedings of the technical meeting, Colorado Springs, Colorado, September 20–24, 1993: U.S. Geological Survey Water-Resources Investigations Report 94–4014.

Butler, D.L., Krueger, R.P., Osmundson, B.C., Thompson, A.L., Formea, J.J., and Wickman, D.W., 1993, Reconnaissance investigation of water quality, bottom sediment, and biota associated with irrigation drainage in the Pine River Project area, Southern Ute Indian Reservation, southwestern Colorado and northwestern New Mexico, 1988–89: U.S. Geological Survey Water-Resources Investigations Report 92–4188, 105 p.

Butler, D.L., Krueger, R.P., Osmundson, B.C., Thompson, A.L., and McCall, S.K., 1991, Reconnaissance investigation of water quality, bottom sediment, and biota associated with irrigation drainage in the Gunnison and Uncompahgre River basins and at Sweitzer Lake, west-central Colorado, 1988–89: U.S. Geological Survey Water-Resources Investigations Report 91–4103, 99 p.

Chafin, D.T., and Kimball, B.A., 1992, Ground-water geochemistry of the near-surface Wasatch Formation, northern Green River basin, Sublette County, Wyoming: U.S. Geological Survey Water-Resources Investigations Report 91–4069, 40 p.

Chapra, S.C., Boyer, J.M., and Runkel, R.L., 1994, Advanced decision support systems for environmental simulation modeling, *in* Morganwalp, D.W., and Aronson, D.A., eds., U.S. Geological Survey Toxic Substances Hydrology Program—Proceedings of the technical meeting, Colorado Springs, Colorado, September 20–24, 1993: U.S. Geological Survey Water-Resources Investigations Report 94–4014.

Dennehy, K.F., Litke, D.W., Tate, C.M., and Heiny, J.S., in press, Environmental setting and its implication to the water quality of the South Platte River basin—Colorado, Nebraska, and Wyoming: Water Resources Bulletin.

Elliott, J.G., 1993, Geomorphic, hydrologic, and erosion data for selected reclaimed hillslopes, the Seneca II Mine, Routt County, Colorado, October 1988–July 1990: U.S. Geological Survey Water-Resources Investigations Report 92–4096, 59 p.

Elliott, J.G., and Parker, R.S., 1992, Potential climate-change effects on bed-material entrainment, the Gunnison Gorge, Colorado, *in* Herrmann, Raymond, ed., Managing water resources during global change, an international conference [American Water Resources Association Annual Conference and Symposium, 28th, November 1–5, 1992, Reno, Nevada]: Bethesda, Md., American Water Resources Association Technical Publication Series TPS–92–4, p. 751–759.

Geldon, A.L., 1989, Ground-water hydrology of the central Raton basin, Colorado and New Mexico: U.S. Geological Survey Water-Supply Paper 2288, 81 p.

_____in press, Geology of Paleozoic rocks in the Upper Colorado River Basin in Arizona, Colorado, New Mexico, Utah, and Wyoming, excluding the San Juan Basin: U.S. Geological Survey Professional Paper 1411–D.

_____in press, Hydrologic properties and ground-water flow systems of the Paleozoic rocks in the Upper Colorado River Basin in Arizona, Colorado, New Mexico, Utah, and Wyoming, excluding the San Juan Basin: U.S. Geological Survey Professional Paper 1411–E.

Herbert, R.A., and Litke, D.W., 1991, Effects of drought on public-supplied water use; three case studies from the central United States, *in* Kirby, W.H., and Tan, Weiyan., comps., Proceedings of the United States-People's Republic of China bilateral symposium on droughts and arid-region hydrology, September 16–20, Tucson, Arizona: U.S. Geological Survey Open-File Report 91–244, p. 309–316.

Kimball, B.A., 1992, Geochemical indicators used to determine source of saline water in Mesozoic aquifers, Montezuma Canyon area, Utah, *in* Subitzky, Seymour, ed., Selected papers in the hydrologic sciences, 1988–92: U.S. Geological Survey Water-Supply Paper 2340, p. 89–106.

Kimball, B.A., Broshears, R.E., McKnight, D.M., and Bencala, K.E., 1992, Effect of instream pH modification on aluminum, *in* Kharaka, Y.K., and Maest, A.S., eds., Proceedings of the International Symposium on Water-Rock Interaction, 7th, Park City, Utah, July 13–18, 1992: Rotterdam, A.A., Balkema, p. 393–396.

Kuhn, Gerhard, 1991, Calibration, verification, and use of a steady-state stream water-quality model for Monument and Fountain Creeks, east-central Colorado: U.S. Geological Survey Water-Resources Investigations Report 91–4055, 149 p.

Kuhn, Gerhard, and Parker, R.S., 1992, Transfer of watershed-model-parameter values to noncalibrated basins in the Gunnison River basin, Colorado, *in* Herrmann, Raymond, ed., Managing water resources during global change, an international conference [American Water Resources Association Annual Conference and Symposium, 28th, November 1–5, 1992, Reno, Nevada]: Bethesda, Maryland, American Water Resources Association Technical Publication Series TPS–92–4, p. 741–750.

Litke, D.W., and Kauffman, L.F., 1993, Analysis of residential use of water in the Denver metropolitan area, Colorado, 1980–87: U.S. Geological Survey Water-Resources Investigations Report 92–4030, 69 p.

McKnight, D.M., Bencala, K.E., Hornish, R.A., and Runkel, R.L., 1994, Difficulties with intermediate scale experiments for studies of iron chemistry in acid mine drainage streams, *in* Morganwalp, D.W., and Aronson, D.A., eds., U.S. Geological Survey Toxic Substances Hydrology Program—Proceedings of the technical meeting, Colorado Springs, Colorado, September 20–24, 1993: U.S. Geological Survey Water-Resources Investigations Report 94–4014.

McMahon, P.B., Litke, D.W., Paschal, J.E., and Dennehy, K.F., in press, Ground water as a source of nutrients and pesticides to streams in the South Platte River basin at low flow: Water Resources Bulletin.

McMahon, P.B., Vroblesky, D.A., Bradley, P.M., Chapelle, F.H., and Gullett, Cheryl, in press, Evidence for enhanced quartz dissolution in organic-acid-rich ground water: Ground Water.

Middelburg, R.F., 1993, Colorado stream water quality, *in* Paulson, R.W., Chase, E.B., Williams, J.S., and Moody, D.W., comps., National water summary, 1990–91—Hydrologic events and stream water quality: U.S. Geological Survey Water-Supply Paper 2400, p. 197–206.

Mueller, D.K., DeWeese, L.R., Garner, A.J., and Spruill, T.B., 1991, Reconnaissance investigation of water quality, bottom sediment, and biota associated with irrigation drainage in the middle Arkansas River basin, Colorado and Kansas, 1988–89: U.S. Geological Survey Water-Resources Investigations Report 91–4060, 84 p.

Mueller, D.K., and Ruddy, B.C., 1993, Limnological characteristics, nutrient loading and limitation, and potential sources of taste and odor problems in Standley Lake, Colorado: U.S. Geological Survey Water-Resources Investigations Report 92–4053, 55 p.

Mueller, D.K., Ruddy, B.C., and Battaglin, W.A., 1994, Relation of nitrate concentrations to land use in the upper midwestern United States, *in* Morganwalp, D.W., and Aronson, D.A., eds., U.S. Geological Survey Toxic Substances Hydrology Program—Proceedings of the technical meeting, Colorado Springs, Colorado, September 20–24, 1993: U.S. Geological Survey Water-Resources Investigations Report 94–4014.

Norris, J.M., Hren, Janet, Myers, D.N., Chaney, T.H., and Childress, C.J., 1992, Water-quality data-collection activities in Colorado and Ohio; Phase III, Evaluation of existing data for use in assessing regional water-quality conditions and trends: U.S. Geological Survey Water-Supply Paper 2295–C, 46 p.

Parker, R.S., 1991, Developing an index of hydrologic drought for the Gunnison River basin, Colorado, *in* Kirby, W.H., and Tan, Weiyan, comps., Proceedings of the United States-People's Republic of China bilateral symposium on droughts and arid-region hydrology, September 16–20, Tucson, Arizona: U.S. Geological Survey Open-File Report 91–244, p. 175–182.

Parker, R.S., Kuhn, Gerhard, Hay, Lauren, and Elliott, J.G., 1992, Effects of potential climate change on the hydrology and the maintenance of channel morphology in the Gunnison River basin, Colorado, *in* Proceedings of the workshop on the effects of global climate change on hydrology and water resources at the catchment scale, February 3–6, 1992, Tsukuba, Japan: JUCHWR [Japan-U.S. Committee on Hydrology, Water Resources and Global Climate Change], Publication 1, p. 399–410.

Paschal, J.E., Jr., and Mueller, D.K., 1991, Simulation of water quality and the effects of wastewater effluent on the South Platte River from Chatfield Reservoir through Denver, Colorado: U.S. Geological Survey Water-Resources Investigations Report 91–4016, 98 p.

Robson, S.G., 1993, Techniques for estimating specific yield and specific retention from grain-size data and geophysical logs from clastic bedrock aquifers: U.S. Geological Survey Water-Resources Investigations Report 93–4198, 19 p.

_____in press, Preparation of specific-yield logs for clastic bedrock aquifers: Ground Water.

Robson, S.G., and Banta, E.R., in press, Ground water atlas of the United States—Segment 2, Arizona, Colorado, New Mexico, and Utah: U.S. Geological Survey Hydrologic Investigations Atlas HA–730–C.

Ruddy, B.C., 1993, Water-quality variations and trends in Monument and Fountain Creeks, El Paso and Pueblo Counties, Colorado, water years 1976–88: U.S. Geological Survey Water-Resources Investigations Report 91–4176, 66 p.

Runkel, R.L., Bencala, K.E., and Broshears, R.E., 1994, An equilibrium-based simulation model for reactive solute transport in small streams, *in* Morganwalp, D.W., and Aronson, D.A., eds., U.S. Geological Survey Toxic Substances Hydrology Program—Proceedings of the technical meeting, Colorado Springs, Colorado, September 20–24, 1993: U.S. Geological Survey Water-Resources Investigations Report 94–4014.

Runkel, R.L., and Broshears, R.E., 1991, One-dimensional transport with inflow and storage (OTIS)—A solute transport model for small streams: Boulder, University of Colorado, Department of Civil Engineering, Center for Advanced Decision Support for Water and Environmental Systems (CADSWES) Technical Report 91–01, 85 p.

Runkel, R.L., and Chapra, S.C., 1993, An efficient numerical solution of the transient storage equations for solute transport in small streams: Water Resources Research, v. 29, no. 1, p. 211–215.

Runkel, R.L., and Restrepo, P.J., 1993, Solute transport modeling under unsteady flow regimes—An application of the modular modeling system, *in* Hon, Ken, ed., Water management in the '90s—A time for innovation, Proceedings of the 20th Anniversary Conference of the Water Resource Planning and Management Division of the American Society of Civil Engineers, Seattle, Washington, May 1–5, 1993: New York, American Society of Civil Engineers, p. 256–259.

Sullivan, J.R., Jr., 1993, Reconnaissance of water quality of Lake Henry and Lake Meredith Reservoir, Crowley County, southeastern Colorado, April–October 1987: U.S. Geological Survey Water-Resources Investigations Report 91–4102, 51 p.

Tobin, R.L., 1993, Sediment transport and water-quality characteristics and loads, White River, northwestern Colorado, water years 1975–88: U.S. Geological Survey Water-Resources Investigations Report 92–4031, 69 p.

Turk, J.T., Campbell, D.H., and Spahr, N.E., 1993, Use of chemistry and stable sulfur isotopes to determine sources of trends in sulfate of Colorado lakes: Water, Air, and Soil Pollution, v. 67, no. 3–4, p. 415–431.

Turk, J.T., and Spahr, N.E., 1991, Rocky Mountains, *in* Charles, D.F., ed., Acidic deposition and aquatic ecosystems; regional case studies: New York, Springer-Verlag, p. 471–501.

Van Liew, W.P., and Robson, S.G., 1993, Hydrology of the Hart Syncline area, northwestern Colorado: U.S. Geological Survey Water-Resources Investigations Report 92–4050, 97 p.

von Guerard, Paul, Parker, R.S., and Dash, R.G., 1993, Assessment of effects of military maneuvers on the streamflow, water quality, and sediment yields at the U.S. Army Pinon Canyon maneuver site, Las Animas County, Colorado: U.S. Geological Survey Water-Resources Investigations Report 91–4095, 84 p.

Walton-Day, Katherine, 1994, Iron and zinc budgets in surface water for a natural wetland affected by acidic mine drainage, St. Kevin Gulch, Lake County, Colorado, *in* Morganwalp, D.W., and Aronson, D.A., eds., U.S. Geological Survey Toxic Substances Hydrology Program—Proceedings of the technical meeting, Colorado Springs, Colorado, September 20–24, 1993: U.S. Geological Survey Water-Resources Investigations Report 94–4014.

Watts, K.R., in press, Regression models of monthly water-level change in and near the Closed Basin Division of the San Luis Valley, south-central Colorado: U.S. Geological Survey Water-Resources Investigations Report 93–4209.

Watts, K.R., and Lindner-Lunsford, J.B., 1992, Evaluation of proposed water-management alternatives to lower the high water table in the Arkansas River valley near La Junta, Colorado: U.S. Geological Survey Water-Resources Investigations Report 91–4046, 59 p.

Weiss, Emanuel, in press, Summary of the regional aquifer-system analysis of the Upper Colorado River Basin in Arizona, Colorado, Utah, and Wyoming, excluding the San Juan basin: U.S. Geological Survey Professional Paper 1411–A.

Williams, R.S., Jr., and Clark, G.M., 1993, Description of techniques used to drill, complete, and develop wells and to test and sample aquifers at a surface coal mine in northwestern Colorado: U.S. Geological Survey Water-Resources Investigations Report 92–4067, 39 p.

_____in press, Hydrology and geochemistry of a surface coal mine in northwestern Colorado: U.S. Geological Survey Water-Resources Investigations Report 92–4187.

Wright, W.G., and Butler, D.L., 1993, Distribution and mobilization of dissolved selenium in ground water of the irrigated Grand and Uncompahgre Valleys, western Colorado, *in* Proceedings of the 1993 American Society of Civil Engineers National Conference on Irrigation and Drainage Engineering, Park City, Utah, July 21–23, 1993: New York, American Society of Civil Engineers, p. 770–777.

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