SUMMARY OF WATER-RESOURCES ACTIVITIES OF THE U.S. GEOLOGICAL SURVEY IN COLORADO--FISCAL YEAR 1987

Compiled by Julie M. Stewart

U.S. Geological Survey

Open-File Report 87-388

Lakewood, Colorado
1987

DEPARTMENT OF THE INTERIOR

DONALD PAUL HODEL, Secretary

U.S. GEOLOGICAL SURVEY

Dallas L. Peck, Director

For additional information
write to:

District Chief
U.S. Geological Survey
Water Resources Division
Box 25046, Mail Stop 415
Denver Federal Center
Lakewood, CO 80225

Copies of this report may be
purchased from:

U.S. Geological Survey
Books and Open-File Reports Section
Federal Center
Box 25425
Denver, CO 80225

CONTENTS

CONTENTS

PLATE

TABLE

SUMMARY OF WATER-RESOURCES ACTIVITIES OF THE U.S. GEOLOGICAL SURVEY IN COLORADO--FISCAL YEAR 1987

INTRODUCTION

Water-resources activities of the U.S. Geological Survey in Colorado consist of collecting water-resources data and conducting 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. This report describes the water-resources investigations in Colorado for the 1987 fiscal year (October 1, 1986, to September 30, 1987).

The U.S. Geological Survey's investigations of the water resources of Colorado are under the direction of C.A. (Jerry) Pascale, District Chief. The Colorado District office is in Building 53, Denver Federal Center, Lakewood, Colorado. The Colorado District has three subdistrict offices, in Grand Junction, Lakewood, and Pueblo. Requests for information should be addressed as follows:

C.A. (Jerry) Pascale, District Chief
U.S. Geological Survey
Water Resources Division
Box 25046, Mail Stop 415
Denver Federal Center
Lakewood, CO 80225
Telephone: (303) 236-4882

Richard O. Hawkinson
Associate District Chief
U.S. Geological Survey
Water Resources Division
Box 25046, Mail Stop 415
Denver Federal Center
Lakewood, CO 80225
Telephone: (303 236-4882)

Sherman R. Ellis
Chief, Hydrologic Records Section
U.S. Geological Survey
Water Resources Division
Box 25046, Mail Stop 415
Denver Federal Center
Lakewood, CO 80225
Telephone: (303) 236-4886

Linda J. Britton
Chief, Publications Section
U.S. Geological Survey
Water Resources Division
Box 25046, Mail Stop 415
Denver Federal Center
Lakewood, CO 80225
Telephone (303) 236-4895

D.J. Lystrom
Chief, Hydrologic Studies Section
U.S. Geological Survey
Water Resources Division
Box 25046, Mail Stop 415
Denver Federal Center
Lakewood, CO 80225
Telephone: (303) 236-4886

R.F. Middelburg, Jr.
Chief, Computer Services Section
U.S. Geological Survey
Water Resources Division
Box 25046, Mail Stop 415
Denver Federal Center
Lakewood, CO 80225
Telephone: (303) 236-4882

R.K. Livingston, Subdistrict Chief
U.S. Geological Survey
Water Resources Division
P.O. Box 1524
Pueblo, CO 81002
Telephone: (303) 544-7155

D.L. Collins, Subdistrict Chief
U.S. Geological Survey
Water Resources Division
P.O. Box 2027
Grand Junction, CO 81641
Telephone: (303) 242-0731, X302

Kathleen Wilke, Subdistrict Chief
U.S. Geological Survey
Water Resources Division
Box 25046, Mail Stop 423
Denver Federal Center
Lakewood, CO 80225
Telephone: (303) 236-9404

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 Survey's responsibilities during its 107-year history, the Survey has remained principally a scientific and technical investigation agency as contrasted with a developmental or regulatory one. Today the Survey is mandated to assess onshore and offshore energy and mineral resources; to provide information for society to mitigate the impact of floods, earthquakes, landslides, volcanoes, and droughts; to monitor the Nation's ground- and surface-water supplies; to study the impact of man on the Nation's water resources; and to provide mapped information on the Nation's landscape and land use. The Survey is the principal source of scientific and technical expertise in the earth sciences within the Department of the Interior and the Federal Government. The 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 Survey.[1]

MISSION OF THE WATER-RESOURCES DIVISION

The mission of the Water-Resources Division, which supports the mission of the 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 consists of:

- Collecting data on the quantity, quality, and use of surface water (rivers, streams, lakes, reservoirs, estuaries, and glaciers); the quantity, and use of ground water (including water in the unsaturated zone); and the quality of precipitation.
- Storing and disseminating these data.

---

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

- Interpreting these data and publishing the results of these interpretations. This involves the inference of hydrologic causes, effects, 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 predicting the 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, USGS, or other Federal agency publications.
- 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. The Division conducts research in a wide variety of scientific disciplines--geochemistry, ecology, geomorphology and sediment transport, water chemistry, ground-water hydrology, and surface-water hydrology--particularly as these disciplines relate to the quantity, flow, and quality of surface water and ground water and to other aspects of the hydrologic cycle. The research 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]

COOPERATING AGENCIES

In Colorado, some of the water-resources data-collection activities and interpretive hydrologic investigations are conducted in cooperation with Federal, State, and local agencies. Those agencies cooperating with the U.S. Geological Survey during fiscal year 1986 and 1987 are:

Arkansas River Compact Administration
Boulder County Public Works Department
Cherokee Water and Sanitation District
Cherry Creek Basin Authority
City and County of Denver, Board of Water Commissioners
City of Arvada
City of Aspen
City of Aurora
City of Boulder
City of Broomfield
City of Colorado Springs, Department of Public Utilities
City of Colorado Springs, Office of the City Manager
City of Englewood, Bi-City Wastewater-Treatment Plant
City of Fort Collins
City of Fruita
City of Glendale
City of Glenwood Springs
City of Longmont
City of Steamboat Springs
City of Thornton
Colorado Department of Health
Colorado Department of Natural Resources
  Division of Mined Lands Reclamation
  Division of Water Resources, Office of the State Engineer
  Colorado Geological Survey
Colorado River Water Conservation District
Delta County Board of County Commissioners
Denver Regional Council of Governments

[2]Source: Mission statement by the Chief Hydrologist, September 28, 1984.

Eagle County Board of Commissioners
Evergreen Metropolitan District
Fountain Valley Authority
Garfield County
Grand County Board of Commissioners
Larimer-Weld Regional Council of Governments
Lost Creek Ground Water Management District
Lower Fountain Water Quality Management Association
Metropolitan Denver Sewage Disposal District No. 1
Mineral County
Moffat County
North Kiowa-Bijou Ground Water Management District
North La Junta Water Conservancy District
Northern Colorado Water Conservancy District
Pikes Peak Regional Building Department
Pitkin County Board of County Commissioners
Pueblo Board of Water Works
Pueblo Civil Defense Agency
Pueblo West Metropolitan Water District
Purgatoire River Water Conservancy District
Rio Blanco County
Rio Grande Water Conservation District
St. Charles Mesa Water Association
Southeastern Colorado Water Conservancy District
Southwestern Colorado Water Conservancy District
Town of Breckenridge
Town of Castle Rock
Trinchera Water Conservancy District
Uncompahgre Valley Water Users Association
Upper Arkansas River Water Conservancy District
Upper Yampa Water Conservancy District
Urban Drainage and Flood Control District
U.S. Air Force Academy
U.S. Air Force Space Command
U.S. Department of the Army
    Corps of Engineers
    Fort Carson
U.S. Department of the Interior
    Bureau of Land Management
    Bureau of Reclamation
    National Park Service
    Office of Surface Mining Reclamation and Enforcement
U.S. Environmental Protection Agency
Water Users No. 1
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 stream discharge and stage, reservoir and lake storage, ground-water levels, well and spring discharge, and the quality of surface and ground water (table 1). Every year some new stations are added and other stations are terminated; thus, the U.S. Geological Survey has both a current and a historical file of hydrologic data. Most water-resources data are stored in the U.S. Geological Survey's WATSTORE (National Water Data Storage and Retrieval System) 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 digital plots. Local assistance in the acquisition of services or products from WATSTORE can be obtained by contacting the District Chief, Lakewood, Colorado.

Table 1.--*Water-resources data-collection stations in operation during fiscal year 1987, 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
Streamflow:	
Continuous (daily) record	287
Seasonal (daily) record	36
Peakflow, crest-stage record	46
Real-time stage and discharge	82
Lakes and reservoirs:	
Stage and content	19
Real-time stage and content	5
Water quality:	
Periodic chemical quality	99
Daily quality monitoring	41
Ground water:	
Periodic water levels	75
Daily water levels	66
Chemical quality	14
Meteorological:	
Daily precipitation and(or) air temperature	24
Periodic precipitation quality	1
Real-time precipitation and(or) air temperature	33

Surface-Water Data

Surface-water discharge (streamflow), stage (water level), 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 river-stage information, have been installed at many 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 GOES (Geostationary Operational Environmental Satellite) and received at the U.S. Geological Survey DRGS (Direct Readout Ground Station) located in Denver, where it is processed and made available to other agencies.

Periodic water-quality data (common ions, nutrients, and(or) trace metals) are obtained at 99 of the surface-water stations listed in table 1. Six of these stations are part of a U.S. Geological Survery nationwide network known as NASQAN (National Stream Quality Accounting Network) and two are part of the nationwide Benchmark network, that provides data used in the evaluation of trends in stream quality.

Daily water-quality monitoring for water temperature, specific conductance, and (or) turbidity is being conducted at 41 sites. Automatic instruments measure the characteristic of interest continuously during the day, enabling the information to be summarized for the day, such as the daily maximum, minimum, and mean.

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 annual for pesticide or radiochemical data. In addition to the water-quality data collected at the aforementioned stations, a variety of information is collected at miscellaneous sites as part of interpretive hydrologic studies. This information also is available from the U.S. Geological Survey files.

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 about 141 observation wells is maintained in eastern Colorado for monitoring fluctuations in water levels, in cooperation with various eastern-slope water-conservancy districts and water-management districts. 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.

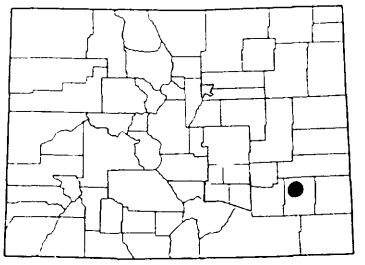
Water-quality data are not collected routinely from wells in the statewide networks. However, a variety of water-quality data were collected at 14 wells during 1986 for interpretive hydrologic investigations. These data are available from the files of the U.S. Geological Survey.

Meteorological Data

Precipitation quantity and (or) air temperature are collected and published at 24 monitoring stations in Colorado. One station, located in Bent County, is part of the nationwide NTN (National Trends Network) program to monitor long-term precipitation-quality changes. Precipitation quantity and (or) air temperature is measured and satellite-telemetered to the U.S. Geological Survey DRGS from 33 stations. Information from the precipitation stations is available to users on request.

INTERPRETIVE HYDROLOGIC INVESTIGATIONS

Forty interpretive hydrologic investigations are being conducted during fiscal year 1987 in cooperation with 70 Federal, State, and local agencies. Hydrologic investigations are being conducted 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 statewide, multistate, and nationwide hydrologic problems. A summary of each investigation, including problem, objectives, approach, progress, and plans follows.



PROJECT TITLE: National Trends Network for Monitoring Atmospheric Deposition

PROJECT NUMBER: CO-83-005

STUDY LOCATION: Bent County, Colorado

COOPERATING AGENCY: None--U.S. Geological Survey funds only

PROJECT CHIEF AND OFFICE: Ronnie D. Steger, Subdistrict Office, Pueblo

PROJECT DURATION: October 1983 to September 1986

PROBLEM: Great variability exists nationwide in precipitation quality and quantity and their potential environmental impacts.

OBJECTIVES: Develop a nationwide information base of precipitation quantity and quality data. Evaluate regional variations in precipitation quantity and quality related to regional land use, as well as the way in which these precipitation quantity and quality variations influence stream discharge and chemistry.

APPROACH: Operate one precipitation station at the Las Animas fish hatchery near Las Animas, Colorado, as part of the National Atmospheric Deposition Network. Obtain information on precipitation quantity, quality, pH, and specific conductance for storm events. Collect samples for chemical analyses and send to the Illinois State Water Survey Laboratory. Coordinate computations of chemical loading and evaluation of areal and temporal variations in precipitation quantity and quality.

PROGRESS: Precipitation site was visited each week throughout the year.

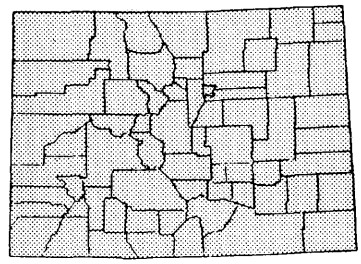
PLANS FOR FY 1987: Weekly visitation of the site will be continued.

PROJECT TITLE: Statewide Water-Use Inventory

PROJECT NUMBER: CO-78-007

STUDY LOCATION: Statewide

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



PROJECT CHIEF AND OFFICE: David L. Litke, District Office, Lakewood

PROJECT DURATION: October 1977 to September 1987

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 requires documentation, so State and local managers and planners may be better informed to make decisions for development of the State's water resources.

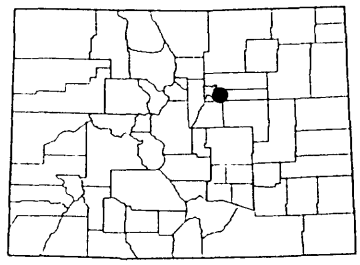
OBJECTIVES: Develop an inventory procedure to obtain both current and future water-use data. Develop a computerized data base that can be accessed by a variety of users.

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

PROGRESS: Water-use data for Colorado for 1985 were collected for twelve categories of water use. Data were summarized for each of Colorado's 63 counties and 98 hydrologic units. An irrigation water-use data base was established for estimating irrigation water use for 1970-85. A computerized data base showing monthly ditch withdrawals for the State's 15,000 ditches also was established.

PLANS FOR FY 87: Site specific water-use information will be entered into an INFO data base. ARC-INFO (proprietary software package) will be investigated as a tool in analysis and presentation of water-use data. A report discussing water use by county in Colorado will be prepared.

PROJECT TITLE: Effects of Sludge Disposal on Ground-Water Quality



PROJECT NUMBER: CO-77-097

STUDY LOCATION: Arapahoe County

COOPERATING AGENCY: Metropolitan Denver Sewage Disposal District No. 1

PROJECT CHIEF AND OFFICE: Neville G. Gaggiani, Subdistrict Office, Lakewood

PROJECT DURATION: May 1977 to September 1988

PROBLEM: In 1983, nitrate-nitrogen concentrations in the hundreds of milligrams per liter were found in the alluvial aquifer within the Lowry sewage-sludge land-disposal site located in Arapahoe County, Colorado. Metropolitan Denver Sewage Disposal District No. 1 has been operating the site for more than 10 years. Although the large concentrations seem to be confined to the site, concern exists that the contamination could spread and affect ground-water quality adjacent to the site.

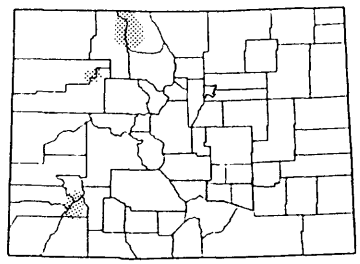
OBJECTIVES: Determine the location of, depth to, and areal extent of alluvial and bedrock aquifers beneath the sludge-disposal site and adjacent area. Determine the direction of ground-water flow and the quality of ground water.

APPROACH: Expand the present ground-water monitoring network within an approximate 28-square-mile area around the sludge-disposal site. Using observation wells, obtain water-level measurements and samples for water-quality analysis. Construct potentiometric-surface maps of the alluvial and bedrock aquifers to aid in determining ground-water flow paths. Solute-transport potential will be evaluated, based on estimates of aquifer hydraulic properties.

PROGRESS: Water-quality samples were collected, and water levels were measured at 28 observation wells. Nitrite plus nitrate concentrations were more than 10 milligrams per liter at some wells on the site; water levels were declining.

PLANS FOR FY 87: Water-quality and water-level monitoring will be continued.

PROJECT TITLE: Effects of Energy-Production Emissions on Colorado Lakes



PROJECT NUMBER: CO-80-131

STUDY LOCATION: Rio Blanco, Garfield, Mesa, and Delta Counties in northwestern Colorado

COOPERATING AGENCY: U.S. Geological Survey, U.S. Environmental Protection Agency, Colorado Department of Health, and Delta County

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

PROJECT DURATION: November 1979 to September 1989

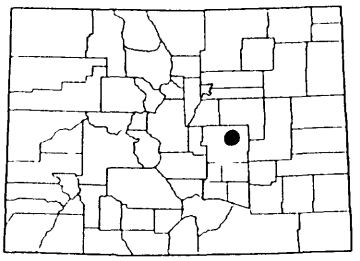
PROBLEM: Current and proposed production of energy in Colorado and surrounding States will release acidic gases and other constituents that can affect the chemistry of precipitation and of poorly buffered lakes and streams. The water resources of the Flat Tops, Mt. Zirkel, and Weminuche Wilderness Areas 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.

OBJECTIVES: Delineate the areas in Colorado most susceptible to the influence of acid rain. Determine within susceptible areas the lakes with 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: 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.

PROGRESS: Data collection was continued and a model of controls on lake chloride and sulfate concentrations was developed. Sampling was continued on three wilderness areas and at precipitation-maintaining sites.

PLANS FOR FY 87: Model will be applied to other areas; sampling will continue.



PROJECT TITLE: Upper Black Squirrel Creek Basin Ground Water

PROJECT NUMBER: CO-81-143

STUDY LOCATION: Black Squirrel Creek basin, El Paso County, Colorado

COOPERATING AGENCY: Cherokee Water and Sanitation District, and City of Colorado Springs, Department of Public Utilities

PROJECT CHIEF AND OFFICE: Douglas L. Cain, Subdistrict Office, Pueblo

PROJECT DURATION: July 1983 through September 1988

PROBLEM: The upper Black Squirrel basin is designated by the State of Colorado as a ground-water basin and a major source of water for future supply. Large water-level declines have occurred in the basin since 1964. Recently, additional water-supply requirements have been created by the new Consolidation Space Operations Center east of Colorado Springs. Existing and anticipated water-supply demands make it necessary to collect and evaluate hydrologic data to monitor ground-water changes, and to use the data to develop a digital (3D model).

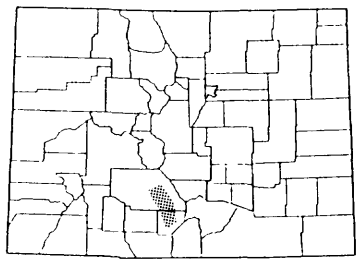
OBJECTIVES: Establish a ground-water level monitoring program consisting of bimonthly measurements. Evaluate changing water-quality conditions in alluvial aquifer. Develop a 3D hydrologic model of ground-water system to determine availability and movement of ground water.

APPROACH: Continue evaluated services program with Cherokee Water and Sanitation District for bimonthly water-level measurements. Measure specific conductance; selectively sample ground water for chemical analysis. Perform aquifer tests. Evaluate all data and develop a digital model of the hydrologic system.

PROGRESS: The ground-water database, GWSI, was updated to the present with hundreds of water-level measurements collected since 1964. Water-level measurements were collected and processed on five continuous ground-water level recorders through 1984. Forty-three wells were sampled for associated chemical constituents. Areas where nitrate concentrations were near or above the drinking-water standard were identified. A two-dimensional ground-water model was developed and calibrated. Projections of future water-level declines were made.

PLANS FOR FY 87: Data will be collected to better define the potentiometric surfaces of the bedrock aquifers and the head gradients between the bedrock aquifers and the alluvial aquifer, and the applicability of temperature-profiling methods in estimating ground-water flow will be evaluated.

PROJECT TITLE: Hydrology of the Closed Basin Project Area, San Luis Valley, Colorado



PROJECT NUMBER: CO-81-146

STUDY LOCATION: Upper San Luis Valley in Saguache, Rio Grande, and Alamosa Counties

COOPERATING AGENCY: U.S. Bureau of Reclamation

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

PROJECT DURATION: October 1980 to September 1987

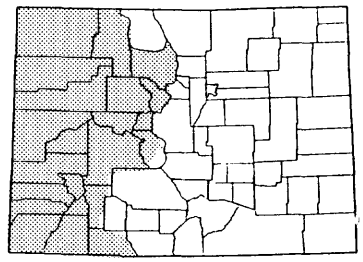
PROBLEM: The Closed Basin project area is an internally drained part of the Closed Basin, that is separated from the Rio Grande drainage in the Upper San Luis Valley. Significant quantities of water, now lost to evapotranspiration, could be salvaged and used for agriculture, and(or) used to partially fulfill Colorado's obligations to the Rio Grande Compact.

OBJECTIVES: Describe and evaluate quantitatively the hydrology of the project area. Construct and interrogate digital models to evaluate the effect of alternative locations of wells and pumping patterns on ground water in the unconfined aquifer and confined zone.

APPROACH: Compile and evaluate existing data on wells, pumpage, vegetation, and ground-water and surface-water inflow to quantify the hydrologic budget. Drill test holes to define hydraulic gradients, geology, hydrogeology, and water quality. Build and interrogate a two-dimensional finite-difference model to estimate well spacing and pumping patterns that would keep drawdown in the unconfined aquifer less than 2 feet at the project-area boundary.

PROGRESS: A two-dimensional model of ground-water flow previously developed to evaluate the potential effects of the Closed Basin Project was revised to use the McDonald-Hirbaugh modules-code. All sensitivity tests and simulations were rerun, using the modular-model source code, and the results were compared to those from the two-D Trescott model. The interpretive report was revised. Compilation of water-level data for the San Luis Valley was begun.

PLANS FOR FY 87: A data report will be completed summarizing ground-water data for the San Luis Valley. Operation of approximately 50 continuous-recording wells will be continued near the perimeter of the Closed Basin Project.



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 AGENCY: None--U.S. Geological Survey funds only

PROJECT CHIEF AND OFFICE: O. James Taylor, District Office, Lakewood

PROJECT DURATION: July 1981 to September 1987

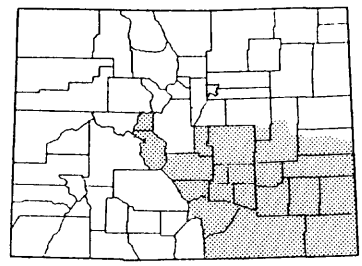
PROBLEM: Water demands are increasing in the Upper Colorado River Basin. Ground-water reservoirs may contain large supplies, but not all have been investigated. Effective water management cannot proceed until quantity and quality of available water supplies have been appraised.

OBJECTIVES: Locate major aquifer systems, estimate the volume of ground water in storage, determine the quality of available ground water, and estimate the hydrologic impacts of major withdrawals and injection.

APPROACH: Compile hydrologic and geochemical data from existing well logs and onsite inventory of wells and springs. Prepare and use simulation models to estimate the effects of withdrawals from, and injection into, various aquifer systems.

PROGRESS: Most analytical work and report writing was completed on this project. A hydrologic atlas and journal article were published. A water-supply paper and WRI report were approved for publication. Completed and ready for review are one professional paper, one hydrologic atlas, and three WRI reports.

PLANS FOR FY 87: All reports will be completed, and project will be terminated.



PROJECT TITLE: Comprehensive Hydrologic Quantity and Quality Model of the Arkansas River basin, Colorado

PROJECT NUMBER: CO-82-159

STUDY LOCATION: The Arkansas River basin of southeastern Colorado

COOPERATING AGENCY: Southeastern Colorado Water Conservancy District

PROJECT CHIEF AND OFFICE: Alan Burns, District Office, Lakewood

PROJECT DURATION: October 1981 to September 1988

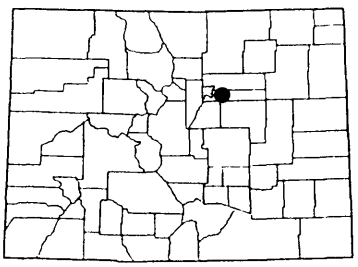
PROBLEM: Major changes in water use and resultant water quality in the Arkansas River basin are having impacts on all water users. The current over-appropriation of surface-water supplies has led to a complex water-supply system of transmountain diversions, reservoir storage, and development of the alluvial aquifer. Currently no consistent, comprehensive means exist to assess the possible water-quantity and -quality effects of the many possible changes in the competing water uses.

OBJECTIVE: Construct and document a model capable of assessing the basinwide quantity and quality impacts resulting from changes in water use. This model would be an interactive, planning-type, stream-network model to simulate the impact of the adjacent alluvial aquifer, simulate a water-quality mix, and include the legal-priority system of Colorado water law.

APPROACH: Develop the model from existing stream-network and stream-aquifer models. Develop stream-aquifer response functions, precipitation-runoff relations, water-quality discharge relations, and irrigation application-recharge factors for entry into the model. Calibrate and demonstrate examples of the model's predictive capabilities in workshops and describe them in a report.

PROGRESS: Two reports are published: one describing the water operations of the basin and the other summarizing hydrographs and statistics of the water resources of the basin. A report describing water-quality relations in the basin is approved for publication. A report documenting the model has been transmitted for final approval, and a report describing the model calibration is being revised after review. A bibliography of water-resources investigations in the basin will be developed, and the model data base will be updated.

PLANS FOR FY 87: All reports will receive Director's approval; data base will be updated, and model will be revised to include capability to use daily distribution of streamflow within a month of occurrence to make monthly simulation of diversions more realistic.



PROJECT TITLE: Effects of Projected Urbanization on Inflows to Cherry Creek Reservoir

PROJECT NUMBER: CO-82-164

STUDY LOCATION: Cherry Creek drainage above Cherry Creek Reservoir, Arapahoe and Douglas Counties, Colorado

COOPERATING AGENCY: Douglas County and Cherry Creek Basin Authority

PROJECT CHIEF AND OFFICE: Martha H. Mustard, Subdistrict Office, Lakewood

PROJECT DURATION: April 1984 to December 1986

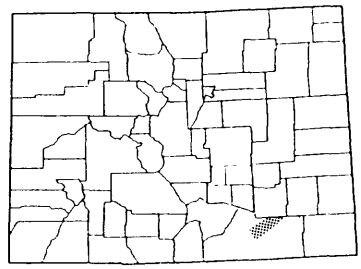
PROBLEM: Cherry Creek Reservoir is a U.S. Army Corps of Engineers flood-control reservoir used extensively for fishing, swimming, and boating, located on the current (1986) edge of the Denver metropolitan-urban area. Urbanization upstream of the reservoir will affect the quantity and quality of runoff entering the reservoir. Changes in chemical composition of runoff, as a result of watershed development, could cause violation of water-quality standards set by the Colorado Water Quality Control Commission and could affect the suitability of the reservoir for recreational activities.

OBJECTIVES: Monitor streamflow and collect samples under ambient and storm-runoff conditions. Define ground-water levels and water quality in the alluvium upgradient of Cherry Creek Reservoir. Develop statistical relations between water-quality loadings and precipitation and basin characteristics.

APPROACH: Monitor the quantity and quality of surface-water inflow in Cherry Creek and several principal tributaries. Precipitation data will be provided by rain gages located in the basin. Variation in water-quality conditions will be defined by a sampling program that includes quarterly ambient and storm-event samples. Monitor the shallow ground-water system; water-level measurements and water samples will be collected at approximately 10 wells to define seasonal variations in the alluvial ground-water system near the reservoirs. Use multiple-regression techniques in the analysis of runoff and water-quality characteristics to determine how these variables relate to rainfall and basin characteristics.

PROGRESS: Water-quality samples were collected from three sites on Cherry Creek Reservoir and from four stations on the major inflows. Flow records were maintained on the four inflow stations, and rain data were collected at six raingages.

PLANS FOR FY 87: Data collection was discontinued December 31, 1986, and project was terminated.



PROJECT TITLE: Assessment of Water Resources and Related Impacts 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 B. von Guerard, Subdistrict Office, Pueblo

PROJECT DURATION: October 1982 to September 1988

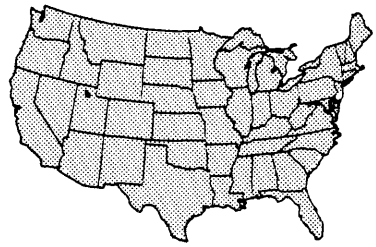
PROBLEM: A 400-square-mile area will be acquired in the Pinon Canyon area by the U.S. Army and used for military training, beginning in 1985. Conversion of land use from grazing may alter streamflow and water quality. These changes could not be quantified in the environmental impact statement for the acquisition, but they 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.

OBJECTIVES: Assess the quantity and quality of both surface- and ground-water resources in the area. Determine the impact of military training on the water resources of the area.

APPROACH: Monitor surface-water flow at 11 streamflow-gaging stations; 2 stations exist, and 9 stations were installed in FY 83. Monitor specific conductance continuously at all stations. Collect sediment samples by automatic samplers at seven stations. Collect water-quality samples of base flow and storm runoff. Determine current (1983-84) reservoir capacity in 49 small reservoirs; 29 of these reservoirs were probed to determine historical sediment contents; all reservoirs will be resurveyed following military training. Inventory existing wells; sample 50 wells. Measure water levels monthly in 10 wells.

PROGRESS: Hydrologic-data collection was continued at 11 streamflow-gaging stations and at 14 precipitation stations. Storm runoff occurred intermittently at all sites from May through August. Ground-water-quality sampling was completed at a total of 27 wells. Monthly monitoring of water levels was continued at a network of 10 wells. Work began on the baseline assessment report, "The Hydrology of Pinon Canyon"; it is scheduled for completion in January 1987.

PLANS FOR FY 87: Operation of the surface-water monitoring network will be continued. Sediment ponds that have had significant inflow over the past 3 years will be resurveyed. Baseline assessment report on the hydrology of Pinon Canyon will be completed. Simulation of surface hydrologic processes, using the watershed model HSPF, will begin. Precipitation sites and quarterly measurement of water levels at a 10-well network will be maintained.



PROJECT TITLE: Statistical Analyses and Regionalization of National Urban-Stormwater Data Base

PROJECT NUMBER: CO-83-176

STUDY LOCATION: Urban study areas nationwide

COOPERATING AGENCY: None--U.S. Geological Survey funds only

PROJECT CHIEF AND OFFICE: Nancy E. Driver, District Office, Lakewood

PROJECT DURATION: January 1983 to September 1987

PROBLEM: Urban planners and managers need information on quantity and quality of runoff and precipitation in their cities if they are to plan adequately for the effects of storm runoff from urban areas receiving water.

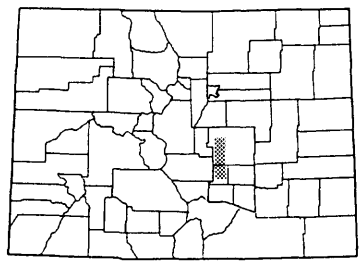
OBJECTIVES: Determine the basin storm characteristics that account for variations in water quality; identify regional variations in factors controlling constituent loads in storm runoff. Use these results to develop methods to transfer the constituent-load information to ungaged areas.

APPROACH: Relate measured storm loads of selected water-quality constituents to basin storm characteristics, using regression techniques. Relate mean-seasonal and mean-annual loads to basin characteristics, using generalized least-squares approach. Use statistical procedures to test the model's usefulness at ungaged sites.

PROGRESS: One data report was completed and published. Second data report is in review. Analysis for the storm loads was completed, and writing has begun. Analysis for the seasonal and annual loads is in progress, using generalized least-squares analysis.

PLANS FOR FY 87: Analysis will be completed. A Water-Supply Paper and two journal articles will be written.

PROJECT TITLE: Sources and Movement of Hazardous Wastes in a Heavily Used Stream-Aquifer System



PROJECT NUMBER: CO-84-180

STUDY LOCATION: El Paso and Pueblo Counties, Colorado

COOPERATING AGENCY: None--U.S. Geological Survey funds only

PROJECT CHIEF AND OFFICE: Douglas L. Cain, Subdistrict Office, Pueblo

PROJECT DURATION: April 1984 to September 1988

PROBLEM: Stream-aquifer systems are among the most important sources of ground-water supply for municipal and agricultural uses in the semiarid west. Concurrently, the streams that are part of these systems often are used heavily for disposal of municipal, industrial, and agricultural waste water, resulting in a large potential for ground-water contamination. Currently, little is known about the concentrations, distribution, sources, and movement of hazardous substances in stream-aquifer systems.

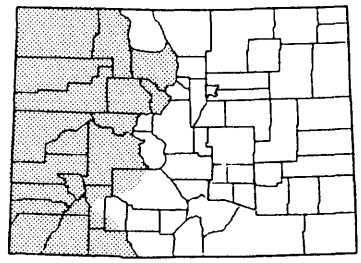
OBJECTIVES: Determine the occurrence and distribution of organic substances and trace metals in the Fountain Creek stream-aquifer system. Determine if the occurrence or concentrations are related to land use or quality of recharge water. Evaluate the concentrations, sources, and movement of specific organic chemicals or metals in a small area of the stream-aquifer system; assess the applicability of the study results to other locations.

APPROACH: Assemble and evaluate existing data on water quality, well location and construction, land use, and waste discharge. Review literature on sampling methods for organics. Collect reconnaissance water-quality data from about 15 wells under each land use. Evaluate reconnaissance data for relation between water quality and land use. Select constituents for intensive study in a small area. Collect samples in area selected, based on ground-water flow and recharge pattern, to determine temporal and spatial distribution, and source and movement of select constituents.

PROGRESS: Reconnaissance-phase report was revised and approved by the Director. Additional sampling of ground water was done to evaluate analytical techniques for volatile organic compounds and to determine the occurrence of selected pesticides. An outline of a journal article, summarizing several of the reconnaissance-phase studies was prepared, and a draft of the article was begun.

PLANS FOR FY 87: The study plan for phase 2 will be finalized, including conceptual design, drilling and sampling plan, and statistical design. Wells will be installed for sampling during phase 2. Sampling of existing wells will be conducted to evaluate various techniques for analysis of volatile organic compounds. The first draft of introductory sections of final report will be prepared, and the journal article summarizing the reconnaissance-phase studies will be completed.

PROJECT TITLE: Dissolved Solids in the Colorado River Basin



PROJECT NUMBER: CO-84-181

STUDY LOCATION: Colorado River Basin

COOPERATING AGENCY: U.S. Bureau of Reclamation and U.S. Geological Survey

PROJECT CHIEF AND AGENCY: David K. Mueller, District Office, Lakewood

PROJECT DURATION: March 1984 to September 1987

PROBLEM: The salt load in the Colorado River causes millions of dollars in damage annually to agricultural, industrial, and municipal users. The U.S. Bureau of Reclamation is in the process of implementing various salinity-control programs in the Upper Colorado River Basin to reduce salt loads to the river. Decreased salt loads from some upper basin areas have been indicated; however, definitive causes for the decreases are not readily apparent. Hence, a need exists to determine if a trend occurs in the salinity data from the monitoring stations, and, if so, to determine the source of the trend.

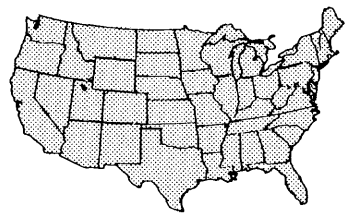
OBJECTIVES: Determine for the Upper Colorado River Basin: (1) General source areas of dissolved-solids concentration and water discharge; (2) concentration variation at each monitoring station; (3) time series of annual dissolved-solids load at each site; (4) long-term trends in dissolved-solids concentration at each of the stations; (5) influence of man's activities on the salt load; (6) a method to determine the natural salt load in the Upper Colorado River Basin; (7) extension of records of streamflow and dissolved solids for selected stations; and (8) revised and updated method to compute monthly streamflow and dissolved solids, so data base can be maintained for future analyses.

APPROACH: Determine general source areas of dissolved-solids concentrations by percentage of dissolved-solids load at the mouth of the Upper Colorado River Basin. Based on historical record, identify the range of concentrations of dissolved solids for each monitoring station. Using state-of-the-art statistical techniques, determine and present the time series of annual dissolved-solids loads, and identify any long-term trends in dissolved-solids concentrations that may exist. Based on development information, determine the natural and historical salt load at each site in the Upper Colorado River Basin.

PROGRESS: Four reports were prepared and are in review. Two reports give the results of characterization and statistical analyses of dissolved-solids loads at 70 streamflow-gaging stations in the Upper Colorado River. The other two reports describe methods used to estimate natural (predevelopment) dissolved-solids discharge and to extend the records of streamflow and dissolved solids for selected stations.

PLANS FOR FY 87: All reports will be completed. Computer programs written for a previous project will be revised to facilitate computation of monthly streamflows and dissolved-solids discharge at gaging stations in the Colorado River Basin. These revisions will help maintain the data base created by the present project, so additional analyses can be made, as new data become available. The revised procedure will be documented in an Open-File Report.

PROJECT TITLE: Preliminary Assessment of Methods for Determination of Evaporation Components by Water Resources Council (WRC) Subregions



PROJECT NUMBER: CO-84-183

STUDY LOCATION: Nationwide

COOPERATING AGENCY: None--U.S. Geological Survey funds only

PROJECT CHIEF AND OFFICE: Norman E. Spahr, District Office, Lakewood

PROJECT DURATION: April 1984 to September 1987

PROBLEM: To estimate renewable water supply on a subregion basis for the National Water Summary, consumptive use must be known. Consumptive use includes industrial and agricultural consumption and net reservoir evaporation. Net reservoir evaporation is water-surface evaporation, excluding natural evapotranspiration that would occur had a reservoir not been constructed. Therefore, for the National Water Summary, estimates of natural evapotranspiration and gross evaporation will be needed on a Water-Resources Division subregion unit basis.

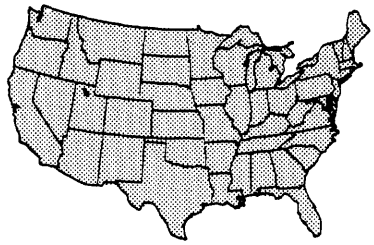
OBJECTIVES: Determine deviations between values from the National Weather Service national evaporation map and values from site-specific studies. Using test basins, determine order and magnitude and feasibility of computing natural basin-evapotranspiration losses as compared to gross-reservoir evaporation. Create a data-base system of reservoirs having storage capacity larger than 5,000 acre-feet. Using created data base, develop history of reservoir development by hydrologic unit. Develop regional relations to estimate surface area from storage capacity; current data do not include measurements of surface area.

APPROACH: Tabulate published and unpublished evaporation rates from energy-budget studies and compare to values from National Weather Service map. Evaluate techniques to determine water-budget components (evaporation and evapotranspiration) on a national basis, using selected test basins; test basins will be selected, based on criteria to simplify water-budget assumptions, that is, best possible cases. If method will not work for best possible conditions, it will not work on a national basis. Using the U.S. Army Corps of Engineers' master inventory of dams, a file of reservoirs with storage capacity larger than 5,000 acre-feet has been generated; this file will be used as a reservoir-data base.

PROGRESS: Storage ratios, drainage areas, and other missing attributes in the reservoir data base were determined and cross-checked. The national evaporation map was digitized and verified.

PLANS FOR FY 87: National maps of runoff, precipitation, and evaporation will be combined to determine net-reservoir evaporation by hydrologic unit for the United States. An update to Water-Supply Paper 1838 and an Open-File Report on the reservoir data base will be completed. Reservoir data base in a menu-driven INFO data-base system will be completed.

PROJECT TITLE: An Update of Fluvial-Sediment Discharge to the Oceans from the United States



PROJECT NUMBER: CO-84-184

STUDY LOCATION: Nationwide

COOPERATING AGENCY: None--U.S. Geological Survey funds only

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

PROJECT DURATION: April 1984 to September 1987

PROBLEM: Knowledge of the amount of sediment transported by the various rivers of the United States is essential to: (1) Designing reservoirs to allow sufficient space to store sediment expected to accumulate in reservoirs; (2) predicting the fate of contaminants, such as pesticides, radionuclides, and toxic metals that can be absorbed to the sediment particles; and (3) indicating regional and continental rates of erosion. A summary of transported sediment will be useful to the hydrologic community.

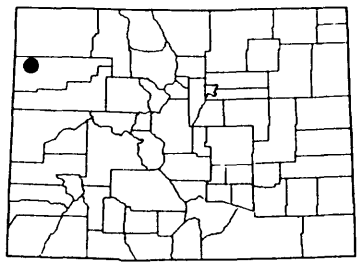
OBJECTIVE: Calculate sediment outflow to the oceans from the major sediment-producing rivers of the United States. In addition, give examples of changes in sediment yields from man's activities upstream, and examples of extreme events and their impact on sediment production.

APPROACH: Calculate sediment yields of major river basins in the United States from data contained in WATSTORE. Record examples of the impacts of man's modifications and of extreme events from the literature.

PROGRESS: A data base was developed by searching the WATSTORE system for stations with daily sediment and periodic-sediment records. The data base (which will become a publication) was completed. The United States was divided into regions to draw the sediment-load maps; approximately half of these regional maps have been completed.

PLANS FOR FY 87: Sediment-load maps for major rivers of each region of the United States will be completed, and an interpretive report will be written.

PROJECT TITLE: Water Quality of Kenney Reservoir



PROJECT NUMBER: CO-84-186

STUDY LOCATION: Rio Blanco County, Colorado

COOPERATING AGENCY: Water Users No. 1

PROJECT CHIEF AND OFFICE: Robert L. Tobin, Field Office, Meeker

PROJECT DURATION: April 1984 to December 1987

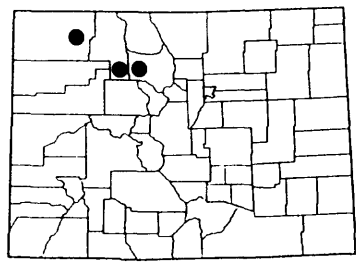
PROBLEM: Kenney Reservoir is a small-capacity reservoir (13,800 acre-feet) scheduled for completion on the White River in summer 1984. The reservoir will have a short hydraulic residence time, except during late summer and fall and in low-flow years. During these periods, the reservoir may develop thermal stratification with associated changes in dissolved oxygen, and in biological and chemical constituents. To evaluate these changes and the impacts of sediment loading to the reservoir, data needs to be collected at several depths throughout the year. This information, combined with sediment inflow-outflow data, will provide a three-dimensional definition of the physical state of the reservoir, including the rate of sediment deposition.

OBJECTIVES: Collect sufficient data to describe chemical and biological conditions and the dynamics that occur within the reservoir during the first 2 years after filling. Make estimates of sediment retention and reservoir trap efficiency. Summarize all data in an interpretive report.

APPROACH: Determine water-quality characteristics with depth seasonally at two or three sites, from profile measurements of temperature, specific conductance, pH, and dissolved oxygen. Determine major ions, nutrients, trace metals, phytoplankton identification, chlorophyll *a* and *b*, and bacteria from samples taken at specific depths. Determine sediment loading to the reservoir from bedload and suspended-sediment collections at streamflow-gaging stations above and below the reservoir. Review data annually for their applicability to meeting study objectives, and make necessary program changes.

PROGRESS: Specified collection of chemical, biological, and sediment data from lakes and major inflow sites is completed. Data indicated that minimal changes in water quality occurred within the reservoir, principally because of the large quantity and good quality of the input waters. Preliminary data indicated that sediment yields to the reservoir are predominantly as suspended sediment, with less than 2 percent as bedload.

PLANS FOR FY 87: All data will be collated and summarized. Interpretive report will be completed. Additional sediment study to quantify sediment transport from tributary basins immediately upstream of the reservoir will be proposed.



PROJECT TITLE: Total Sediment Transport at Reservoir Sites in Western Colorado

PROJECT NUMBER: CO-84-187

STUDY LOCATION: Proposed reservoir sites, western Colorado

COOPERATING AGENCY: Colorado River Water Conservation District

PROJECT CHIEF AND OFFICE: David L. Butler, Subdistrict Office, Grand Junction
Robert L. Tobin, Field Office, Meeker

PROJECT DURATION: March 1984 to September 1987

PROBLEM: Sediments transported by rivers flowing into reservoirs are deposited throughout the length of the impoundment. Deposits may occur in the upper reaches of the reservoir that are controlled by hydraulics; as water depths increase and flow velocity decreases, bedload or coarser material is dropped first; subsequently, sand-sized material is deposited. Ultimately, finer silt and clay fractions in suspension are deposited, usually farther within the reservoir. To estimate total load and sedimentation rate, the following information is required: (1) Water discharge; (2) suspended-sediment concentration and size distribution; and (3) bedload-transport rate and size distribution.

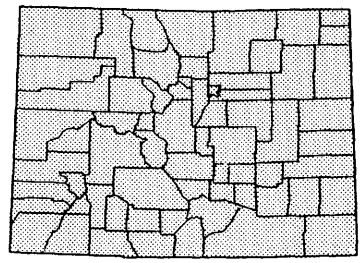
OBJECTIVE: Measure the total inflow of suspended sediment and bedload into reservoirs or through reaches where reservoirs may be impounded. Estimate the effect of sediment deposition.

APPROACH: (1) Using standard techniques, collect suspended-sediment, bed material, and bedload data; (2) develop suspended-sediment, bedload, and total sediment-discharge relations, based on the collected data and on estimates from empirical techniques such as the Colby and modified Einstein equations; (3) compute annual sediment discharges at potential reservoir locations, using the sediment ratings and streamflow data; and (4) estimate trap efficiency of the reservoir, specific weight of the deposited sediment, and distribution of the sediment within the reservoir to assist in the design of reservoir structure and operating pilings.

PROGRESS: Analysis of sediment data collected at proposed reservoir sites on Rock Creek and Muddy Creek was completed. Total sediment discharge into the proposed Rock Creek Reservoir was estimated to be 768 tons/year for 1953-1980; this rate of sediment discharge would reduce water-storage capacity by less than 1 percent after 100 years. Total sediment discharge into the proposed reservoir on Muddy Creek near Kremmling was estimated to be 83,000 tons/year for 1983-1985. Water-storage capacity of the proposed reservoir would decrease 10 percent after 100 years. These estimates of reservoir sedimentation assume no change in sediment-transport conditions in Rock Creek and Muddy Creek basins. A sediment data-collection program to define total sediment transport in Fortification Creek was begun. Sediment characteristics of seasonal hydrographs were defined.

PLANS FOR FY 87: The Rock Creek and Muddy Creek reports are completed and approved for publication. Sediment-collection program for Fortification Creek will be continued, and formats for figures and tables for the final report will be prepared.

PROJECT TITLE: Study of Colorado Water-Quality Monitoring Activities



PROJECT NUMBER: CO-84-192

STUDY LOCATION: Statewide

COOPERATING AGENCY: None--U.S. Geological Survey funds only

PROJECT CHIEF AND OFFICE: J. Michael Norris, District Office, Lakewood

PROJECT DURATION: September 1984 to September 1987

PROBLEM: Although water-quality information is collected by many Federal, State, and local agencies and universities, no coordination exists between these groups to provide information regarding who is collecting water-quality information; what type of information is collected; where the information is collected; where the information is available; or how accurate the data are. This lack of coordination may lead to duplication of water-quality-data collection and fragmented data bases. Not only could the efficiency of water-quality-data collection be improved by coordination between these groups, but a better understanding of the water quality could be obtained by combining all the comparable data collected.

OBJECTIVES: (1) Determine the Federal, State, and local agencies, and universities collecting water-quality data and the types of information collected; (2) determine the accuracy and comparability of the information collected by the various groups; and (3) determine the suitability of data found comparable for a regional water-quality assessment.

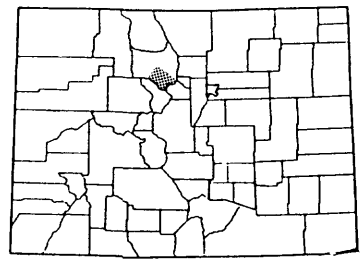
APPROACH: The study was divided into three phases. Phase I identified and inventoried those agencies or institutions collecting water-quality information in 1984. Information obtained included the types of data being collected and a rough estimate of laboratory expenditures. Information included from questionaires completed by those agencies or institutions identified as collecting water-quality information was used to screen some of the information, based on general criteria, such as availability of the data for public use, and whether the sites from which the information was collected were readily locatable. Phase II of the study was to determine the accuracy of the information collected and to determine the comparability of the data by evaluating the quality assurance and quality control of the sample collection and laboratory-analysis procedures. Information obtained from questionaires sent to organizations meeting the Phase-I criteria was used to determine the comparability and accuracy of the water-quality data collected on a constituent basis. Water-quality data meeting the Phase II criteria was considered of sufficient quality for use in a regional water-quality assessment. Phase III of the study determined the adequacy or suitability of the data meeting the Phase II criteria to perform a regional water-quality assessment. This determination included an evaluation of the amount of data

APPROACH--Continued:
available and the aerial definition provided by the data-collection sites with adequate data. This analysis was done to determine if the existing data were adequate to address two major questions on a regional scale: (1) Can the existing water quality be defined; and (2) can changes in the water quality be detected.

PROGRESS: Phase I report was approved and published; Phase II report has been approved; Phase III report has been written and is ready for review.

PLANS FOR FY 87: Phase III report will be reviewed, approved, and prepared for publication.

PROJECT TITLE: Wetland, Ground-Water, and Surface-Water Relationships in a Subalpine Valley in Grand County, Colorado



PROJECT NUMBER: CO-85-193

STUDY LOCATION: North-central Colorado

COOPERATING AGENCY: City and County of Denver, Board of Water Commissioners

PROJECT CHIEF AND OFFICE: Barbara C. Ruddy, Subdistrict Office, Lakewood

PROJECT DURATION: October 1984 to October 1987

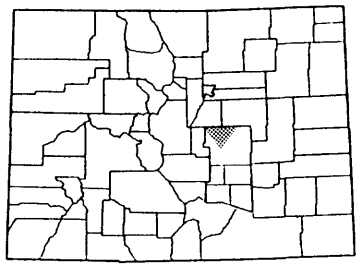
PROBLEM: Surface water from the South Fork of the Williams Fork River is being considered for diversion to another basin. Wetland areas along the banks of the South Fork receive water from side-slope discharge, from riverbank overflow, from subsurface contribution along losing reaches of the river, or from a combination of these sources. If the wetlands are receiving significant amounts of water from the river, then a reduction in river discharge may impact the wetland areas.

OBJECTIVES: Identify the hydrologic connection between the South Fork Williams Fork River, the adjacent wetlands, and the wetland ground-water system. Evaluate the hydrologic effects of diverting water from the South Fork River on adjacent wetlands.

APPROACH: Collect hydrologic data at four wetland sites and meteorological data at two stations. Design the well network at each site to define the geometry of the wetland water table; determine the direction of wetland ground-water flow from this information. Determine the water chemistry of the ground water and surface water and determine ground-water flow directions in the wetland. Determine if overbank flooding of the wetlands occur. Combine the streamflow information with the wetland ground-water information to help delineate interaction between the river, the wetland ground water, and the wetlands.

PROGRESS: Nine wells and one streamflow-gaging station were installed at lower site no. 3. The interaction of the streamflow and wetland is more complicated at site 3 than it is at site 2. The direction of flow varies by season and within the wetland itself. The ground-water chemistry indicates that some ground water close to the stream may be affected by the stream. Piezometers need to be installed at site 3 to better define the slope of the water table. The amount of precipitation in 1985 and 1986 was approximately the same, but the runoff patterns were different; larger runoff and higher ground-water levels occurred in 1986.

PLANS FOR FY 87: An interpretive report will be written. Partial data collection may be continued in future years to define longer term variations in the flow regime.



PROJECT TITLE: Hydrologic Response of the Denver Basin Bedrock Aquifers to Pumpage in Northern El Paso County, Colorado

PROJECT NUMBER: CO-85-194

STUDY LOCATION: Denver Basin, east-central Colorado

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

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

PROJECT DURATION: October 1984 to September 1987

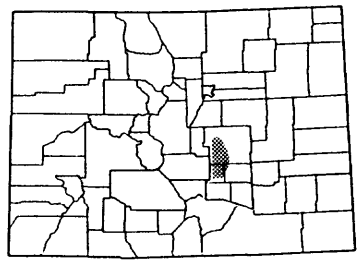
PROBLEM: Large-scale development of bedrock-water supplies in northern El Paso County will produce large water-level declines in the aquifers and could cause dewatering in updip parts of the bedrock formations, which may reduce the volume of water supplied from wells. Further reductions in pumping rates might be required, if existing water rights along Monument and Fountain Creeks are damaged by development of the bedrock aquifers.

OBJECTIVE: Provide a current hydrologic evaluation of conditions in the bedrock aquifers of El Paso County and use this information as a basis for an updated model capable of simulating the response of the aquifers to proposed pumpage in El Paso County.

APPROACH: Collect additional water-level measurements, aquifer tests, and well logs to update similar data collected in 1980. Rebuild the southern part of the existing Denver Basin model at a finer grid spacing, using these data. Calibrate the updated model against rates of measured ground-water discharge to base flow in Monument and Fountain Creeks. Use the calibrated model to simulate the response of the aquifers to proposed pumping in northern El Paso County.

PROGRESS: A gain-and-loss investigation was made in January 1986. The steady-state ground-water model was calibrated. The transient-state model was calibrated against two calibration periods: 1958-78 and 1978-85. Two simulation scenarios were run with the model. About half of the model runs needed for the sensitivity analysis were made. The parts of the text describing introduction, natural hydrologic system, and simulated hydrologic-system description and calibration were written (first draft).

PLANS FOR FY 87: At least three additional model-simulation scenarios will be run. Sensitivity analysis will be completed. The text and illustrations will be completed (covering simulations and sensitivity analysis).



PROJECT TITLE: Transit Losses along Fountain Creek Associated with Return Flows of Transmountain Water Utilized by the City of Colorado Springs

PROJECT NUMBER: CO-85-195

STUDY LOCATION: Fountain Creek from Colorado Springs to Pueblo, Colorado

COOPERATING AGENCY: City of Colorado Springs, Department of Public Utilities

PROJECT CHIEF AND OFFICE: Gerhard Kuhn, Subdistrict Office, Pueblo

PROJECT DURATION: January 1985 to January 1987

PROBLEM: Return flows of imported water used by the City of Colorado Springs flow into Fountain Creek, where they have been treated as natural streamflow in the past. However, in the future, the City of Colorado Springs intends to make full use of its transmountain-diversion rights, through a complex water-rights exchange agreement. Because the return flows have been treated as natural streamflow, existing streamflow records are insufficient in documenting that part of the return flows reaching the mouth of Fountain Creek, one of the points for the exchange agreement. In addition to the complex effects that diversion and reuse have on streamflow along Fountain Creek, the system also is subject to variable ground-water pumpage, localized runoff from thunderstorms, occasional dry reaches during low-flow periods, and significant streamflow losses, as recharge to the Widefield aquifer and Fountain Creek alluvium.

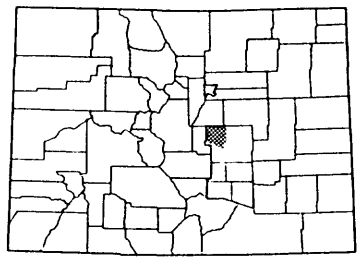
OBJECTIVES: The overall purpose is to determine the fate of transmountain diversions to Fountain Creek in the reach between the Colorado Springs wastewater-treatment plant and the mouth of Fountain Creek. Specific objectives are to (1) Determine the "natural" flow of Fountain Creek downstream from Colorado Springs; (2) determine the transit loss associated with both continuous and noncontinuous releases of return flows into Fountain Creek; and (3) quantify return flows reaching the Arkansas River.

APPROACH: Because the hydrologic complexity of the problem will require the development and use of hydrologic or hydraulic models of the Fountain Creek system, select or develop the models on the basis of their data requirements and their ability to meet study objectives within a reasonable level of accuracy. Test the models, using existing records of streamflow, surface-water diversions, ground-water pumpage, and water use. Include in the final report a data summary, description of technical approach, and discussion of the transit losses of the return flows, for a variety of release and streamflow conditions.

PROGRESS: Transit losses for transmountain-return flows were determined for the Fountain Creek stream-aquifer system, using the U.S. Geological Survey's J349 model. A method of applying the results to daily stream-flow conditions was developed and tested with real data. Report of study results and application method was completed and sent to colleague review in September 1986.

PLANS FOR FY 87: Report will be revised as necessary following colleague review and submitted for approval. An interactive computer program that can be used to compute daily transit losses (or gains) for return flows of transmountain return flows will be designed and written, using the study results.

PROJECT TITLE: Sediment-Transport Characteristics and their Effects on Aquatic Life in the Fountain Creek Basin above Widefield, Colorado



PROJECT NUMBER: CO-85-196

STUDY LOCATION: Colorado Springs and vicinity in Arkansas River basin

COOPERATING AGENCY: City of Colorado Springs, Department of Public Utilities

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

PROJECT DURATION: January 1985 to September 1989

PROBLEM: Expanding urbanization in the Colorado Springs area is likely to increase stream-sediment loads during development. As development continues, the increase in impervious land areas may cause an increase in the magnitude and frequency of streamflow peaks. Resultant increase in bed scour and bank erosion will effect changes in channel morphology and may be detrimental to existing aquatic life. Increased channel erosion may affect riparian vegetation, stream-side recreation, diversion headgates, and other manmade structures.

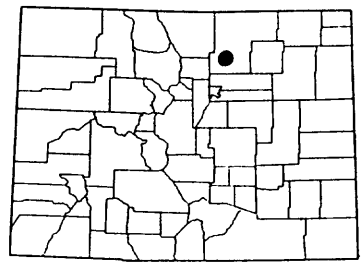
OBJECTIVES: Define source areas of sediment and provide information on current sediment loads, on channel stability, and on changes observed during the study. Relate existing stream-sediment conditions to aquatic life in Fountain and Monument Creeks.

APPROACH: Incorporate systematic collection of sediment and biological data at a network of six sites. Collect 50 sediment samples at each site. Collect three bedload samples per site, with bottom material and suspended samples for full-size analysis. Establish channel cross sections at each site. Conduct biological sampling for benthic invertebrates at five sites. Delineate sediment-source areas by synoptic sampling at 20 sites.

PROGRESS: Sediment and biological data collection were continued. The sediment-source area report was started and is scheduled for completion early in 1987.

PLANS FOR FY 87: Sediment-data collection will be maintained at six sites; biological-data collection will be maintained at five sites. Sediment-source area report will be completed.

PROJECT TITLE: Ground-Water-Quality Effects of Soil Application of Sewage Sludge on Farmland near Denver, Colorado



PROJECT NUMBER: CO-85-197

STUDY LOCATION: North-central Colorado

COOPERATING AGENCY: Metropolitan Denver Sewage Disposal District No. 1

PROJECT CHIEF AND OFFICE: Neville G. Gaggiani, Subdistrict Office, Lakewood

PROJECT DURATION: October 1984 to September 1988

PROBLEM: Metropolitan Denver Sewage Disposal District No. 1 is beginning a program of disposal of anaerobic, digested, activated sludge, by land application to farmland. The sludge will be injected about 6 to 10 inches into the soil, using a vehicle with a device that plows at the same time. Although the sludge will be applied at agronomic rates, the potential exists for leaching of organic and inorganic compounds into the ground water.

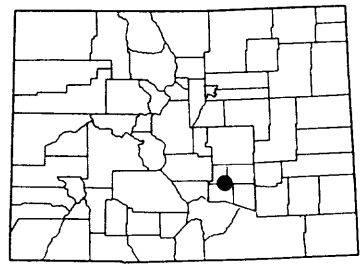
OBJECTIVE: Determine the effects of soil application of sewage on the ground-water quality. To accomplish this, determine the general flow rate, amount, and quality of the water in the saturated and unsaturated zones.

APPROACH: After a suitable site has been selected, install piezometers, lysimeters, and a recording rain gage. Collect water samples from the saturated and unsaturated zone before sludge is applied, so that normal background conditions can be determined. After sludge is applied, sample the wells and lysimeters three times each growing season. Determine direction of flow from water levels in wells on and near the site. Use the Kendall rank correlation coefficient to test areal-concentrations variations.

PROGRESS: Water-quality samples were obtained after the first yearly sewage-sludge application. Precipitation and ground-water levels were monitored.

PLANS FOR FY 87: Water-quality sampling and precipitation and ground-water level monitoring will be continued.

PROJECT TITLE: Comprehensive Water-Quality Evaluation of Pueblo Reservoir, Including the Effects of Potential Contamination



PROJECT NUMBER: CO-85-198

STUDY LOCATION: Central Colorado

COOPERATING AGENCY: Southeastern Colorado Water District; Fountain Valley Authority; Pueblo West Metropolitan Water District; Pueblo Board of Water Works; and St. Charles Mesa Water Association

PROJECT CHIEF AND OFFICE: Patrick F. Edelmann, Subdistrict Office, Pueblo

PROJECT DURATION: March 1985 to September 1989

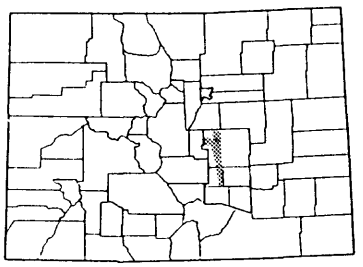
PROBLEM: Pueblo Reservoir is a multiple-use reservoir. Reservoir water is used for municipal, industrial, agricultural, and recreational purposes. Pueblo Reservoir receives storm runoff, salt loading from irrigation-return flows, extensive recreational use, upstream mine drainage, discharge from municipal and industrial wastewater, and transportation spills. Recent concerns over marked increase in taste and odor problems and other potential water-quality problems that may affect Pueblo Reservoir's many uses have led to a comprehensive water-quality evaluation of Pueblo Reservoir.

OBJECTIVES: Define vertical, areal, and seasonal variations of physical, chemical, and biological characteristics in Pueblo Reservoir. Develop methods to predict reservoir response to various contaminants. Evaluate management alternatives to maximize the reservoir's long-term suitability for various uses.

APPROACH: Collect and evaluate physical, chemical, and biological data on the reservoir inflow, the reservoir, and the reservoir outflow for 3 years. Compile and classify potential contaminants. Calibrate reservoir model to aid in understanding circulation patterns and residence-time stratification. Using information from data-collection effort, the model, and list of potential contaminants, predict reservoir response to various contaminants. Evaluate various management alternatives.

PROGRESS: Physical, chemical, and biological data were collected at several reservoir locations throughout the year. Data indicated that chemical stratification occurred in the reservoir. Compilation of potential contaminants indicated largest contamination potential occurred from acid-mine drainage and from accidental spills from transport by highway and rail. A preliminary draft report was completed.

PLANS FOR FY 87: Data collection will be continued; model calibration will begin; statistical analyses of data will begin. Data evaluation will continue. The preliminary report will be revised and submitted for Director's approval.



PROJECT TITLE: Trends in Water Quality of Monument and Fountain Creeks, El Paso and Pueblo Counties, Colorado

PROJECT NUMBER: CO-85-200

STUDY LOCATION: El Paso and Pueblo Counties, Central Colorado

COOPERATING AGENCY: City of Colorado Springs, Department of Public Utilities

PROJECT CHIEF AND OFFICE: Patrick F. Edelmann, Subdistrict Office, Pueblo

PROJECT DURATION: January 1985 to September 1989

PROBLEM: Development of land and ground water in the Colorado Springs area is likely to cause changes in the water quality of Monument and Fountain Creeks. These changes could cause water quality to become a limiting factor for some stream uses.

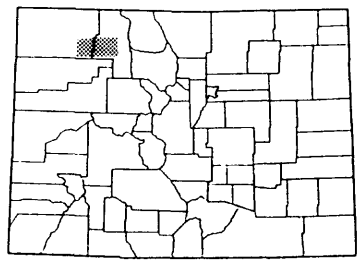
OBJECTIVES: Evaluate spatial changes in water quality of Monument and Fountain Creeks. Determine time trends for selected water-quality constituents, where data permit. Make a preliminary assessment of the effects of ground-water seepage on the water quality of Monument Creek.

APPROACH: Continue water-quality-data collection on Monument and Fountain Creeks. Collect ground-water samples from wells adjacent to Monument Creek. Evaluate surface-water-quality data, using various statistical techniques to test for trends.

PROGRESS: Water-quality samples were collected monthly at four stations on Monument Creek and five stations on Fountain Creek. Samples were analyzed for nutrients, selected major constituents, and trace constituents.

PLANS FOR FY 86: Data collection will be continued at nine surface-water stations; preliminary evaluations of available data will be made.

PROJECT TITLE: Geomorphic Stability of Reclaimed Land Surfaces in the Green River Coal Resource Region



PROJECT NUMBER: CO-85-201

STUDY LOCATION: Northwestern Colorado

COOPERATING AGENCY: Colorado Department of Natural Resources, Division of Mined Land Reclamation

PROJECT CHIEF AND OFFICE: John G. Elliott, District Office, Lakewood

PROJECT DURATION: February 1985 to September 1988

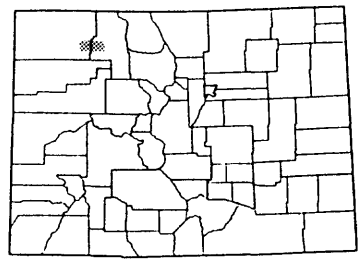
PROBLEM: Recently reclaimed surface-mined areas in the western United States have a large potential for erosion problems. Hillsides and small drainage basins often are regraded to slopes or shapes different from their original configuration, and they undergo severe rilling, gullying, or slumping. Several of the reclaimed mine sites in northwestern Colorado have exhibited these problems. This type of erosion may be from the lack of established vegetation on regraded slopes, or it may be from improper reconstruction of the reclaimed surfaces. Previous studies have examined some of the variables that are critical to slope and channel stability; other studies have attempted to predict general erosion potential and long-term sediment loss. By studying specific sites that exhibit a variety of soil, slope, vegetation, and climatic characteristics, dominant factors that control erosion can be identified; mitigating actions can be outlined by management agencies; and some future problems may be avoided.

OBJECTIVES: Document the type, severity, and location of erosion problems in surface-mined areas of northwestern Colorado, where reclamation has been attempted. Identify the hydrologic and geomorphic processes responsible for erosion problems at these sites. Develop a threshold-type model of slope stability-instability, using data from sites that show no evidence of severe erosion and from sites that are experiencing severe erosion.

APPROACH: Collect geomorphic, hydrologic, and climatic data from 20 to 30 mined and unmined sites in northwestern Colorado. Include these sampled variables: Slope angle and aspect, type and density of vegetation cover, drainage-basin size and shape, soil type, precipitation, size and spacing of gullies or rills, and age of reclamation. Develop regression equations illustrating the relations between dependent variables and "quasi-independent" variables for both disturbed and undisturbed sites. Develop guidelines for future collection and interpretation of data in other areas.

PROGRESS: Fourteen valley-side slopes at five mines were studied intensively. Slope profiles were surveyed, and measurements were made of erosion features, vegetation density, soil characteristics, and infiltration rate. Geomorphic characteristics of several first- and second-order watersheds partially were summarized from aerial photographs and topographic maps. Preliminary analyses indicate rill erosion of valley-side slopes is associated with slope length, slope angle, and vegetation density. Gullying of valley bottoms may be triggered or sustained by subtle topographic irregularities, increased post-mining drainage areas, and deforestation.

PLANS FOR FY 87: The project will be extended for one field season to expand data base and scope of study.



PROJECT TITLE: Impacts of Coal-Mine Development on Ground-Water Resources in the Twentymile Park Area, Northwest Colorado

PROJECT NUMBER: CO-85-203

STUDY LOCATION: Routt County, Colorado

COOPERATING AGENCY: Colorado Department of Natural Resources, Division of Mined Land Reclamation

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

PROJECT DURATION: June 1985 to September 1988

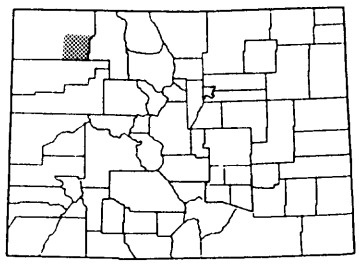
PROBLEM: Existing coal mines and proposed new mines in the area will pump water from the Mesaverde Group to prevent mine flooding. This pumpage, coupled with leaching of soluble minerals from mine tailings into the bedrock or alluvial aquifers, may affect adversely the ground-water resources in the area. Asssessment of probable mining impacts on the water resources is required as part of the mine-permitting procedures followed by the Colorado Division of Mined Land Reclamation. The complex hydrologic system in the basin makes accurate assessment of the mining impacts difficult or impossible, without access to better data and modeling techniques.

OBJECTIVE: Quantitatively define the ground-water flow system in the area and develop a ground-water solute-transport model of the basin capable of simulating mining impacts on the ground-water flow system.

APPROACH: Compile existing hydrologic data from files of State and Federal agencies; check data onsite; update with new onsite data. Map the geological structure of the Twentymile Park basin and subdivide the geologic units into hydrologic units, for purposes of modeling. Construct and use a multilayer ground-water-flow and solute-transport model to simulate impacts of mine pumping and leaching of tailings.

PROGRESS: Project activities began in June 1985. Basic hydrologic data were compiled from files of various State and Federal agencies and from information provided by mining companies. These data and results of field studies were used to compile maps showing geologic structure, thickness, depth, and lateral extent of the principal geohydrologic units in Twentymile Park. Aquifer characteristics were defined from aquifer tests and results of laboratory analyses of cores. A three-layer distributed-parameter model of the steady-state ground-water flow system was constructed and is undergoing calibration.

PLANS FOR FY 87: Information gained from flow modeling will be coupled with existing data and water-chemistry data to help define the parameters of a solute-transport model of the aquifer system. Model construction and calibration will be completed and simulation of mine-impact scenarios will begin. Preparation of the final report will begin.



PROJECT TITLE: Hydrologic Characterization of the Hart Syncline Area, Northwest Colorado

PROJECT NUMBER: CO-85-206

STUDY LOCATION: Northwestern Colorado

COOPERATING AGENCIES: U.S. Bureau of Land Management and Moffat County

PROJECT CHIEF AND OFFICE: William P. Van Liew, Subdistrict Office, Lakewood

PROJECT DURATION: July 1985 to September 1987

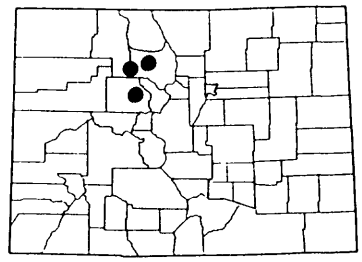
PROBLEM: The U.S. Bureau of Land Management has the responsibility of determining suitability of potential coal-lease tracts for mining. To facilitate the decision-making processes, that include whether or not to lease, type of mining to permit, and amount of control necessary in handling waste discharge and overburden material, the existing ground-water and surface-water systems need to be understood and described in terms of water availability, flow characteristics, and quality.

OBJECTIVE: Describe baseline hydrologic conditions in the Hart Syncline area.

APPROACH: Drill and complete 14 wells and obtain water samples for chemical analysis. Run pumping tests on selected wells. Install continuous recorders on two streams, Waddle Creek and Deep Rock Creek. Take water-quality samples at the streamflow-gaging sites. Interpret new and existing data to: (1) Determine aquifer(s) location, aquifer(s) hydraulic properties, and aquifer(s) water chemistry; and (2) determine surface-water discharge, surface-water chemistry, sediment load, and gaining and losing sections of selected streams.

PROGRESS: Water levels were measured monthly in 26 bedrock wells and 12 alluvial wells. Streamflow was measured monthly at each of two streamflow-gaging stations. Waddle Creek and Deep Rock Gulch were sampled for suspended sediment during high flow. Hydraulic tests of bedrock aquifers were conducted at five sites; hydraulic tests of alluvial aquifers were conducted at seven sites. Fifty water samples were collected from wells, springs, and streams for analysis of chemical constituents. One seepage run was conducted on Waddle Creek; one seepage run was conducted on Deep Rock Gulch. Analysis of data and characterization of predevelopment hydrologic conditions in the area are ongoing.

PLANS FOR FY 87: Water levels in wells will be measured monthly, and streamflow gages will be serviced monthly through calendar year 1986. Data collected during FY85 and FY86 will be compiled and analyzed, and an interpretive report will be written.



PROJECT TITLE: Effects of Proposed Reservoirs on Water Quality in Western Colorado

PROJECT NUMBER: CO-86-211

STUDY LOCATION: Colorado River basin, Western Colorado

COOPERATING AGENCY: Colorado River Water Conservancy District

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

PROJECT DURATION: November 1985 to September 1988

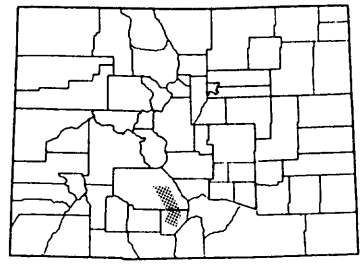
PROBLEM: Impoundment of water in reservoirs can have major effects on the quality of waters stored in and released from the reservoirs. Water-quality changes can result from: (1) Thermal and dissolved-solids stratification; (2) increased nutrient concentration; and (3) sedimentation. In addition, reservoirs can affect downstream channel morphology because of reduced peak streamflow and reduced suspended sediment. Thermal stratification and increased nutrients can cause undesirable algae blooms and depletion of dissolved oxygen in reservoirs. Release of cold water with depleted dissolved oxygen can affect adversely downstream-fishing habitat. Trapping of sediment by reservoirs causes sedimentation in the reservoirs and could accelerate erosion of the downstream channel.

OBJECTIVES: (1) Estimate thermal and dissolved-solids stratification potential in proposed reservoirs and temperature and dissolved-solids concentration of the outflows; (2) estimate dissolved-oxygen depletion potential in proposed reservoirs and dissolved-oxygen concentration of the outflows; (3) estimate effect of proposed reservoirs on sediment load and sedimentation rates; and (4) estimate effects of proposed reservoirs on downstream-channel morphology.

APPROACH: (1) Collect daily discharge, temperature, and specific-conductance data at proposed reservoir sites (Rock and Muddy Creeks) and at inflow and outflow sites at existing reservoirs (Green Mountain and Williams Fork); (2) collect chemical samples at all stream sites for major constituents, nutrients, organic carbon, and biochemical oxygen demand (BOD); measure dissolved oxygen, temperature, specific conductance, and pH; (3) collect total sediment data at proposed sites during first year of study; (4) gather climatological data and reservoir-operation and area-capacity data for proposed and existing reservoirs; (5) measure temperature, dissolved oxygen, specific conductance distribution within existing reservoirs, and collect water-quality samples for analysis of major constituents, nutrients, organic carbon and BOD; (6) calibrate and verify water-quality model for temperature, dissolved oxygen, and specific conductance at existing reservoirs; apply calibrated model to proposed reservoirs; (7) test empirical methods for estimating nutrient concentrations and eutrophication potential of proposed reservoirs; and (8) research methods to estimate qualitative changes in channel morphology downstream of dams; collect necessary data to apply such methods.

PROGRESS: Streamflow and water-quality data were collected at Rock and Muddy Creeks for proposed reservoir sites and from Blue River and Williams Fork for inflow and outflow to Green Mountain and Williams Fork Reservoirs. Total sediment data were collected at Rock and Muddy Creeks. Two vertical profiles and water-quality samples were collected at existing reservoirs. Capacity-area-elevation tables were obtained for all reservoirs. The Flaming Gorge model was loaded on the U.S. Geological Survey PRIME computer system; gathering of input data for this model was started. Preliminary analysis of data showed very small sediment and small nutrient loads in Rock Creek and larger sediment and nutrient loads in Muddy Creek. A phosphorus mass-balance model was tested, and results showed small eutrophication potential at the Rock Creek site and large eutrophication potential at the Muddy Creek site.

PLANS FOR FY 87: For existing reservoirs (Green Mountain and Williams Fork Reservoir) collection of daily flow, temperature, and conductance data at inflow and outflow gages will be continued. Six water-quality samples will be collected at each site. Three sampling runs will be conducted for each reservoir to obtain profile data for temperature, dissolved oxygen, conductance, and pH. Water-quality samples will be collected at inflow and outflow end of reservoirs. Model calibrations will be run using 1986 water year data. Proposed sites (Rock and Muddy Creeks): Another season of daily flow, temperature, and conductance data will be collected. Necessary onsite work downstream of each damsite will be done for channel-geomorphology study. Model simulations for temperature, conductance, and dissolved oxygen will be run. Some empirical methods to predict nutrient concentrations and eutrophication potential will be tested.



PROJECT TITLE: Estimating Water-level Declines Due to Pumping in the Closed Basin Division of the San Luis Valley, South-central Colorado

PROJECT NUMBER: CO-86-212

STUDY LOCATION: San Luis Valley, south-central Colorado

COOPERATING AGENCY: U.S. Bureau of Reclamation

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

PROJECT DURATION: October 1985 to September 1987

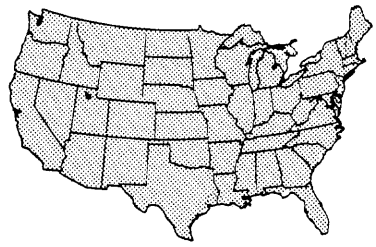
PROBLEM: Drawdown in the water-table aquifer resulting from ground-water withdrawals in the Closed Basin Division of the San Luis Valley Project is limited to a maximum of 2 feet at the project's boundary. Because seasonal and long-term variations in natural recharge and discharge and in irrigation practices also produce water-level changes, differentiating between water-level response to project pumpage and to climatic conditions and irrigation practices will be difficult.

OBJECTIVE: Determine water-level response to project pumpage at the boundary of the Closed Basin Division. Determine water-level response to climate and irrigation practices because water-level measurements record total response to all recharge and discharge.

APPROACH: Analyze water-level data from about 50 wells to define long-term trends and cyclic fluctuations of the water table for the period prior to project pumping, pre-1985. Use equations developed from multiple-linear regression and harmonic analysis (a method for transforming cyclic data) to predict water-level response to climate and irrigation. Assume the difference between observed and predicted water levels (after project pumping begins), if significantly different from regression error, to be water-level response to project pumpage.

PROGRESS: Water-level data were retrieved for all observation wells in the San Luis Valley from WATSTORE and Amdahl and GWSI. Streamflow records, climatological data, and electrical consumption for irrigation data were obtained. Hydrographs for all observation wells were plotted. Analysis for long-term trends was started; preliminary analyses showed a correlation between long-term water-level trends and streamflow and electrical-energy use for irrigation.

PLANS FOR FY 87: Data analysis will be completed. An annotated outline and a draft of a report will be prepared. Report will be reviewed and submitted for approval.



PROJECT TITLE: Applied Hydrology Seminar for PHC's (Probable Hydrologic Consequence) and CHIA's (Cumulative Hydrologic Impact Analysis)

PROJECT NUMBER: CO-86-213

STUDY LOCATION: National coal areas

COOPERATING AGENCY: U.S. Office of Surface Mining Reclamation and Enforcement

PROJECT CHIEF AND OFFICE: Alan W. Burns, District Office, Lakewood

PROJECT DURATION: January 1986 to September 1987

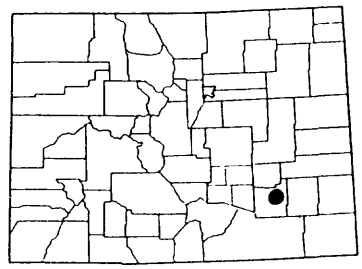
PROBLEM: Due to the diversity of educational and training background, State and Federal reviewers of surface-mining applications may not have extensive enough hydrologic training and background to properly and adequately evaluate mining applications and to prepare cumulative hydrologic-impact analyses.

OBJECTIVE: Provide mine-plan reviewers with training and knowledge to recognize and evaluate the adequacy of hydrologic data; the description of probable hydrologic consequences, based on the interpretation of these data; and the procedures and methods for developing cumulative hydrologic impact analyses.

APPROACH: Develop a training course primarily directed to, but not limited to, permit reviewers and inspectors. Include in topics to be covered in the course material: A background and history of the environmental considerations of PHC's (Probable Hydrologic Consequences) and CHIA's (Cumulative Hydrologic Impact Analyses); the review of probable hydrologic consequences in permit applications; and the preparation, scope, and use of cumulative hydrologic impact analyses.

PROGRESS: A training course was designed for permit reviewers and inspectors for the U.S. Office of Surface Mining (OSM), Reclamation and Enforcement. A preview of the course was presented to OSM.

PLANS FOR FY 87: Ten 3½-day training courses will be presented for the U.S. Office of Surface Mining, Reclamation and Enforcement, at locations throughout the coal regions of the United States.



PROJECT TITLE: Hydrologic Analysis of High-water Table near North La Junta, Colorado

PROJECT NUMBER: CO-86-214

STUDY LOCATION: Arkansas River valley near North La Junta, Colorado

COOPERATING AGENCY: North La Junta Water Conservancy District

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

PROJECT DURATION: January 1986 to December 1987

PROBLEM: The high-water table that has developed in the Arkansas River Valley alluvial aquifer has caused economic loss to local residents because of flooded basements and structural damage to basements. The high-water table probably results from changes in water use, climate, streamflow, and channel geometry, but the relative importance of these factors is not known. The effects of proposed remedial measures to lower the water table need to be evaluated.

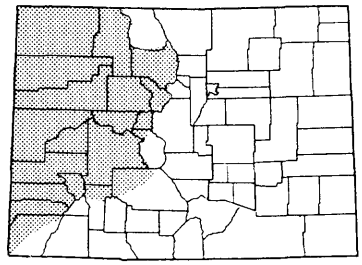
OBJECTIVE: Define and quantify the causes of the high-water table in the North La Junta area: specifically quantify stream-aquifer interaction; determine causes of the high-water table; and evaluate remedial actions to lower the water table.

APPROACH: Evaluate quantitatively the inflow-outflow of the stream-aquifer system. Collect data to define ground-water use, water-level fluctuations, leakage from Fort Lyon Canal, stream-aquifer flux, changes in channel geometry, and surface-water use. Develop a numerical model of transient-flow conditions and use to evaluate remedial actions to lower the water table.

PROGRESS: Water levels in the observation-well network were monitored on a weekly basis. Six observation wells were installed. Well maintenance was performed. Existing data from literature and computer-data bases were compiled. Ground-water site-inventory data base for wells in observation-well network was updated.

PLANS FOR FY 87: Analysis and report will be completed.

PROJECT TITLE: Preliminary Assessment of Water in Bedrock Aquifers Beneath Land Administered by the Bureau of Land Management in western Colorado



PROJECT NUMBER: CO-86-215

STUDY LOCATION: Western Colorado

COOPERATING AGENCY: U.S. Bureau of Land Management

PROJECT CHIEF AND OFFICE: Glenn A. Hearne, District Office, Lakewood

PROJECT DURATION: February 1986 to September 1987

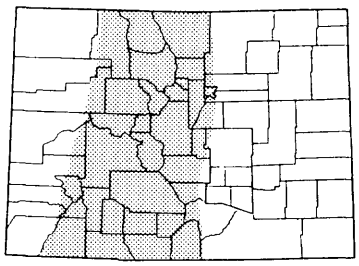
PROBLEM: Recently enacted State legislation has defined the term "nontributary ground water." For most areas, water is considered nontributary if withdrawal of ground water does not capture the flow of a stream at a rate greater than one-tenth of one percent of the annual rate of withdrawal after 100 years. The U.S. Bureau of Land Management needs to know where streamflow capture could be less than 0.1 percent of the annual rate of withdrawal after 100 years and the volume of water in storage under these public lands.

OBJECTIVES: Estimate whether withdrawals from the major aquifers beneath land administered by the U.S. Bureau of Land Management in Colorado will result in streamflow capture greater than or less than 0.1 percent of the rate of withdrawals after 100 years. Quantify the volume of water under lands administered by the U.S. Bureau of Land Management that is estimated to result in streamflow capture of less than 0.1 percent of the rate of withdrawals after 100 years.

APPROACH: Identify those areas and geologic units for which data are not adequate to estimate streamflow capture. Estimate streamflow capture, assuming the simple geometry of a semi-infinite two-dimensional aquifer bounded on one side by a linear stream. For selected regions, use simulation models to project the rate of streamflow capture resulting from the pumping of hypothetical wells for 100 years; using the simulation model results, a 0.1-percent stream-depletion line will be located approximately. Estimate as a product of area and specific yield the volume of water under lands administered by the U.S. Bureau of Land Management, that is estimated to result in streamflow capture of less than 0.1 percent of the rate of withdrawals after 100 years.

PROGRESS: No areas of nontributary ground water were identified, based on an analysis of two-dimensional flow in an infinite half-plane and a confined storage coefficient. Hydraulic-conductivity values needed to produce nontributary ground water were so low, that they were associated with confining beds rather than aquifers.

PLANS FOR FY 87: The preliminary conclusion will be tested for its sensitivity to the assumptions of: (1) An infinite linear stream; and (2) two-dimensional flow. These estimates will be done with analytic or numeric models. A specific case study will be prepared for Piceance basin to estimate the characteristics needed to result in less than 0.1 percent streamflow capture in 100 years.



PROJECT TITLE: Assessing peak streamflow from snowmelt in Colorado

PROJECT NUMBER: CO-86-216

STUDY LOCATION: Selected river basins in mountainous areas in Colorado

COOPERATING AGENCY: Colorado Department of Natural Resources

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

PROJECT DURATION: February 1986 to September 1988

PROBLEM: Cloud seeding to increase mountain snowpack in Colorado is done by commercial operators, and cloud-seeding research is done by government agencies. These programs in Colorado are regulated by the Colorado Department of Natural Resources (DNR), and permits require that seeding be suspended when the water content of the snowpack reaches a given percentage. As more cloud-seeding projects develop and public awareness of these activities increases, understanding the relation between the snowpack and potential flooding downstream becomes more important. Physically based criteria using meteorologic and hydrologic parameters are needed, including a mechanism to translate the water content of the snowpack in the watershed to downstream flood peaks and volumes.

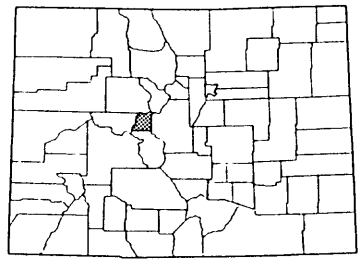
OBJECTIVE: Evaluate the probability distribution of peak streamflows from snowmelt for streams draining mountain watersheds, using a watershed model.

APPROACH: Calibrate and verify PRMS (Precipitation-Runoff Modeling System) on a series of watersheds, and couple the calibrated PRMS model to the ESP (Extended Streamflow Prediction) model to identify the probability of flood discharges for a range of historic and simulated climatic conditions.

PROGRESS: Precipitation-Runoff Modeling System model was calibrated to data from the Animas River at Durango, Colorado. Predicted peak streamflow from snowmelt compared well with measured values for the period 1912 through 1984, although deviations of as much as 3,000 cubic feet per second occurred in individual years. Even with these large outliers, the measured and predicted flood-frequency curves were similar. Use was made of extended streamflow prediction system to predict flood frequency for particular values of the snow pack.

PLANS FOR FY 87: Project suspended due to lack of funds.

PROJECT TITLE: Upper Arkansas Surface-Water Toxics



PROJECT NUMBER: CO-86-217

STUDY LOCATION: Arkansas River near Leadville, Colorado

COOPERATING AGENCY: None--U.S. Geological Survey funds only

PROJECT CHIEF AND OFFICE: Briant A. Kimball, District Office, Lakewood

PROJECT DURATION: February 1986 to September 1989

PROBLEM: Past mining of ore deposits in the Leadville, Colo., area has yielded economic amounts of gold, silver, copper, lead, zinc, iron, and bismuth. Water flowing through abandoned tailings and from 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 occurring within the 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 mechanisms controlling trace-element concentrations in streams in general.

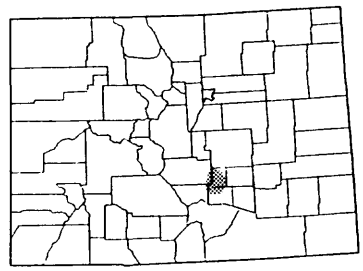
OBJECTIVES: Characterize the within-stream chemical processes that control the transport and distribution of trace elements in streams of the Leadville area. Characterize the chemistry of sediment and sediment coatings that are active in controlling the dissolved concentrations of trace elements. Quantify the time and length scales for chemical and hydrologic processes that affect the metals, and determine the extent to which chemical equilibrium has been attained. Quantify suspended-sediment concentration and particle-size distribution at various stream-flow regimes.

APPROACH: Define the transition from natural conditions to areas affected by acid-mine drainage. Determine concentration, mineralogy, and particle-size distribution of suspended sediment and colloidal material. Use the chemical analyses, combined with x-ray diffraction and scanning electron microscopy, to determine the mineral and organic phases that control heavy-metal concentrations. Test these results by an in-stream transport experiment. Stable-isotope distributions also may prove useful in evaluating diagenetic changes.

PROGRESS: Monthly sampling was conducted since April 1986 at three locations with acid-mine drainage, and at main-stem sites above and below each acid input to the Arkansas River. Twenty-one sites were sampled over a 24-hour period in April 1986, including samples for dissolved constituents, suspended sediment, and bed materials. Discharge was measured for each sample. Samples also were obtained for isotope determinations of both light stable isotopes and heavy metal isotopes. In August 1986, a 48-hour injection experiment was conducted on St. Kevin Gulch. Lithium chloride was injected to obtain discharge measurements and traveltime, and hourly samples were collected for major ions and metals. A significant part of the experiment was to evaluate the diurnal fluctuations of metal concentrations. Concentrations of ferrous iron indicate a large variation in response to changes in light intensity. These data give a better definition of the processes involved in the photoreduction of iron and the metals that are affected by the changes in iron-oxidation state.

PLANS FOR FY 87: Monthly sampling will continue through the year. Additional sampling for next year will include: (1) Sampling of stream cross sections downstream from acid streams; (2) synoptic sampling on California Gulch to observe the variation of metals; and (3) a second synoptic sampling of the 21 sites that were sampled in FY86. A second instream experiment on St. Kevin Gulch will be conducted in the summer of 1988. Laboratory work defining rates of metal sorption on the bed material of St. Kevin Gulch will help prepare for the instream experiment. Sediment cores will be obtained from Pueblo Reservoir to identify metal fluxes from sediments to the reservoir. This sampling will be combined with synoptic sampling downstream from Leadville to the reservoir to observe the changes that occur and to determine the effects of metal loadings downstream.

PROJECT TITLE: Effects of Current and Projected Wastewater Effluents on Fountain and Monument Creeks, Colorado



PROJECT NUMBER: CO-86-218

STUDY LOCATION: Fountain and Monument Creeks, Central Colorado

COOPERATING AGENCY: Pikes Peak Area Council of Governments

PROJECT CHIEF AND OFFICE: Gerhard Kuhn, Subdistrict Office, Pueblo

PROJECT DURATION: April 1986 to December 1988

PROBLEM: Fountain and Monument Creeks receive wastewater effluent from numerous communities and developments. Because of future population growth in the area, wastewater discharges to the creeks are expected to increase, possibly causing violations of State stream water-quality standards and degrading stream classifications. No means currently are available to assess the impact of current and projected wastewater effluents on Fountain and Monument Creeks.

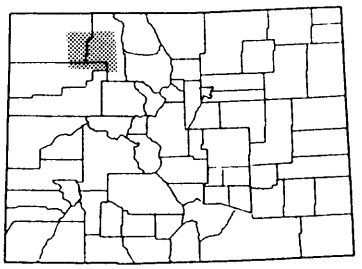
OBJECTIVES: Calibrate and verify a one-dimensional surface water-quality model for Fountain and Monument Creeks for constituents commonly associated with wastewater effluents. Use the calibrated and verified model to simulate projected wastewater-management plans. Estimate concentrations of nonionized ammonia in the creeks.

APPROACH: Collect and evaluate water-quality data for 24-hour periods as near the 7-day, 10-year low flow as possible for seasons of critical water-quality conditions. Conduct traveltime and reaeration studies at two-flow regimes. Use existing methods to estimate concentrations of nonionized ammonia in the streams. Adopt a one-dimensional surface water-quality model to the stream.

PROGRESS: The first 24-hour sampling of reach one (Fountain Creek to Fountain) and reach two (Monument Creek) was completed in July 1986. Some traveltime data were obtained for the two reaches.

PLANS FOR FY 87: Two 24-hour samplings of reach three (Fountain Creek from Colorado Springs to Pueblo) will be completed. The second 24-hour sampling of reaches one and two will be completed. All reaeration and traveltime studies will be completed and analyzed. The model will be calibrated and verified as data analysis and time permit.

PROJECT TITLE: Hydrologic Data Base for Coal Areas in northwestern Colorado



PROJECT NUMBER: CO-86-219

STUDY LOCATION: Northwestern Colorado

COOPERATING AGENCY: U.S. Bureau of Land Management

PROJECT CHIEF AND OFFICE: Neville Gaggiani, Subdistrict Office, Lakewood

PROJECT DURATION: June 1986 to September 1987

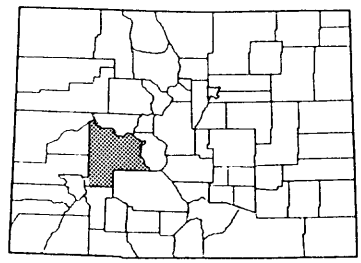
PROBLEM: Since the 1970's, many studies have been conducted by public agencies and private companies in northwestern Colorado that are related directly or indirectly to coal hydrology. These studies have included assessments on the surface water, ground water, and surface- and ground-water quality of the area. Since data from these studies have not been compiled on one automated data-processing system, new studies in the area must consume many months gathering these data from many sources.

OBJECTIVES: Compile and publish a list of sites where non-proprietary surface-water, ground-water, and water-quality data pertaining to the study area are available. Construct data files on the U.S. Geological Survey PRIME computer system that will be available to the public and the private sectors. Establish a maintenance and updating procedure for computer files.

APPROACH: Contact all Federal and private groups involved with the coal-mining industry to determine the availability and acceptability of existing data. The acceptable data will be formatted into tables according to U.S. Geological Survey standards. The data sets will be stored in existing data storage and retrieval systems (WATSTORE). Requested retrievals, if possible, will be in a format compatible with the mainframe that will be used. The type and source of proprietary data will be noted in the report. However, the data will not be recorded nor made available in this data base. Procedures to update the data base on an annual basis will be established. This process will not include the reduction of data but only the output of available data into the data file that includes only specific types of data arranged in a specific format.

PROGRESS: Site-description data from 233 ground-water and 82 surface-water sites in the study area were written on a floppy disk by a State agency, Colorado Mine Land Reclamation Division (CMLRD) and transferred to the U.S. Geological Survey PRIME computer. A Data Base III Plus format was set up for water-quality data to be entered by CMLRD.

PLANS FOR FY 87: Data transfer into the U.S. Geological Survey PRIME computer system will be completed, and a report will be published listing all sites where data are available.



PROJECT TITLE: Sediment Discharge into Paonia Reservoir and Channel Geomorphology of East Muddy and Muddy Creeks, Gunnison County, Colorado

PROJECT NUMBER: CO-86-220

STUDY LOCATION: Gunnison County, west-central Colorado

COOPERATING AGENCY: U.S. Bureau of Reclamation

PROJECT CHIEF AND OFFICE: Cynthia L. Appel, Subdistrict Office, Grand Junction

PROJECT DURATION: June 1986 to September 1988

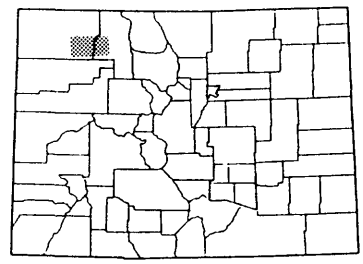
PROBLEM: A debris slide containing about 140 million cubic yards of material has moved about 220 feet westward into East Muddy Creek. The slide severely damaged State Highway 133 (presently being rebuilt). Paonia Reservoir is about 1 mile downstream of the slide; the slide currently (June 1986) is moving 2 to 3 feet per day. The debris slide and resulting highway construction has increased the sediment discharge into Paonia Reservoir. Documentation of the increase in sediment discharge into the reservoir is needed for managers to forecast the long-term effects of the slide and related activities. In addition, projecting changes in channel geometry and location from the slide may aid planners at this site, as well as at other sites, where slides threaten roads or streams in western Colorado.

OBJECTIVES: Determine change in sediment load from mass movement and man's activities controlling the slide. Determine the amount of sediment discharge into Paonia Reservoir and the trap efficiency of the reservoir. Determine any further changes in channel geometry and location of Muddy Creek from the debris slide and related highway construction.

APPROACH: Compile existing data, including channel cross-sections surveyed by the Colorado Geological Survey and the U.S. Bureau of Reclamation, detailed geologic maps (pre- and post-slide movement), and stream-discharge records for streamflow-gaging stations upstream and downstream of Paonia Reservoir. Establish gaging stations upstream of the slide on East Muddy Creek, on West Muddy Creek, and on Muddy Creek above Paonia Reservoir. Collect and analyze bed material, bedload, and suspended-sediment samples, and measure stream discharge twice monthly. Establish and survey four to five channel cross sections between the debris slide and Paonia Reservoir.

PROGRESS: Two temporary streamflow-gaging stations were constructed, one on East Muddy Creek and the other on West Muddy Creek. Stream discharge was measured four times at two stations, six times at one station, and seven times at two stations. Suspended-sediment samples were collected during each visit. A complete size analysis will be done on approximately one-half the sediment samples collected. Bedload-sediment samples will be collected twice at the three gaging stations above Paonia Reservoir. Stage-discharge rating curves have been computed, and the stream-discharge record for water year 1986 is being compiled. On Muddy Creek, just upstream of Paonia Reservoir, three channel cross sections were surveyed by the U.S. Bureau of Reclamation in 1962 and 1969. Initial computations indicate as much as 15 feet of deposition occurred since 1962 at the site closest to the reservoir.

PLANS FOR FY 87: Stream-discharge records will be collected from October 1 to mid-November and from early April through mid-July at the streamflow-gaging stations on East and West Muddy Creeks; the stations will be closed the rest of the calendar year. The State Department of Water Resources will continue to monitor discharge at the stations on Muddy Creek upstream and downstream of Paonia Reservoir. Stream discharge will be measured six times; suspended-sediment samples will be collected at five stations. Pebble counts will be conducted at three stations upstream of Paonia Reservoir. The three-channel cross sections will be resurveyed. Aerial photographs and geologic maps from pre- and post-slide movement will be compared to determine changes in the location and geometry of East Muddy Creek near the debris slide. Results of the sediment analysis will be compiled. Data analysis will be completed, and a draft report will be written.



PROJECT TITLE: Hydrology and Geochemistry of Reclaimed Coal Spoil in Northwestern Colorado

PROJECT NUMBER: CO-86-222

STUDY LOCATION: Northwestern Colorado

COOPERATING AGENCY: U.S. Bureau of Land Management, Colorado Department of Natural Resources, Division of Mined Lands Reclamation; and U.S. Office of Surface Mining Reclamation and Enforcement

PROJECT CHIEF AND OFFICE: Robert S. Williams, Jr., District Office, Lakewood

PROJECT DURATION: January 1987 to September 1990

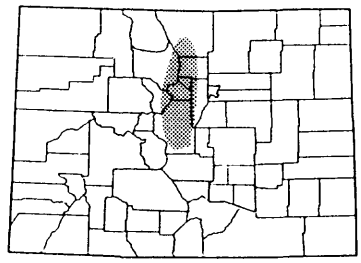
PROBLEM: Regulatory and management agencies determine site suitability for surface coal mining. The agencies need to be able to determine the quantity and quality of water that could flow through and discharge from a coal spoil. The agencies also need to know the duration of any impacts. Quantity, quality, and duration information can assist agencies in regulatory and management decisions.

OBJECTIVES: Describe the processes controlling the hydrology of reclaimed coal spoils. Determine the sources of recharge to and discharge from reclaimed coal spoils. Determine the rate of water movement through reclaimed coal spoils. Determine the geochemistry of a reclaimed coal spoil and the magnitude of change in concentrations of dissolved constituents in coal-spoil discharge.

APPROACH: Use available hydrologic data to conceptualize the hydrology of potential coal-spoil sites. Assess existing precipitation gages, stream gages, wells, and soil-water access tubes installed from previous studies for use in this study. Select and instrument existing coal-spoil sites to determine the water balance for the site. Develop a steady-state ground-water model to simulate the coal-spoil ground-water system. Determine recharge, discharge, and rates of movement of water through coal spoil. Conduct laboratory analysis of spoil material, such as batch-mixing experiments and column studies, to evaluate the magnitude and duration of water-chemistry changes in coal-spoil aquifers.

PROGRESS: Six mine sites were toured for the purposes of determining mine ground-water and surface-water flow systems, locating available instrumentation, and determining mine-operator interest in cooperating in the project. Three or four sites were deemed suitable for the study, and equipment is being purchased for installation.

PLANS FOR FY 87: All equipment will be installed, and ground-water, surface-water, and water-quality monitoring will begin on monthly, quarterly, or annual frequencies, as appropriate.



PROJECT TITLE: Acidification of Lakes along the Colorado Front Range

PROJECT NUMBER: CO-86-223

STUDY LOCATION: Colorado Front Range

COOPERATING AGENCY: Colorado Department of Natural Resources

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

PROJECT DURATION: January 1987 to September 1989

PROBLEM: Estimates of acidification amounts for lakes along the Colorado Front Range are based on unreliable historical data, because of uncertainty in the effect of differences in precipitation, sampling, and analytical procedures during periods of data collection.

OBJECTIVES: Determine acidification amounts for lakes along the Colorado Front Range; validate a model that estimates lake chemistry from watershed characteristics. Test a new model that determines whether a lake watershed is conservative with respect to sulfate to determine whether the model is transferable to other areas.

APPROACH: Determine acidification amounts by using a model based on regional lake-sulfate concentrations. Resample most, or all, of the lakes used in the original comparison; determine all major ions; select a subset of lakes to determine the variance to pH and alkalinity diurnally and seasonally to insure reliability of the statistical significance of the results.

PROGRESS: Project beginning in 1987.

PLANS FOR 1987: Available data for lakes along the Colorado Front Range will be analyzed, a detailed work plan will be prepared, and collection of water-quality samples for selected lakes will be initiated.

AVAILABILITY OF COLORADO DISTRICT REPORTS

Published reports are announced in the U.S. Geological Survey monthly periodical "New Publications of the Geological Survey."

U.S. GEOLOGICAL SURVEY: OPEN-FILE REPORTS--are available only through:

U.S. Geological Survey
Books and Open-File Reports Section
Federal Center
Box 25425
Denver, CO 80225

When ordering, please use the open-file number and full title.

U.S. GEOLOGICAL SURVEY: WATER-RESOURCES INVESTIGATIONS REPORTS--Most are available through Books and Open-File Reports (same address as above). When ordering, please use the Water-Resources Investigations Report number and full title.

U.S. GEOLOGICAL SURVEY: WATER-RESOURCES DATA REPORTS for Colorado and for the 1986 water year--are available only from:

National Technical Information Service
U.S. Department of Commerce
Springfield, VA 22161

When ordering, please use the NTIS number.

Selected Water-Resources Investigations reports are available only from the National Technical Information Service (same address as above) When ordering, please use the NTIS number.

U.S. GEOLOGICAL SURVEY: PROFESSIONAL PAPERS, BULLETINS, WATER-SUPPLY PAPERS, TECHNIQUES OF WATER-RESOURCES INVESTIGATIONS, CIRCULARS--are available from:

U.S. Geological Survey
Books and Open-File Reports Section
Federal Center
Box 25425
Denver, CO 80225

U.S. GEOLOGICAL SURVEY: WATER-RESOURCES INVESTIGATIONS OPEN-FILE REPORTS are listed in the U.S. Geological Survey monthly periodical "New Publications of the Geological Survey" in section Reports Available Only Through Certain Geological Survey Field Offices, and are available only from:

District Chief
U.S. Geological Survey
Water Resources Division,
Colorado District
Room H-2104, Bldg. 53
Telephone: (303) 236-4882

Mailing Address:

U.S. Geological Survey
P.O. Box 25046, Mail Stop 415
Denver Federal Center
Denver, Colorado 80225

U.S. GEOLOGICAL SURVEY: MAPS--may be purchased by mail at:

Distribution Branch
U.S. Geological Survey
P.O. Box 25286, Denver Federal Center
Denver, Colorado 80225

or over the counter at:

Public Inquiries Office
U.S. Geological Survey
Room 169, Federal Building
1961 Stout Street
Denver, Colorado 80202
Telephone: (303) 844-4169

Distribution Branch
U.S. Geological Survey
Building 810, Entrance E7
Denver Federal Center
Denver, Colorado 80225
Telephone: (303) 236-7477

REPORTS PUBLISHED OR RELEASED DURING FISCAL YEAR 1987

Water-Resources Data Reports

[Reports available from U.S. Geological Survey, Books and Open-File Reports Section, Box 25425, Denver Federal Center, Denver, CO 80225, except as indicated]

1. Britton, L.J., and Gaggiani, N.G., 1986, Water-quality data for Arvada Reservoir, Denver metropolitan area, Colorado: U.S. Geological Survey Open-File Report 86-489, 200 p.
2. Reed, R.L., 1987, Water-level records for the northern High Plains of Colorado, 1970-86: U.S. Geological Survey Open-File Report 87-26, 314 p.
3. Stewart, J.M., compiler, 1986, Summary of water-resources activities of the U.S. Geological Survey in Colorado--Fiscal Year 1986: U.S. Geological Survey Open-File Report 86-70, 70 p.
4. U.S. Geological Survey, 1987, Water resources data for Colorado--Water year 1986, Volume 1, Missouri River basin, Arkansas River basin, Rio Grande basin: U.S. Geological Survey Water-Data Report CO 86-1; available only from the U.S. Department of Commerce, National Technical Information Service, Springfield, VA 22161 (in press).
5. _____1987, Water resources data for Colorado--Water year 1986, Volume 2, Colorado River basin: U.S. Geological Survey Water-Data Report CO 86-2; available only from U.S. Department of Commerce, National Technical Information Service, Springfield, VA 22161 (in press).

Water-Resources Interpretive Reports

1. Banta, E.R., 1986, Example evaluation of a permit application for a proposed hazardous-waste landfill in eastern Adams County, Colorado: U.S. Geological Survey Water-Resources Investigations Report 86-4131, 17 p.
2. Britton, L.J., Anderson, C.L., Goolsby, D.A., and Van Haveren, B.P., in press, Summary of the U.S. Geological Survey and U.S. Bureau of Land Management National coal-hydrology program, 1974-84: U.S. Geological Survey Professional Paper 1464.
3. Britton, L.J., and Gaggiani, N.G., in press, Water-quality assessment of Arvada Reservoir, Denver metropolitan area, Colorado: U.S. Geological Survey Water-Resources Investigations Report 87-4107.
4. Brooks, Tom, 1986, Geohydrology and potential hydrologic effects of underground coal mining in the Rapid Creek basin, Mesa County, Colorado: U.S. Geological Survey Water-Resources Investigations Report 86-4172, 28 p.
5. Butler, D.L., 1986, General surface- and ground-water qualities in a coal-resource area near Durango, southwestern Colorado: U.S. Geological Survey Water-Resources Investigations Report 86-4073, 53 p.
6. _____in press, Sediment discharge in Rock Creek and the effect of sedimentation rate on the proposed Rock Creek Reservoir, northwestern Colorado: U.S. Geological Survey Water-Resources Investigations Report 87-4026, 23 p.
7. Cain, Doug, in press, Relations of specific conductance to streamflow and selected characteristics of the Arkansas River basin, Colorado: U.S. Geological Survey Water-Resources Investigations Report 87-4041.
8. Cain, Doug, and Edelmann, Patrick, 1986, A reconnaissance water-quality appraisal of the Fountain Creek alluvial aquifer between Colorado Springs and Pueblo, Colorado, including trace elements and organic constituents: U.S. Geological Survey Water-Resources Investigations Report 86-4085, 45 p.
9. Campbell, D.H., and Turk, J.T., in press, Influence of sulfur-dioxide emissions on stream chemistry in the western United States: Water Resources Research.
10. Chaney, J.H., Hren, Janet, Childress, C.J.O., Norris, J.M., and Meyers, D.M., in press, Water-quality data-collection activities in Colorado and Ohio, 1984, *in* American Water Resources Association Symposium, Syracuse, N.Y., May 17-20, 1987, Proceedings: Bethesda, Md., American Water Resources Association.
11. Driver, N.E., and Lystrom D.J., 1986, Estimation of urban storm-runoff loads, *in* Engineering Foundation Conference on Urban Runoff Quality--Impact and Quality Enhancement Technology, Henniker, N.H., June 23-27, 1986, Proceedings: New York, American Society of Civil Engineers, p. 122-132.
12. _____in press, Estimation of urban storm-runoff loads and volumes in the United States, *in* International Conference on Urban Storm Drainage, 4th, Lausanne, Switzerland, August 31-September 4, 1987, Proceedings: Lausanne, Switzerland, International Association for Hydraulic Research and International Association on Water Pollution Research and Control.
13. Driver, N.E., and Williams, R.S., Jr., 1986, Hydrogeology of and potential mining impacts on strippable lignite areas in the Denver aquifer, east-central Colorado: U.S. Geological Survey Water-Resources Investigations Report 84-4366, 39 p.

14. Elliott, J.G., 1986, Determination of annual sediment load from the Yampa River, Dinosaur National Monument, Colorado: Conference on Science in the National Parks, Fort Collins, Colo., July 13-18, 1986, Proceedings: Hancock, Mich., George Wright Society (in press).
15. Elliott, J.G., and DeFeyter, K.L., 1986, Sediment-data sources and estimated annual suspended-sediment loads of rivers and streams in Colorado: U.S. Geological Survey Water-Resources Investigations Report 86-4344 (in press).
16. Hearne, G.A., and Dewey, J.D., in press, Hydrologic analysis of the Rio Grande basin above Embudo, New Mexico: U.S. Geological Survey Water-Resources Investigations Report 86-4113, 244 p.
17. Hearne, G.A., Lindner-Lunsford, Jaye, Cain, Doug, Watts, K.R., Tobin, R.L. Teller, R.W., Schneider, P.A., Jr, and Gearhart, M.J., in press, Colorado ground-water quality, *in* National Water Summary 1986: U.S. Geological Survey Water-Supply Paper 2325.
18. Hearne, G.A., and Litke, D.W., 1987, Ground-water flow and quality near Canon City, Colorado: U.S. Geological Survey Water-Resources Investigations Report 87-4014, 72 p.
19. Jarrett, R.D., 1987a, Closure on hydraulics of high-gradient streams: American Society of Civil Engineers Journal of Hydraulic Engineering, July 1987, v. 113, no. 7, p. 927-929.
20. _____1987b, Hydrologic research related to the 1976 Big Thompson River flood, Colorado, *in* Big Thompson Symposium, "What Have We Learned Since the Big Thompson Flood, July 1986," Boulder, Colo., 1986, Proceedings: Boulder, University of Colorado Natural Hazards Information Center Special Publication (in press).
21. Jarrett, R.D., and Costa, J.E., in press, Evaluation of the flood hydrology in the Colorado Front Range using precipitation, streamflow, and paleoflood data for the Big Thompson River basin: U.S. Geological Survey Water-Resources Investigations Report 87-4117.
22. Jarrett, R.D., and Malde, H.E., 1987, Paleodischarge of the late Pleistocene Bonneville flood, Snake River, Idaho, computed from new evidence: Geological Survey of America Bulletin (in press).
23. Kimball., B.A., in press, 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 1986: U.S. Geological Survey Water-Supply Paper 2340.
24. Kuhn, Gerhard, in press, Methods to determine transit losses for return flows of transmountain water in Fountain Creek between Colorado Springs and the Arkansas River, Colorado: U.S. Geological Survey Water-Resources Investigations Report 87-4119.
25. Liebermann, T.D., Middelburg, R.F., and Irvine, S.A., in press, User's manual for estimation of dissolved-solids concentrations and loads in surface water: A computerized method using data from WATSTORE--National water data storage and retrieval system of the U.S. Geological Survey: U.S. Geological Survey Water-Resources Investigations Report 86-4124.
26. Lindner-Lunsford, J.B., and Ellis, S.R., in press, Comparison of conceptually based and regression rainfall-runoff models, Denver, Metropolitan area, Colorado, and potential applications in urban areas: U.S. Geological Survey Water-Resources Investigations Report 87-4104.

27. Livingston, R.K., and Minges, D.R., in press, Techniques for estimating regional flood characteristics of small rural watersheds in the plains region of eastern Colorado: U.S. Geological Survey Water-Resources Investigations Report 87-4094.
28. Mueller, D.K., and Osen, L.L., in press, Estimation of natural dissolved-solids discharge in the Upper Colorado River Basin, western United States: U.S. Geological Survey Water-Resources Investigations Report 87-4069.
29. Mustard, M.H., Driver, N.E., Chyr, John, and Hansen, B.G., in press, U.S. Geological Survey urban-stormwater data base of constituent storm loads; characteristics of rainfall, runoff, and antecedent conditions; and basin characteristics: U.S. Geological Survey Water-Resources Investigations Report 87-4036.
30. Norris, J.M., in press, Surface water-quality characteristics in the upper North Fork Gunnison River basin, Colorado: U.S. Geological Survey Water-Resources Investigations Report 86-4152, 53 p.
31. _____in press, Application of the Precipitation-Runoff Modeling System to small basins in the Parachute Creek basin, Colorado: U.S. Geological Survey Water-Resources Investigations Report 86-4115, 38 p.
32. Parker, R.S., and Litke, D.W., in press, Calibration of a dissolved-solids model for the Yampa River basin between Steamboat Springs and Maybell, northwestern Colorado: U.S. Geological Survey Water-Resources Investigations Report 86-4190, 47 p.
33. Ruddy, B.C., in press, Sediment discharge in Muddy Creek, and the effect of sedimentation rate on the proposed Wolford Mountain Reservoir near Kremmling, Colorado: U.S. Geological Survey Water-Resources Investigations Report 87-4011.
34. Teller, R.W., and Chafin, D.T., 1986, Selected drill-stem test data for the Upper Colorado River Basin: U.S. Geological Survey Water-Resources Investigations Report 84-4146, 112 p.
35. Trieste, D.J., and Jarrett, R.D., in press, Roughness coefficients of large floods, *in* American Society of Civil Engineers Irrigation and Drainage Specialty Conference, Portland, 1987, Proceedings.
36. Turk, J.T., 1987, Use of regional lake-sulfate concentrations in the evaluation of watershed processes in high-elevation parts of the western United States, *in* Congress of the Societas Internationalis Limnologiae, XXIII, Hamilton, New Zealand, February 8-14, 1987, Proceedings: Stuttgart, West Germany, E. Schweizerbart'Sche, Verlag Sbuchhandlung, v. 23 (in press).
37. Turk, J.T., and Campbell, D.H., 1987a, Smelter sulfur-dioxide emissions and atmospheric deposition of sulfate: (Director approved for release).
38. _____1987b, Estimates of acidification of lakes in the Mt. Zirkel Wilderness Area, Colorado: Water Resources Research (in press).
39. Weiss, Emanuel, 1987, Boundary integral-equation-method modeling of a regional aquifer using geostatistics, *in* National Water Well Association Conference on Solving Ground Water Problems With Models, Denver, Colo., February 10-12, 1987, Proceedings: Dublin, Ohio, National Water Well Association (in press).
40. Williams, R.S., Jr., and Hammond, S.E., in press, Soil-water hydrology and geochemistry of coal spoil at a reclaimed surface mine in Routt County, Colorado: U.S. Geological Survey Water-Resources Investigations Report 86-4350.

DEPOSITORIES

Reports are available for examination at the following U.S. Geological Survey depositories:

Colorado District Office, Water Resources Division, Room H-2101, Building 53 (mailing address: Box 25046, Mail Stop 415), Denver Federal Center, Denver, CO 80225.

Public Inquiries Office, Room 169 Federal Building, 1961 Stout Street, Denver, CO 80202.

Library, Denver West Office Park, Building 3, 1526 Cole Boulevard at West Colfax Avenue, Golden, Colo. (mailing address: Box 25046, Mail Stop 914, Denver Federal Center, Denver CO 80225).

Library, Room 4A100, 950 National Center, 12201 Sunrise Valley Drive, Reston, VA 22092.

Library, 345 Middlefield Road, (mailing address: Mail Stop 55, Building 5), Menlo Park, CA 94025.

U.S. Department of the Interior, National Resources Library, Gifts and Exchange Section, 18th and C Streets NW, Washington, DC 20240.

PROJECTS COMPLETED EXCEPT FOR REPORTS DURING
FISCAL YEAR 1987

Project number	*Project title*	*Project Chief*
CO-113	Hydrology of Proposed Coal-Mining Areas, Moffat, Rio Blanco, and Routt Counties	Randolph S. Parker
CO-117	Monitoring of the Hydrologic System in North Park, Jackson County, Colorado	Gerhard Kuhn
CO-179	Analysis of the Sediment-Data Network in Colorado	John G. Elliott
CO-202	Modeled Impacts of Surface Coal Mining on Dissolved Solids in the Yampa River Basin, Northwest Colorado	George W. Linn

☆ U.S. GOVERNMENT PRINTING OFFICE: 1987—776-490/65,006 REGION NO. 8