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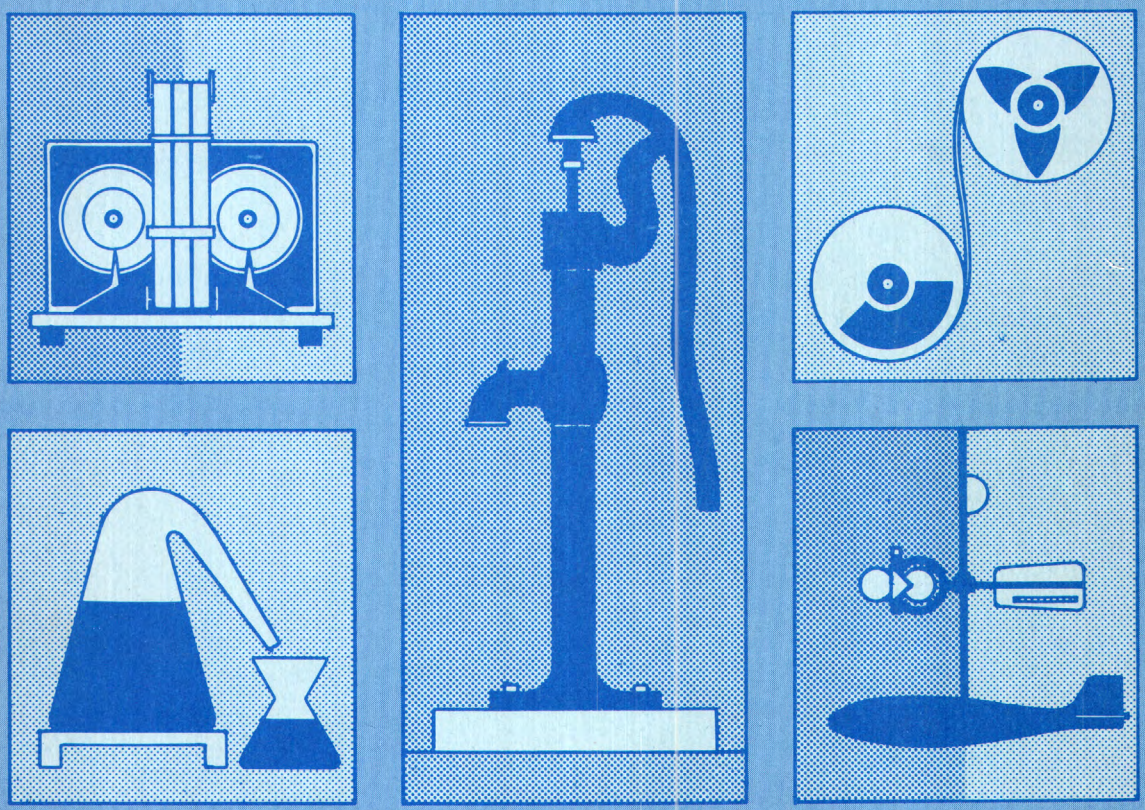
WATER-RESOURCES INVESTIGATIONS OF THE U.S. GEOLOGICAL SURVEY IN COLORADO--Fiscal Year 1977



U.S. Geological Survey
Open-File Report 77-532

WATER-RESOURCES INVESTIGATIONS OF THE U.S. GEOLOGICAL SURVEY IN COLORADO--Fiscal Year 1977

Compiled by D. E. Hillier and J. B. Weeks

U.S. GEOLOGICAL SURVEY

Open-File Report 77-532

Lakewood, Colorado

June 1977

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WATER-RESOURCES INVESTIGATIONS OF THE U.S. GEOLOGICAL SURVEY IN COLORADO--Fiscal Year 1977

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INTRODUCTION

Water-resources investigations 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 1977 fiscal year (October 1, 1976, to September 30, 1977).

The U.S. Geological Survey's investigations of the water-resources of Colorado are under the direction of James E. Biesecker, District Chief. The Colorado District office is located in Building 53, Denver Federal Center, Lakewood, Colo. (fig. 1). The Colorado District has four subdistrict offices located in Grand Junction, Lakewood, Meeker, and Pueblo (fig. 1). Requests for information should be addressed as follows:

J. E. Biesecker, District Chief
U.S. Geological Survey
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Box 25046, Mail Stop 415
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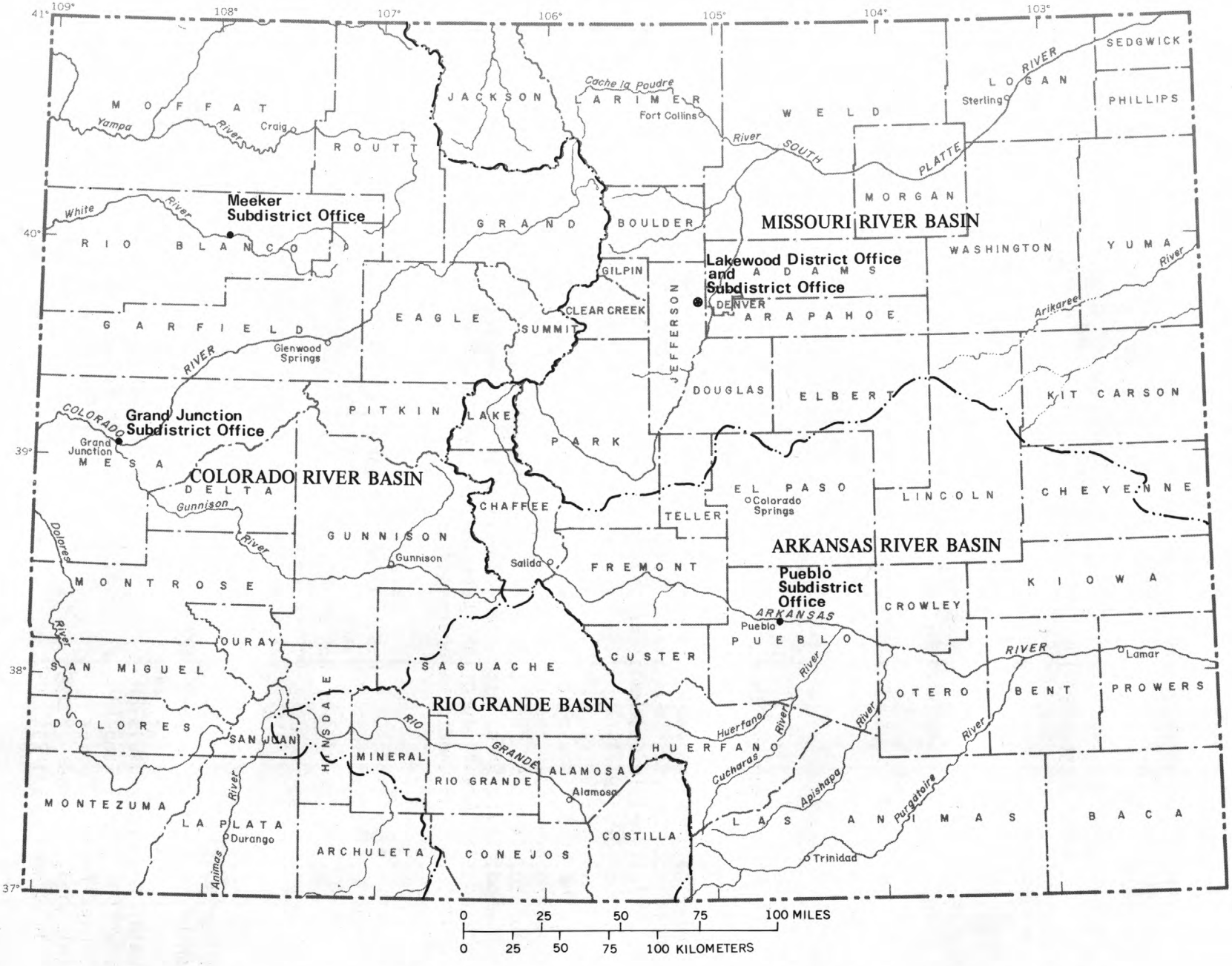

Figure 1.--Location of major river basins and offices of the U.S. Geological Survey's Colorado District.

D. L. Collins, Subdistrict Chief
U.S. Geological Survey
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P. O. Box 2027
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V. W. Norman, Subdistrict Chief
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Water Resources Division
P. O. Box 810
Meeker, Colorado 81641
Telephone: 303-878-5086

R. E. Fidler, Subdistrict Chief
U.S. Geological Survey
Water Resources Division
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COOPERATING AGENCIES

In Colorado, the collecting of some of the water-resources data and the conducting of some of the interpretive hydrologic investigations are accomplished in cooperation with Federal, State, and local agencies. Those agencies cooperating with the U.S. Geological Survey during fiscal year 1977 are:

Arkansas River Compact Administration
Boulder City and County Health Department
City of Aspen
City of Aurora
City of Colorado Springs, Office of the City Manager and
  Department of Public Utilities
City and County of Denver, Board of Water Commissioners
City of Fort Collins
City of Glenwood Springs
Colorado City Water and Sanitation District
Colorado Department of Health
Colorado Department of Highways
Colorado Department of Natural Resources
  Division of Water Resources,
    Office of the State Engineer
  Colorado Water Conservation Board
  Colorado Geological Survey
Colorado River Water Conservation District
Colorado West Council of Governments
Denver Regional Council of Governments
Eagle County Commissioners
El Paso County Board of Commissioners
El Paso County Water Association
Jackson County
Jefferson County Health Department
Metropolitan Denver Sewage Disposal District No. 1
North West Colorado Council of Governments
Pikes Peak Area Council of Governments
Pitkin County Board of County Commissioners

Pueblo Area Council of Governments
Rio Grande Water Conservation District
Routt County Department of Environmental Health
Southeastern Colorado Water Conservancy District
Southwestern Water Conservation District
St. Vrain and Left Hand Creek Water Conservancy District
University of Colorado
Urban Drainage and Flood Control District
U.S. Air Force Academy
U.S. Department of the Army
    Corps of Engineers
    Rocky Mountain Arsenal
    Waterways Experiment Station
U.S. Department of the Navy
U.S. Department of Housing and Urban Development,
  Federal Insurance Administration
U.S. Department of the Interior
    Bureau of Indian Affairs
    Bureau of Land Management
    Bureau of Mines
    Bureau of Reclamation
    Fish and Wildlife Service
U.S. Department of Transportation, Federal Highway Administration
U.S. Environmental Protection Agency
U.S. General Services Administration

COLLECTION OF WATER-RESOURCES DATA

Hydrologic-data stations are maintained at selected locations throughout Colorado to 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. Every year stations are added and others are terminated; thus, the U.S. Geological Survey has both a current and a historical file of hydrologic data. All data collected are stored in the U.S. Geological Survey's National Water Data Storage and Retrieval System (WATSTØRE) 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 or graphs, statistical analyses, and digital plots. Local assistance in the acquisition of services or products from WATSTØRE can be obtained from the District Chief, Lakewood, Colo.

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. Discharge and stage data currently are being obtained at the number of long-term stations given below.

Station classification		*Number of stations*
Stream stations		526
Continuous record	443	
Partial record	83	
Lake and reservoir stations		24
Total		550

The number and type of stations located in each county are shown on plate 1 and in table 1 (p. 8, 9).

Water-quality data are obtained at 111 of the long-term surface-water stations listed above and also at 15 other long-term surface-water-quality sites where discharge and stage are not measured routinely (pl. 1 and table 1). These stations are used to monitor the quality of surface water in Colorado. Some of these stations also are part of a U.S. Geological Survey nationwide network known as the National Stream Quality Accounting Network (NASQAN), which is used to detect nationwide trends in water quality. The types of data determined at these stations are given below. Inasmuch as several types of data may be determined at a particular station and not all types of data are determined at each station, the numbers given below will not equal the total number of stations given earlier.

Data classification			*Number of stations*
Physical data			126
Water temperature		126	
Daily	61		
Monthly	53		
Quarterly	9		
Intermittently	3		
Specific conductance		124	
Daily	57		
Monthly	55		
Quarterly	9		
Intermittently	3		
pH		124	
Daily	5		
Monthly	95		
Quarterly	21		
Intermittently	3		
Suspended-sediment data			68
Daily		35	
Monthly		33	
Chemical data (inorganic constituents)			122
Monthly		96	
Quarterly		21	
Semiannually		2	
Intermittently		3	
Chemical data (pesticides)			11
Quarterly		3	
Semiannually		2	
Annually		6	
Radiochemical data			8
Quarterly		5	
Semiannually		1	
Annually		2	
Bacteriological data			19
Monthly		17	
Quarterly		2	
Biological data			18
Monthly		15	
Quarterly		3	

In addition to the water-quality data collected at the long-term stations, a variety of water-quality data also are collected at numerous sites during the course of many interpretive hydrologic studies. These data are available from the files of the U.S. Geological Survey.

Ground-Water Data

Water levels in wells are a key parameter for monitoring ground-water trends; however, they must be integrated with other observations and ground-water investigations in order to have the fullest meaning and usefulness. A network of 49 observation wells (pl. 1) is maintained in Colorado by the U.S. Geological Survey. In addition, a network of about 1,050 observation wells is maintained in Colorado in cooperation with the Colorado Department of Natural Resources, Division of Water Resources, Office of the State Engineer, for monitoring fluctuations in water levels. Other wells known as "project wells" are used for specific (generally short-term) investigations and, although they are not part of the observation-well networks, data obtained from them also are available. The numbers of wells currently being measured are given below.

Frequency of measurement	*Number of wells*
Monthly	27
Bimonthly	52
Quarterly	21
Annually	2,352
Intermittently	1,866
Total	4,218

The numbers of wells located in each county are shown in table 1 (p. 8, 9).

Water-quality data are not collected routinely from wells in the statewide networks. However, a variety of water-quality data are collected at numerous wells during the course of many interpretive hydrologic investigations, which may include water-quality data from some statewide observation wells. These data are available from the files of the U.S. Geological Survey.

INTERPRETIVE HYDROLOGIC INVESTIGATIONS

Forty-three interpretive hydrologic investigations are being conducted during fiscal year 1977. These include 6 statewide investigations, 6 regional investigations, 11 investigations in the Missouri River basin, 5 investigations in the Arkansas River basin, 2 investigations in the Rio Grande basin, and 13 investigations in the Colorado River basin. The summaries of each of the investigations that follow consist of a map showing the location of the area of the investigation and a brief description of the investigation's purpose, objective, approach, progress, and plans.

Table 1.--*Water-resources data-collection stations operated during fiscal year 1977, by county*

County	Surface-water stations				Ground-water stations
	Continuous record	Partial record	Lake and reservoir	Water quality	Wells
Adams---------	3	8	0	1	98
Alamosa-------	1	0	0	0	69
Arapahoe------	3	5	0	3	80
Archuleta-----	7	0	0	0	9
Baca----------	0	2	0	0	172
Bent----------	3	0	1	1	127
Boulder-------	5	5	0	5	1
Chaffee-------	8	0	0	0	7
Cheyenne------	0	1	0	0	57
Clear Creek---	1	0	0	0	0
Conejos-------	10	0	1	1	25
Costilla------	6	0	0	0	42
Crowley-------	0	0	0	0	37
Custer--------	3	3	0	0	43
Delta---------	15	0	0	1	3
Denver--------	2	4	0	0	4
Dolores-------	2	0	0	0	1
Douglas-------	2	0	1	0	16
Eagle---------	29	1	0	5	9
Elbert--------	0	2	0	0	23
El Paso-------	9	0	0	0	185
Fremont-------	5	1	0	2	8
Garfield------	19	0	0	11	14
Gilpin--------	0	0	0	0	0
Grand---------	26	0	4	1	14
Gunnison------	9	0	2	0	27
Hinsdale------	6	0	0	0	2
Huerfano------	2	1	0	0	5
Jackson-------	9	0	0	5	3
Jefferson-----	9	9	1	5	55
Kiowa---------	0	0	0	0	20
Kit Carson----	0	1	0	0	343

Table 1.--*Water-resources data-collection stations operated during fiscal year 1977, by county*--Continued

County	Surface-water stations				Ground-water stations
	Continuous record	Partial record	Lake and reservoir	Water quality	Wells
Lake----------	4	0	1	1	3
La Plata------	12	0	1	1	8
Larimer-------	17	0	2	7	93
Las Animas----	7	8	2	0	0
Lincoln-------	0	2	0	0	15
Logan---------	0	3	0	0	268
Mesa----------	32	4	1	21	7
Mineral-------	5	0	0	0	0
Moffat--------	10	3	0	9	26
Montezuma-----	6	1	0	1	9
Montrose------	7	1	1	2	13
Morgan--------	3	1	0	2	322
Otero---------	6	0	0	0	176
Ouray---------	2	0	0	0	4
Park----------	4	0	1	0	0
Phillips------	0	0	0	0	98
Pitkin--------	30	0	1	0	7
Prowers-------	3	3	0	0	301
Pueblo--------	7	2	1	0	191
Rio Blanco----	37	1	0	29	60
Rio Grande----	4	0	0	0	37
Routt---------	10	0	0	5	15
Saguache------	7	0	0	0	40
San Juan------	1	0	0	0	0
San Miguel----	9	2	0	0	5
Sedgwick------	1	1	0	1	109
Summit--------	19	0	2	1	6
Teller--------	0	0	0	0	0
Washington----	0	1	0	0	101
Weld----------	5	4	0	5	431
Yuma----------	1	3	1	0	374
Totals---	443	83	24	126	4,218

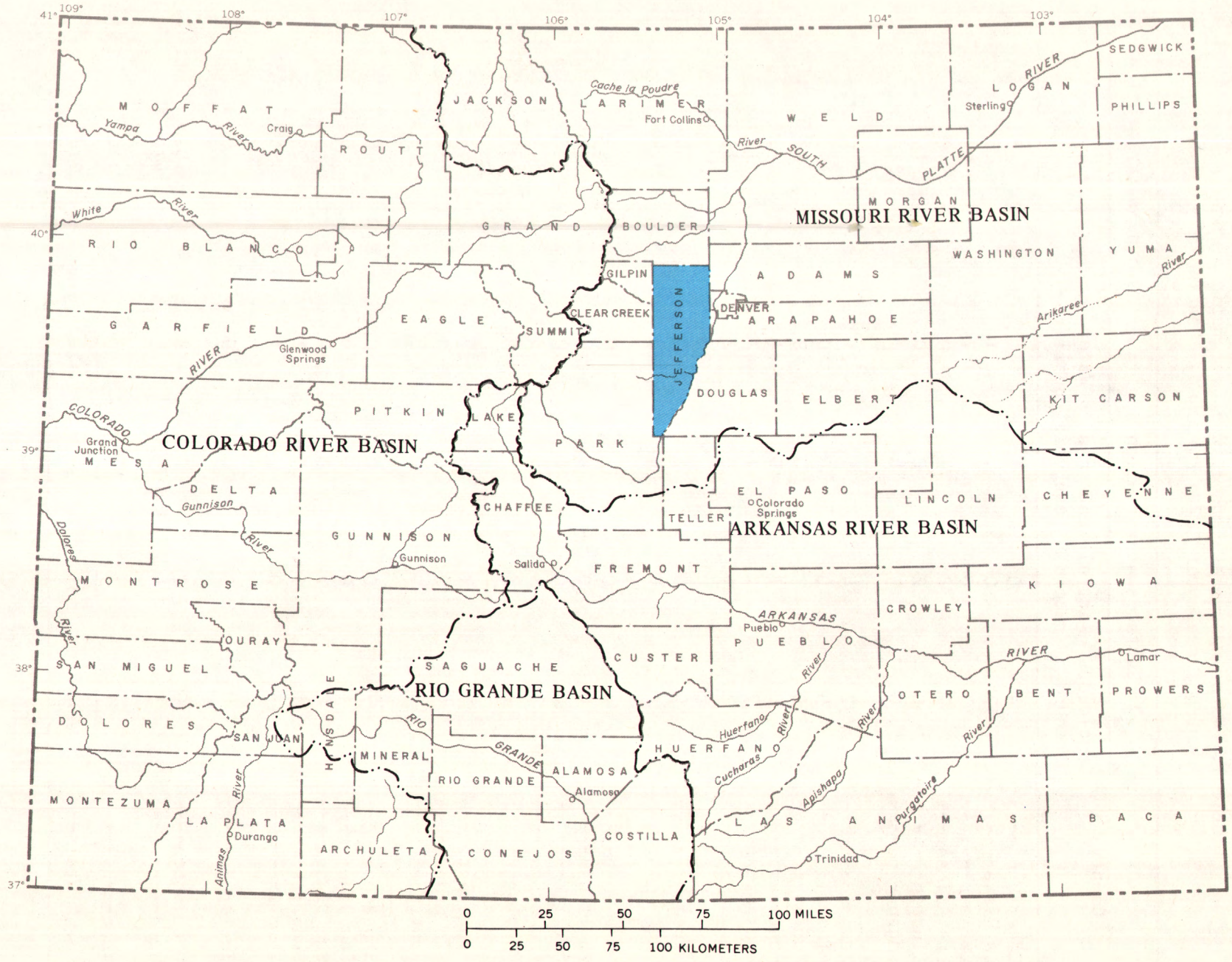

Figure 2.--Location of Jefferson County.

PROJECT TITLE: Special Flood Insurance Studies (fig. 2)

COOPERATING AGENCY: U.S. Department of Housing and Urban Development, Federal Insurance Administration

PROJECT CHIEF: Rulon C. Christensen, District Office, Lakewood

PERIOD OF PROJECT: January 1973 to September 1978

Problem.--The National Flood Insurance Act of 1968 directs the U.S. Department of Housing and Urban Development to operate a flood-insurance program through the Federal Insurance Administration. Flood studies are needed in selected areas to determine applicable flood-insurance premium rates.

Objective.--Develop hydrologic and hydraulic data for actual and hypothetical floods with 10-, 50-, 100-, and 500-year recurrence intervals. Provide the data to the Federal Insurance Administration for their use in operating the flood-insurance program.

Approach.--Compute magnitudes and profiles of floods using ground surveys, photogrammetric techniques, and computer models. Delineate areas that would be inundated on planimetric maps.

Progress.--Report for Palmer Lake area in El Paso County completed and transmitted to the Federal Insurance Administration. Contracts for aerial photography and analysis and for ground surveys awarded to private firms. Contractors will complete field-data collection in an unincorporated area of Jefferson County and begin the collection of field data in the Golden and Morrison areas of Jefferson County. Hydrologic and hydraulic computations have been made for 149 stream miles and flood-prone-area maps have been completed in preliminary form for 200 stream miles in the unincorporated area of Jefferson County.

Plans.--Complete the study of the unincorporated area of Jefferson County and prepare a final report. Complete hydrologic and hydraulic computations for streams in the Golden and Morrison areas.

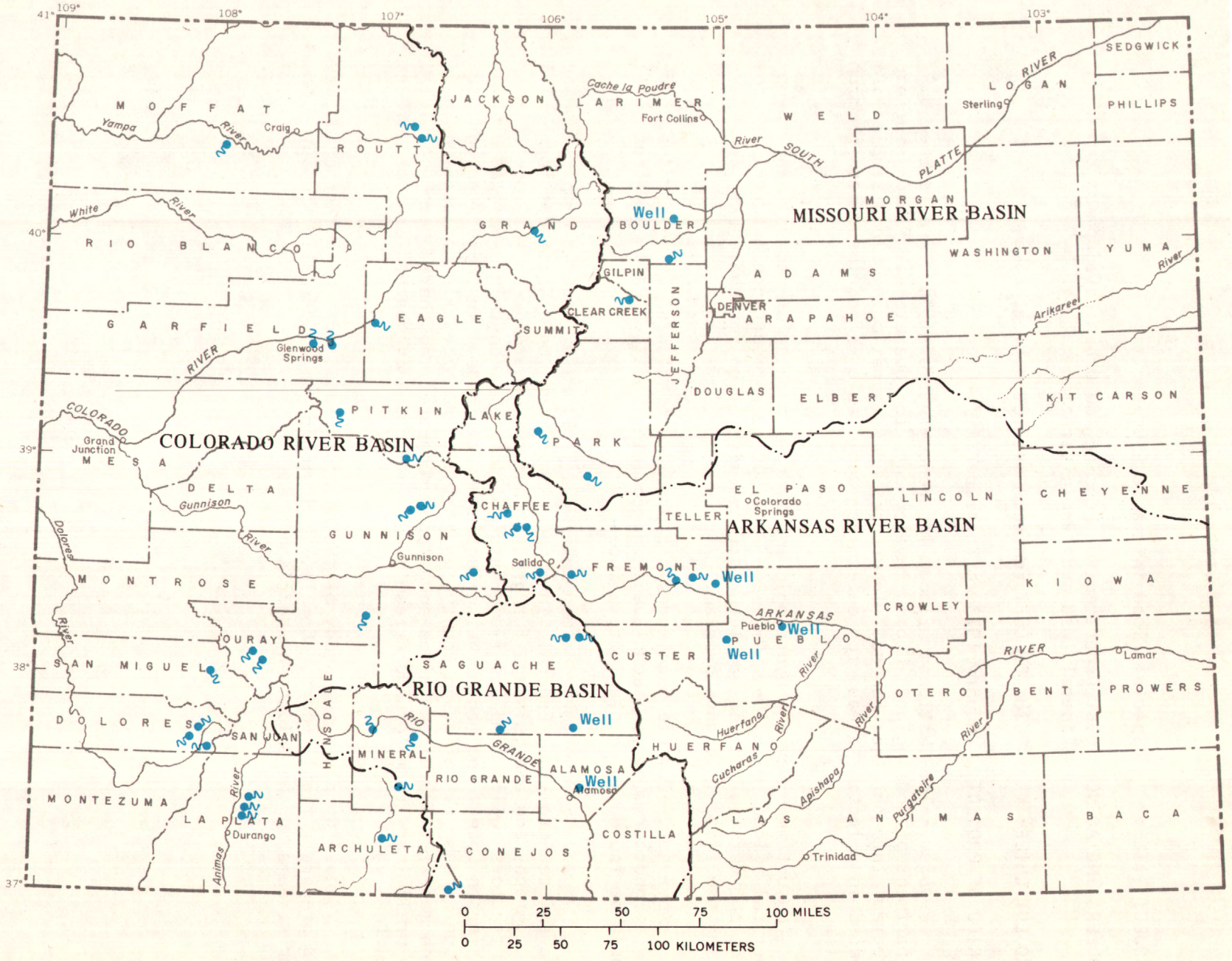

Figure 3.--Location of geothermal springs and wells.

PROJECT TITLE: Chemical Analyses of Thermal Waters, Modeling of Geothermal Systems, and Coordination of Grants for Geothermal Research in Colorado (fig. 3)

COOPERATING AGENCY: None

PROJECT CHIEF: Robert E. Moran, District Office, Lakewood

PERIOD OF PROJECT: July 1974 to September 1979

Problem.--Geothermal resources in Colorado are evidenced by the presence of approximately 50 thermal springs and wells located principally in the western two-thirds of the State. The amount of energy that can be developed from the geothermal sources is unknown. Data are not available to determine the magnitude of the resource, to assess the possibilities for development, or to evaluate the impact and legal ramifications of development on nonthermal waters. An understanding of the hydrologic system in the geothermal areas is needed for the administration of water laws in the State.

Objectives.--Collect and analyze water samples from all known thermal springs and wells. Determine the hydrologic systems associated with the geothermal areas. Use the data collected to develop and calibrate geothermal computer models of the hydrologic systems that can be used to predict the effects of development. Provide expertise and training to the staffs of the agencies awarded grants to collect field data and determine the hydrologic systems.

Approach.--Award grants to collect field data and determine the hydrologic systems of the geothermal areas. Analyze water samples for common constituents in laboratories of the U.S. Geological Survey. Analyze water samples for carbon, hydrogen, and oxygen isotopes in a private laboratory on a contract basis. Develop and calibrate geothermal computer models.

Progress.--Grants have been awarded to the Colorado Department of Natural Resources, Division of Water Resources, Office of the State Engineer, and to the Colorado Geological Survey. All routine water-quality sampling has been completed. Collection of samples for determination of isotopes is continuing. All geophysical field work has been completed. Geologic mapping is continuing. Data analysis has been started.

Plans.--Complete all water-quality sampling and geologic mapping. Coordinate interpretation of data and completion of final reports by grantees. Develop and calibrate geothermal computer model for an area in the upper Arkansas River basin.

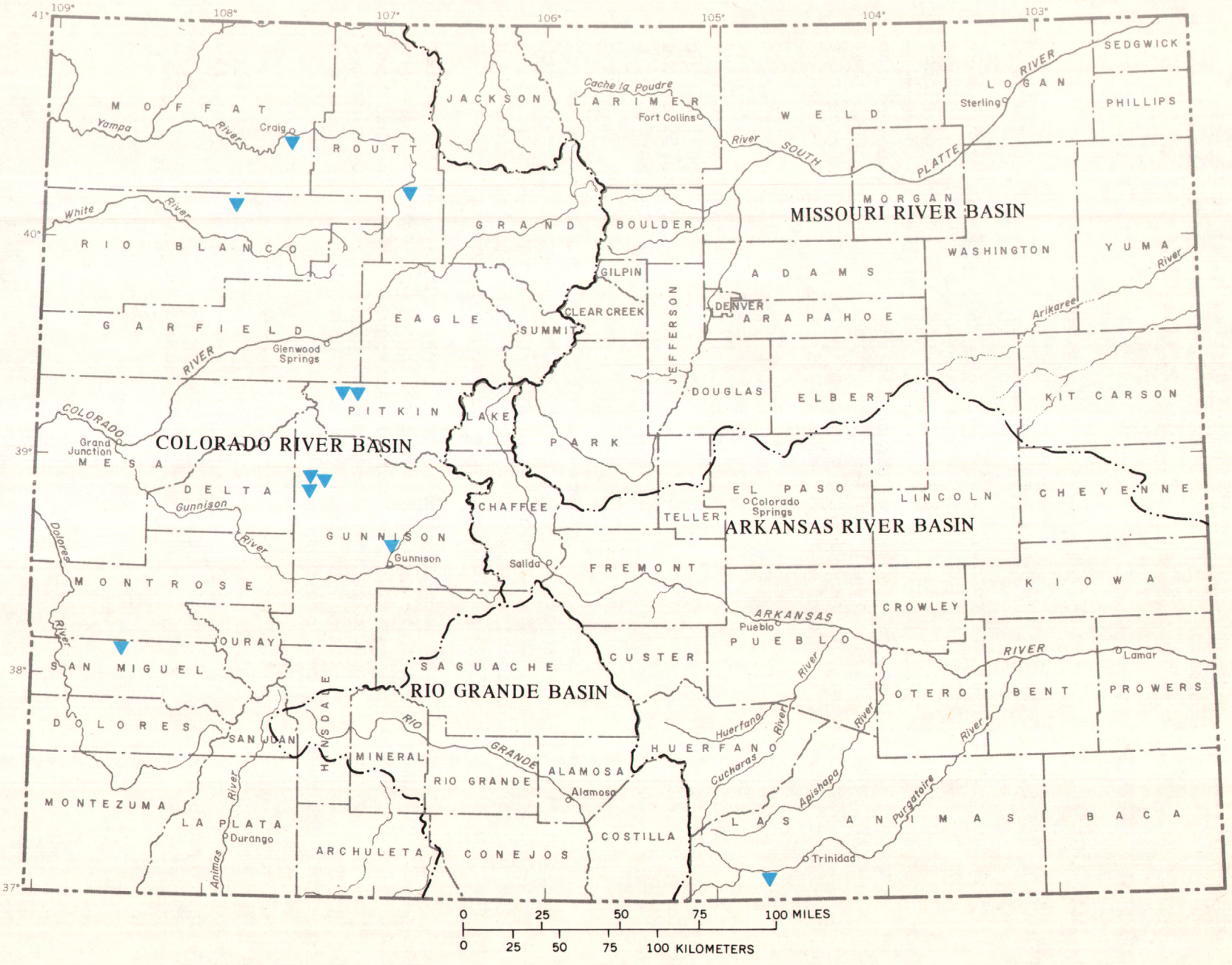

Figure 4.--Location of underground coal mines.

PROJECT TITLE: Quality of Water in Underground Coal Mines (fig. 4)

COOPERATING AGENCY: U.S. Environmental Protection Agency

PROJECT CHIEF: Robert E. Moran, District Office, Lakewood

PERIOD OF PROJECT: April 1976 to March 1978

Problem.--Underground coal mining is increasing in Colorado in response to the Nation's effort to develop additional energy sources. State and local officials need to know the quality of water that would be discharged or that is being discharged to the land surface from underground coal mines so that the effects of the discharged water on existing surface- and ground-water quality can be determined.

Objectives.--Determine the quality of water stored in, or discharged from, underground coal mines. Determine the volume of water being discharged.

Approach.--Collect samples for determination of physical properties and chemical constituents. Physical properties to be determined include pH, water temperature, specific conductance, and dissolved oxygen. Chemical constituents to be determined include major ions, organic carbon, nutrients, radium-226, aluminum, antimony, arsenic, boron, cadmium, chromium, copper, lead, lithium, mercury, molybdenum, selenium, vanadium, and zinc. Determine the volume of water flowing from the mines using current-meter or volumetric techniques. Determine, by calculation from company records or by indirect-determination techniques, the volume of water being pumped from the mines.

Progress.--Water-quality samples from 11 mines have been collected and analyzed.

Plans.--Continue data-collection activities.

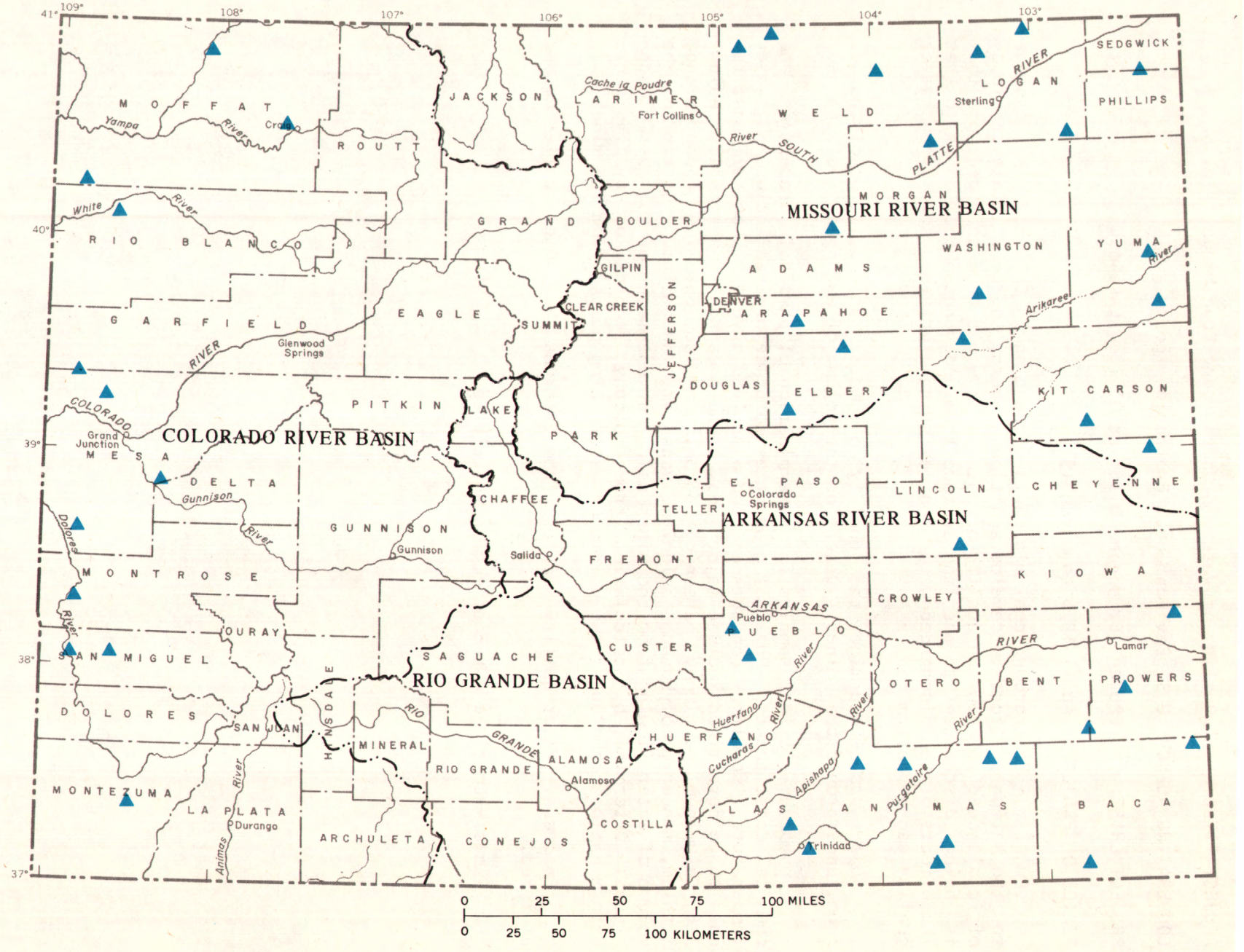

Figure 5.--Location of rainfall–runoff stations in small watersheds crossed by State highways.

PROJECT TITLE: Peak Discharge and Frequency of Floods in Small Watersheds (fig. 5)

COOPERATING AGENCY: Colorado Department of Highways

PROJECT CHIEF: Russell K. Livingston, Subdistrict Office, Lakewood

PERIOD OF PROJECT: Continuous since July 1968

Problem.--Flood characteristics of small watersheds in Colorado are poorly defined. Existing techniques for estimating the magnitude and frequency of floods are applicable only to large drainage areas. Data are lacking for small watersheds, and estimates made from existing data are likely to be substantially in error.

Objective.--Collect data and develop techniques for estimating the magnitude and frequency of floods in small watersheds with emphasis on those watersheds crossed by State highways where data will be economically significant in the design of bridges and culverts. Develop a computer model to predict rainfall-runoff relations that can be modified for each watershed based on the hydrologic and physical characteristics of the individual watersheds.

Approach.--Collect data from 47 rainfall-runoff recorder installations located throughout the State. Incorporate data collected from long-term stream-gaging stations located in small watersheds in Colorado, data collected from the National Weather Service's rain-gage network in Colorado and adjacent States, and data collected for related studies currently in progress.

Progress.--Rainfall-runoff data are being collected and analyzed. Computer model developed and calibrated for selected watersheds where sufficient data are available.

Plans.--Continue to calibrate computer model for watersheds as data become available. Continue data collection. Prepare reports summarizing data collected during successive 3-year periods.

Reports published or released during fiscal year 1976.--See reference 3 under Water-Resources Data Reports at back of report.

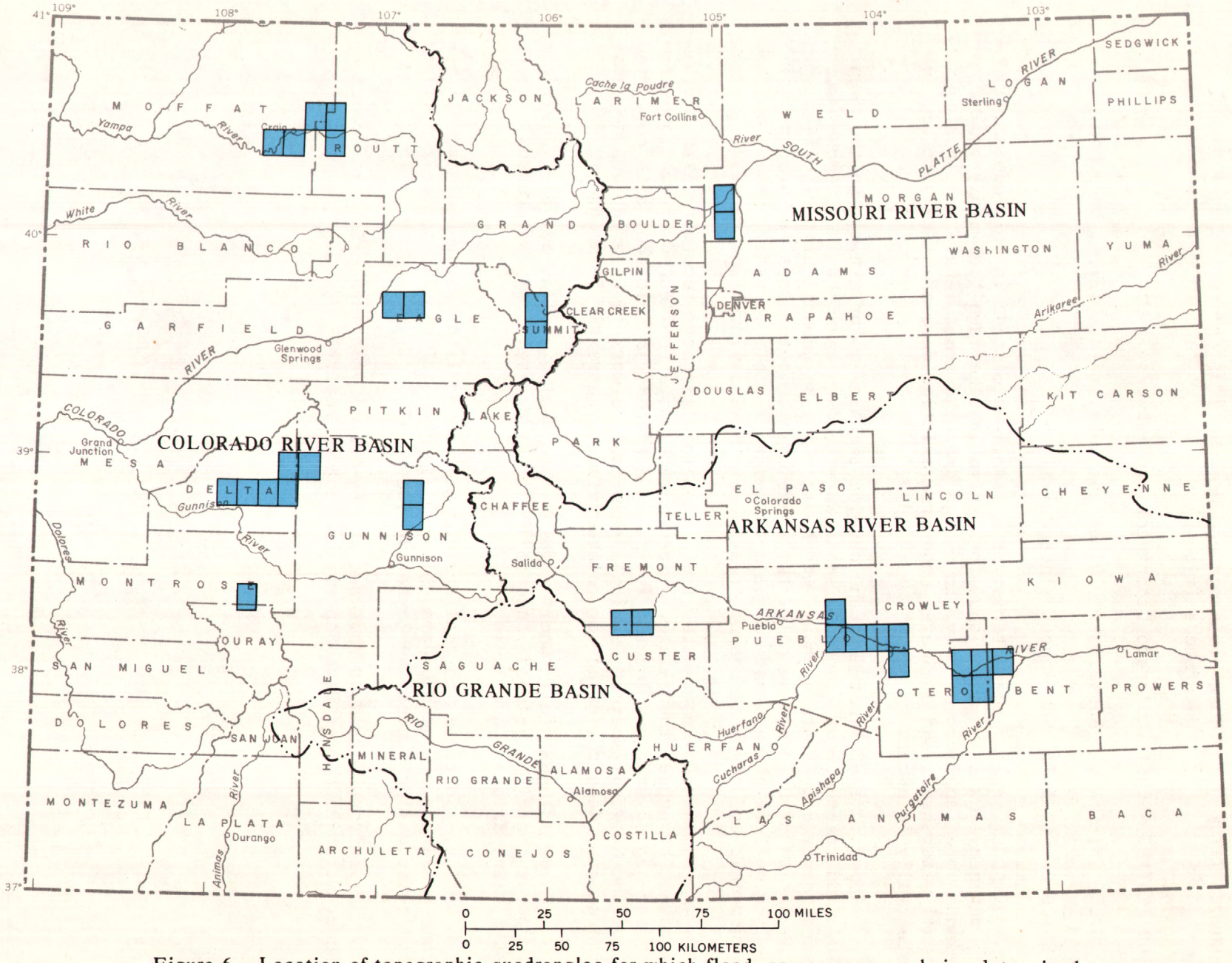

Figure 6.--Location of topographic quadrangles for which flood-prone areas are being determined.

PROJECT TITLE: Flood-Hazard Mapping (fig. 6)

COOPERATING AGENCY: None

PROJECT CHIEF: Jerald F. McCain, District Office, Lakewood

PERIOD OF PROJECT: Continuous since February 1973

Problem.--U.S. House of Representatives Document 465 outlines a national program to provide flood-hazard information. The U.S. Geological Survey has been assigned the responsibility to outline on Geological Survey topographic maps those flood-prone areas that would be inundated by a flood with a 100-year recurrence interval, using information on the maps and data from existing flood-frequency studies.

Objective.--Delineate on topographic maps the extent of areas that would be inundated by a flood with a 100-year recurrence interval in and adjacent to communities and cities having populations greater than 2,500.

Approach.--Use data from existing flood-frequency studies. Use relations between flood depth, discharge, frequency of occurrence, and drainage area to define flood profiles and flood boundaries (100-year recurrence interval) along streams for which data from historical floods may or may not exist. Use regional flood-depth frequency relations where they can be defined.

Progress.--One hundred fifty-five maps have been completed prior to fiscal year 1976. Thirty-three maps are in various stages of completion.

Plans.-Complete and release the 33 maps presently being compiled.

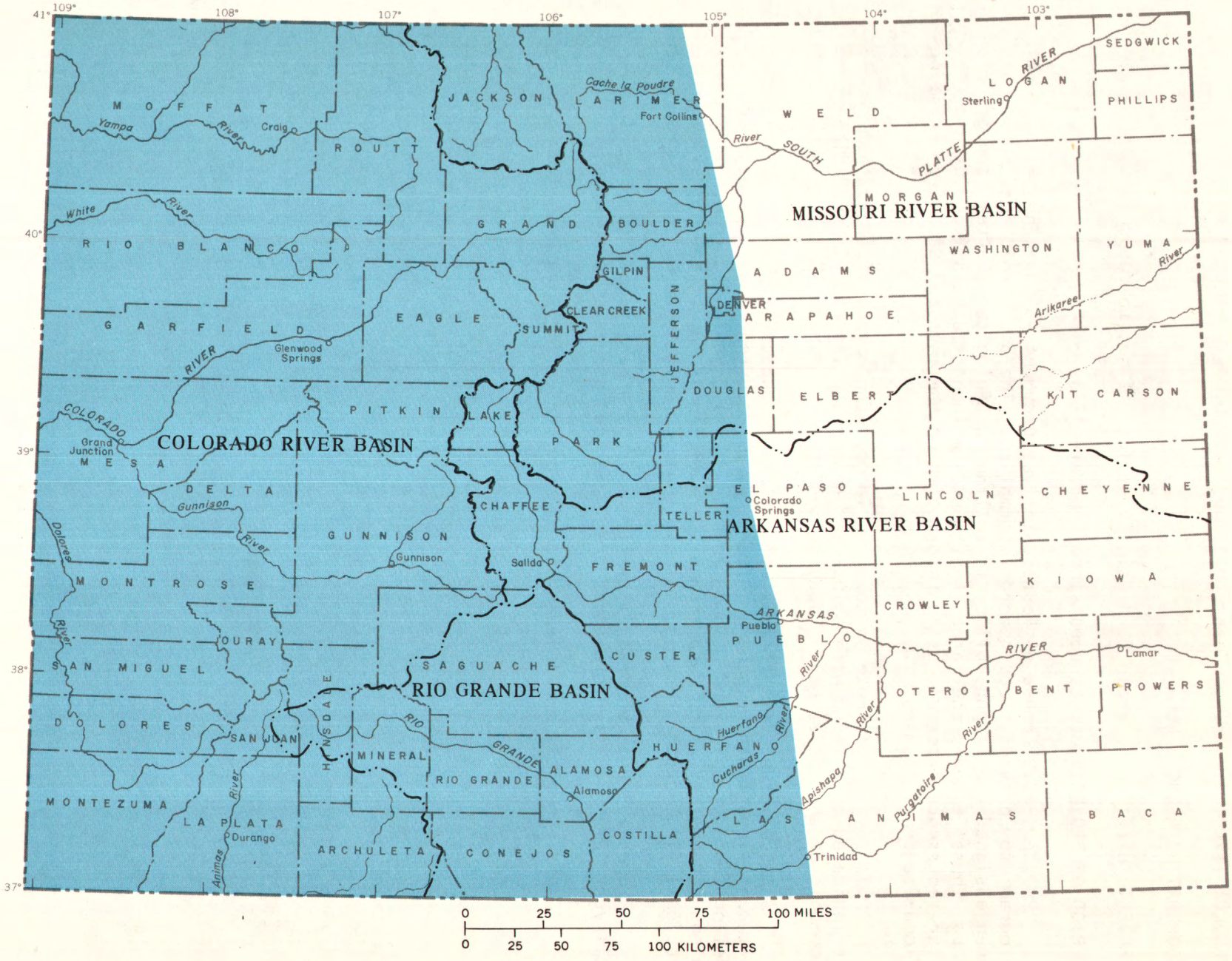

Figure 7.--Area for which flood hydrology of foothill streams is being determined.

PROJECT TITLE: Flood Hydrology of Foothill Streams in Colorado--Planning Phase (fig. 7)

COOPERATING AGENCY: Colorado Department of Natural Resources, Colorado Water Conservation Board

PROJECT CHIEF: Jerald F. McCain, District Office, Lakewood

PERIOD OF PROJECT: July 1976 to September 1978

Problem.--More than three-fourths of Colorado's total population is concentrated along or near foothill sections at the base of high mountains. Streams along the foothills receive flooding from both snowmelt and rainfall, but by far the most destructive type of flood results from "cloudburst-type" rainfall associated with severe thunderstorms during summer months. Because of the mixed-population characteristics of floods in foothill areas, standard techniques for flood-frequency analysis are inadequate for defining flood characteristics for the streams. Additionally, insufficient hydrologic data exist for foothill streams to allow an adequate analysis of flood frequency.

Objectives.--Develop a comprehensive plan for establishing a hydrologic-data-collection network in foothill areas of Colorado and for conducting research in analysis of data for mixed-population flood areas. The plan will be coordinated with Federal, State, and local agencies engaged in flood studies in Colorado and a cooperative investigation will be started in fiscal year 1978.

Approach.--Evaluate existing streamflow and precipitation gaging stations and design a network of hydrologic-data stations to provide the required information. Conduct field reconnaissance to locate suitable sites for establishing project stations. Develop plans for research studies of statistical techniques of processing mixed-population flood records and for studying geomorphic characteristics of foothill streams.

Progress.--Potential cooperating agencies have been contacted and plans are being formulated to begin activity on data collection and research in fiscal year 1978. Existing gaging stations and flood records are being evaluated and a network design is underway.

Plans.--Complete network design and plans for research activities. Coordinate final plans with cooperating agencies.

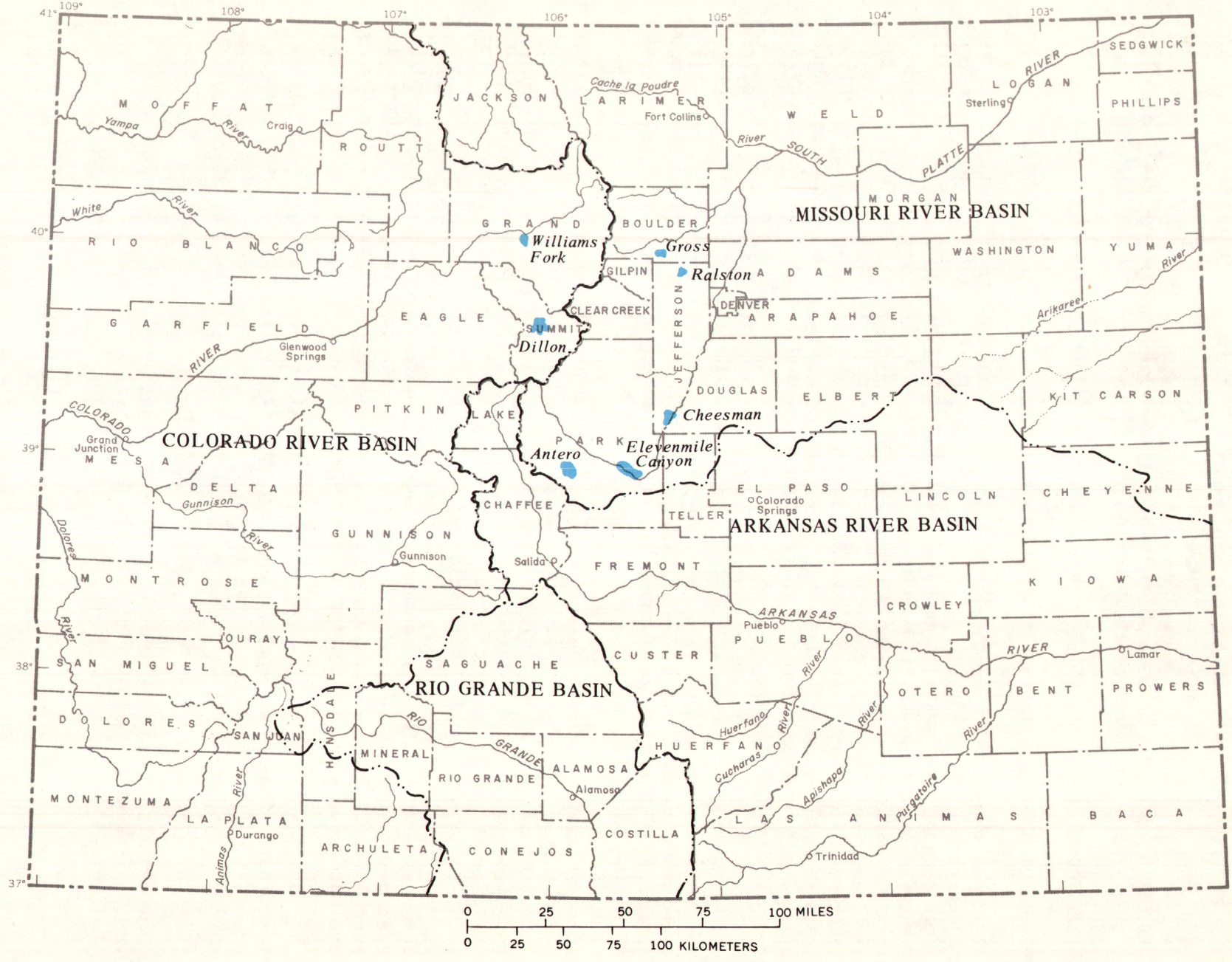

Figure 8.--Location of water-supply reservoirs.

PROJECT TITLE: Determination of Evaporation and Thermal Regime of Selected Reservoirs and Lakes (fig. 8)

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

PROJECT CHIEF: D. Briane Adams, Subdistrict Office, Grand Junction

PERIOD OF PROJECT: May 1972 to May 1979

Problem.--The Denver Board of Water Commissioners operates one of the Nation's most complex water-collection, storage, and distribution systems. Water is stored in seven reservoirs on both sides of the Continental Divide for eventual use in the Denver metropolitan area. As part of its water-right appropriation, the Board of Water Commissioners is required to account for water loss by evaporation from the reservoirs. The Board of Water Commissioners needs to know the volume of water being evaporated and if there are methods to reduce the amount of evaporation.

Objectives.--Determine total annual evaporation and seasonal and annual variations in evaporation from each reservoir. Determine the effects of altitude, wind shelter, and reservoir operation on evaporation. Study methods for improving relation between pan and reservoir evaporation. Develop computer models of the water-temperature variations of selected reservoirs to show whether changes in reservoir operation might produce more desirable water-temperature variations or reduce evaporation.

Approach.--Review all existing data. Install and operate mass-transfer and pan-evaporation equipment at all reservoirs. Conduct energy-budget analyses at all reservoirs.

Progress.--Annual volumes of water being evaporated have been determined for all reservoirs using mass-transfer and pan-evaporation techniques. Energy-budget analyses are completed for Dillon, Elevenmile Canyon, and Gross Reservoirs. A progress report has been published summarizing data collected and interpretations from 1967 through 1973. Energy-budget analyses have been started for Ralston Reservoir and Cheesman Lake.

Plans.--Complete energy-budget analysis at Ralston Reservoir. Initiate energy-budget analysis at either Antero or Williams Fork Reservoirs. Continue energy-budget analysis at Cheesman Lake. Continue mass-transfer analyses at all reservoirs.

Reports published or released during fiscal year 1976.--See reference 1 under Water-Resources Interpretive Reports at back of report.

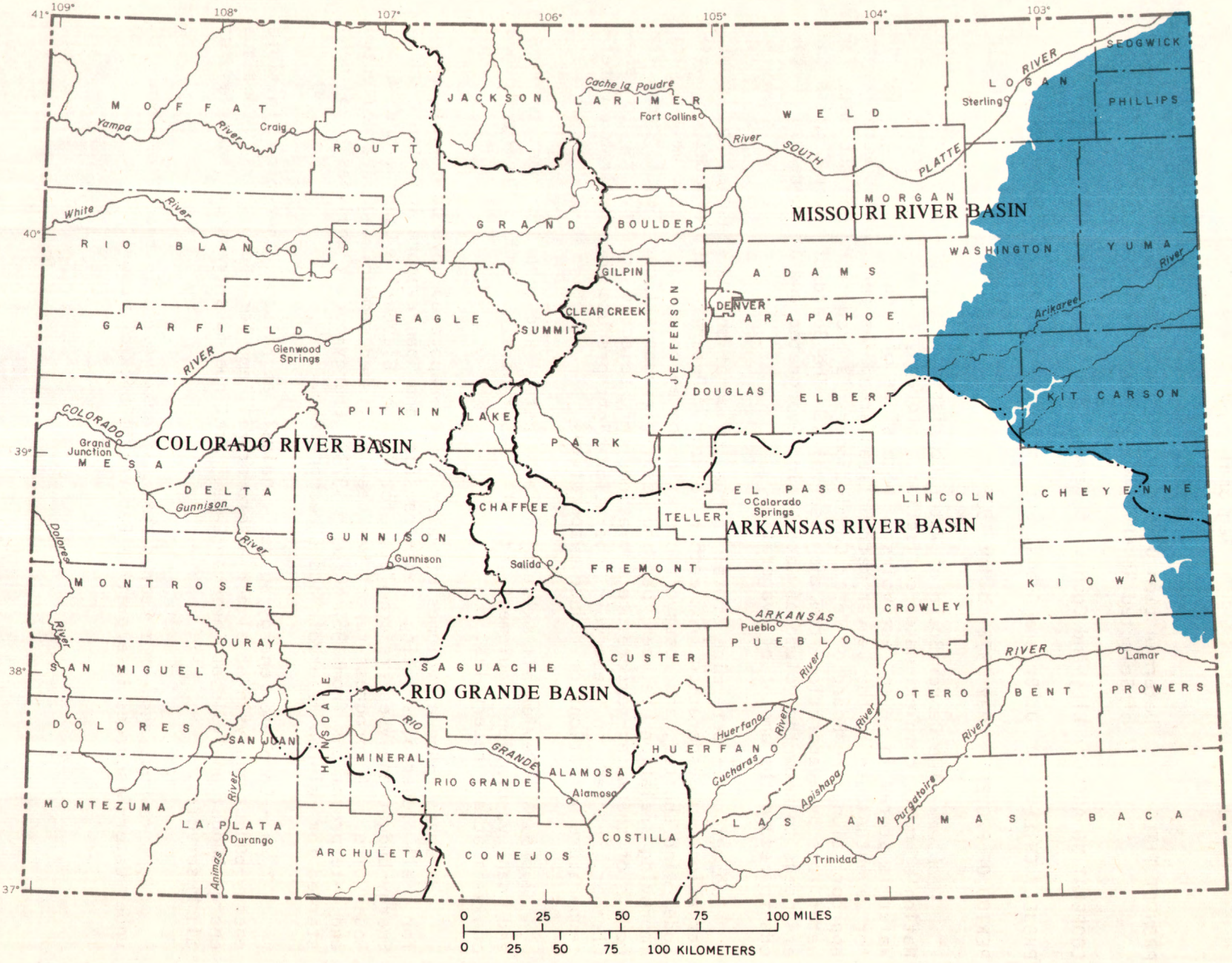

Figure 9.--Location of the High Plains of Colorado.

PROJECT TITLE: Water-Management Study of the High Plains of Colorado (fig. 9)

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

PROJECT CHIEF: Ronald G. Borman, District Office, Lakewood

PERIOD OF PROJECT: Continuous since July 1968

Problem.--State and local management agencies are managing the ground-water supply in the High Plains where increased pumpage for irrigation is depleting the supply. The agencies need a basis for predicting and then evaluating the effects of proposed changes in ground-water use.

Objectives.--Document the depletion of the ground-water supply. Collect data defining the hydrologic characteristics of the Ogallala aquifer. Develop a computer model to predict the effects of continued ground-water use. Monitor long-term water-level trends.

Approach.--Locate and obtain hydrologic data from all wells that pump more than 100 gallons per minute. From these wells, develop a monitoring network that will reflect water-level changes in the entire area. Collect and compile data to determine aquifer properties, recharge, return flow, consumptive use, and water quality. Develop a computer model to predict the effects of changes in water-management practices.

Progress.--Data have been collected from about 3,200 wells. A monitoring network of about 600 wells has been established and water levels are being measured yearly prior to the start of the irrigation season. Areas of water-level declines have been identified and are being monitored. The hydrologic characteristics of the Ogallala aquifer have been defined for much of the study area. Computer models have been developed, calibrated, and tested for five areas within the High Plains.

Plans.--Continue to measure water levels on a yearly basis. Continue to collect data that will define the hydrologic characteristics of the Ogallala aquifer. Investigate the possibilities of developing a computer model for the entire High Plains. Prepare yearly reports documenting water-level measurements. Prepare periodic reports documenting long-term water-level trends.

Reports published or released during fiscal year 1976.--See reference 6 under Water-Resources Data Reports at back of report.

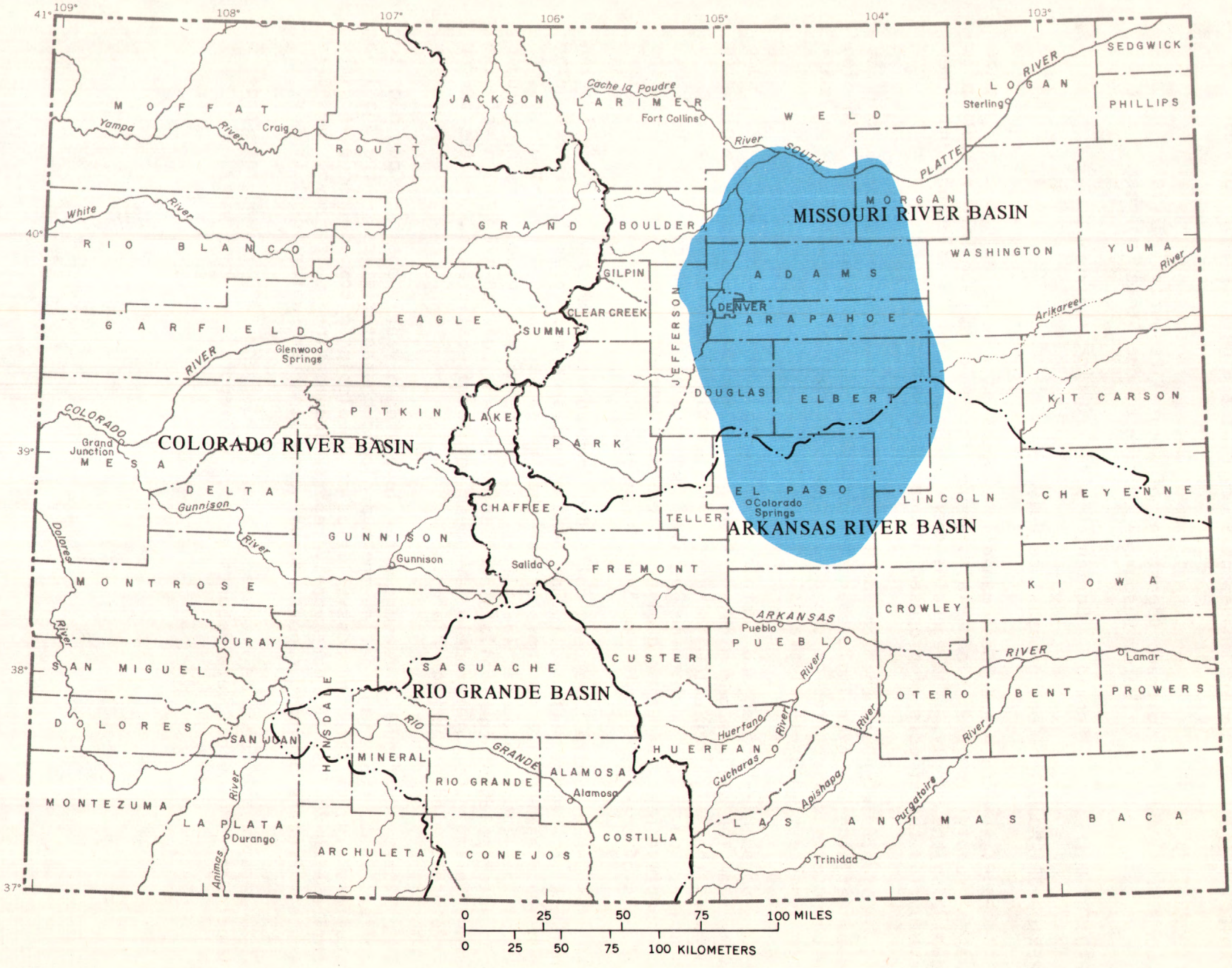

Figure 10.--Location of the Denver Basin.

PROJECT TITLE: Ground-Water Resources of the Denver Basin (fig. 10)

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

PROJECT CHIEF: Donald E. Hillier, District Office, Lakewood

PERIOD OF PROJECT: July 1975 to September 1978

Problem.--The Denver Basin is underlain by four major artesian aquifers. Increased pumpage from these aquifers, especially in localized areas in and near the major population centers along the Front Range, has resulted in a rapid decline of the aquifers' potentiometric surfaces as water is being withdrawn from the aquifers faster than it is being recharged. The geohydrology of the basin is complex and few data are available to determine water movement within and between aquifers, major areas of recharge to and discharge from the aquifers, chemical quality of water in the aquifers, and development potential of the multiple-aquifer system. A knowledge of the geohydrologic system of the basin is needed by State and local officials so that they can more effectively manage the resource.

Objectives.--Determine the effects of intensive ground-water development in local areas. Define the geohydrologic system of the basin.

Approach.--Establish an observation-well network to monitor water levels in the four aquifers. Conduct aquifer tests to determine the transmissivity, hydraulic conductivity, and storage coefficients of the four aquifers. Collect and analyze water samples to determine the water quality of the four aquifers. Determine if enough geohydrologic data are available to construct and calibrate a computer model of the multiple-aquifer system.

Progress.--A report describing the hydrology of the Arapahoe aquifer in the Englewood-Castle Rock area south of Denver has been completed. An observation-well network has been established in the area. Existing hydrologic data are being examined to determine if data are available to construct and calibrate a computer model.

Plans.--Determine the number of wells completed in each of the four aquifers throughout the basin. Assemble all available water-quality and aquifer-test data for evaluation.

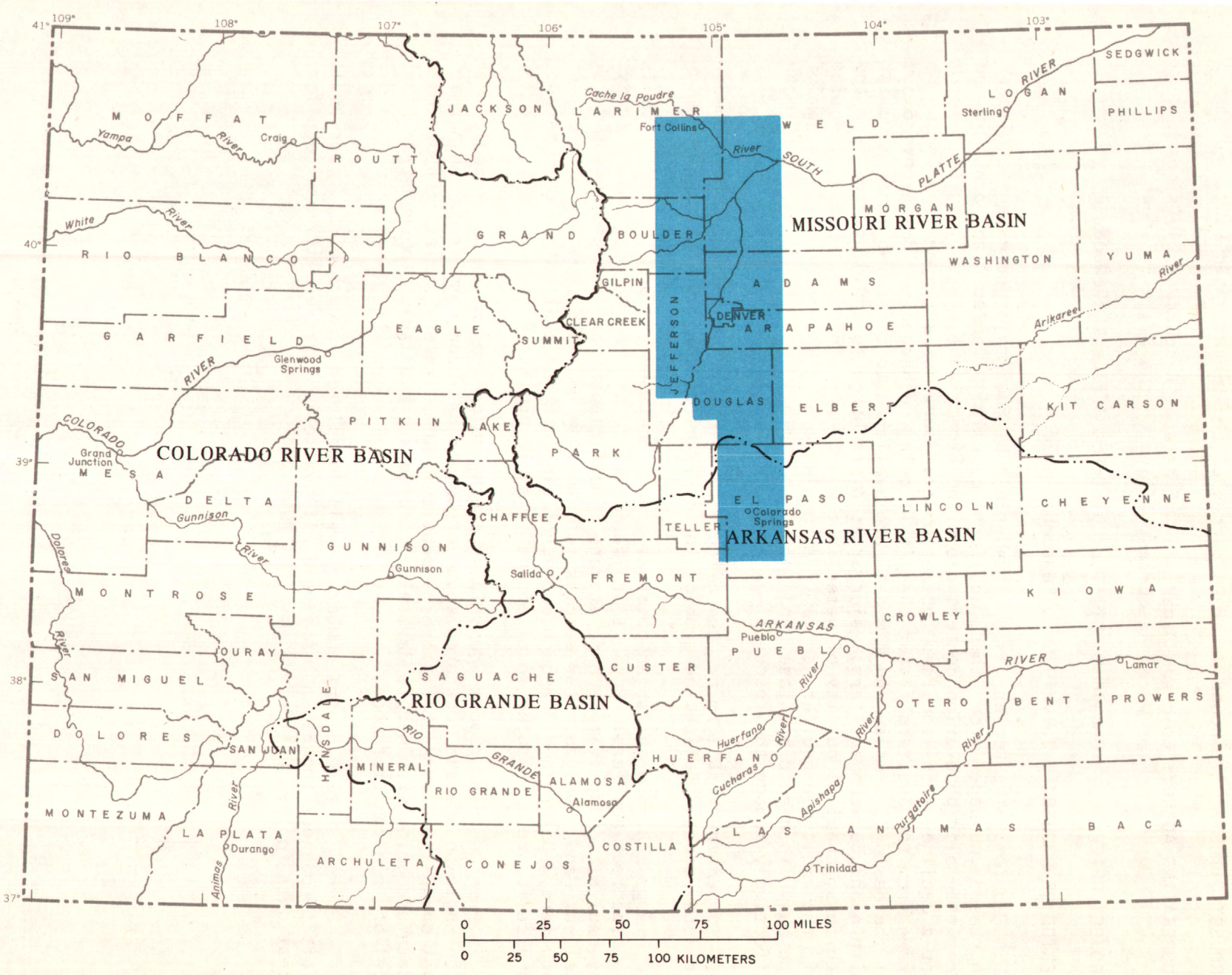

Figure 11.--Location of the Front Range urban corridor.

PROJECT TITLE: Environmental and Resource Demonstration Study of the Central Colorado Front Range Urban Corridor (fig. 11)

COOPERATING AGENCY: None

PROJECT CHIEF: Donald E. Hillier, District Office, Lakewood

PERIOD OF PROJECT: January 1971 to October 1977

Problem.--The central Colorado Front Range urban corridor is experiencing rapid urbanization. This growth imposes severe demands on water and land resources. In order for urban planners and managers to be better able to cope with demands for additional water supplies, pollution of waters, deleterious changes in runoff characteristics created by urbanization, and the necessity of choosing between alternative land-use proposals, they need to have a knowledge and understanding of how urbanization affects the geohydrologic system.

Objectives.--Demonstrate how geohydrologic data can be used to benefit urban planning, what types of geohydrologic data are most useful to planners, and the relations of geohydrologic data to existing and planned zoning and other land-use practices. Determine and demonstrate how earth scientists can present geohydrologic data in a form that is comprehensible and usable by urban planners and managers.

Approach.--Present geohydrologic data in single-factor form on maps accompanied by a brief text that clearly indicates to urban planners and managers the significance of data as related to urban planning.

Progress.--Maps presenting information about lakes, flood-prone areas, and the availability of published hydrologic data have been published. Maps in progress will present information about the location of hydrologic units containing water-table aquifers, chemical quality of water in the water-table aquifers, altitude of the water table, and depth to water.

Plans.--Complete the maps currently in progress. Evaluate the need for presenting additional information that would be beneficial to urban planners and managers.

Reports published or released during fiscal year 1976.--See references 2, 3, 19, and 20 under Water-Resources Interpretive Reports at back of report.

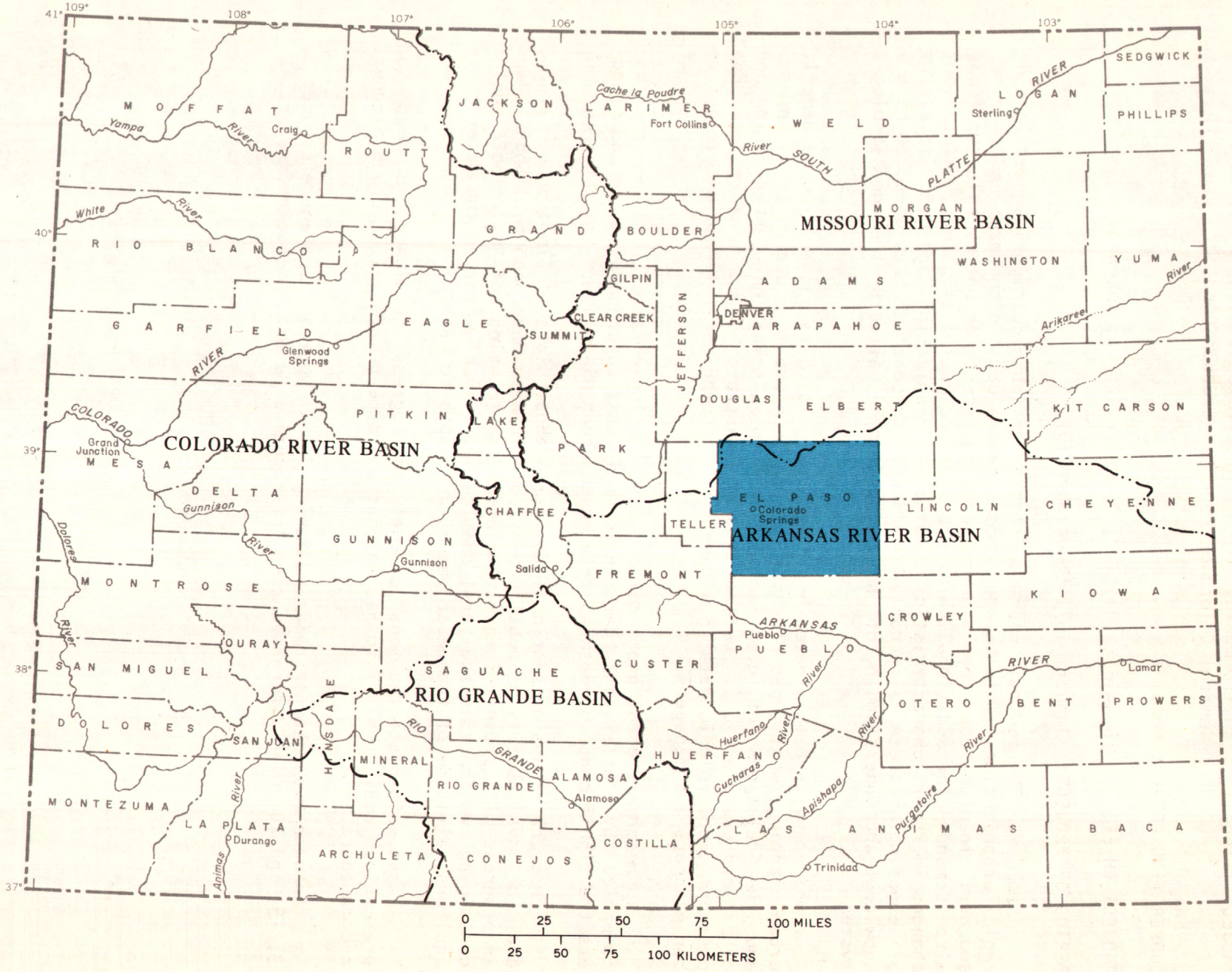

Figure 12.--Location of El Paso County.

PROJECT TITLE: Water Resources of El Paso County (fig. 12)

COOPERATING AGENCIES: City of Colorado Springs, El Paso County Board of Commissioners, Pikes Peak Area Council of Governments, and the U.S. Air Force Academy

PROJECT CHIEF: Richard E. Fidler, Subdistrict Office, Pueblo

PERIOD OF PROJECT: July 1972 to June 1978

Problem.--El Paso County, which includes the city of Colorado Springs, is one of the most rapidly growing urban areas in the State. Knowledge of the water resources of the county is needed by State and local officials to adequately plan for future development.

Objectives.--Determine the occurrence and availability of ground water, including depth to water and yield of aquifers. Document current ground-water development, annual ground-water withdrawal, and the effects of current development. In conjunction with the county planning director, who will provide estimates of rate and location of future population increases, predict future ground-water development and identify and describe the effects of this anticipated development. Estimate the mean annual flow and the 2-, 5-, 10-, and 50-year peak discharges of streams draining the mountainous part of the county. Determine the water quality of streams and aquifers. Synthesize these data so that the feasibility of water projects can be readily determined.

Approach.--Make an inventory of all wells yielding more than 100 gallons per minute. Establish a network of observation wells. Determine streamflow characteristics using channel geometry and other techniques. Determine stream quality using field observations of selected constituents and parameters that indicate the relative quality of the water. Collect samples of ground water for chemical analysis. Develop a computer model of the Dawson aquifer, which is the principal source of water in the northern one-half of the county.

Progress.--Most objectives attained and results published. Current data collection is being used to refine results and to upgrade the predictive capability of the computer model.

Plans.--Continue to collect selected hydrologic data for additional refinement of results and upgrading of the predictive capability of the computer model.

Reports published or released during fiscal year 1976.--See references 14, 16, and 24 under Water-Resources Interpretive Reports at back of report.

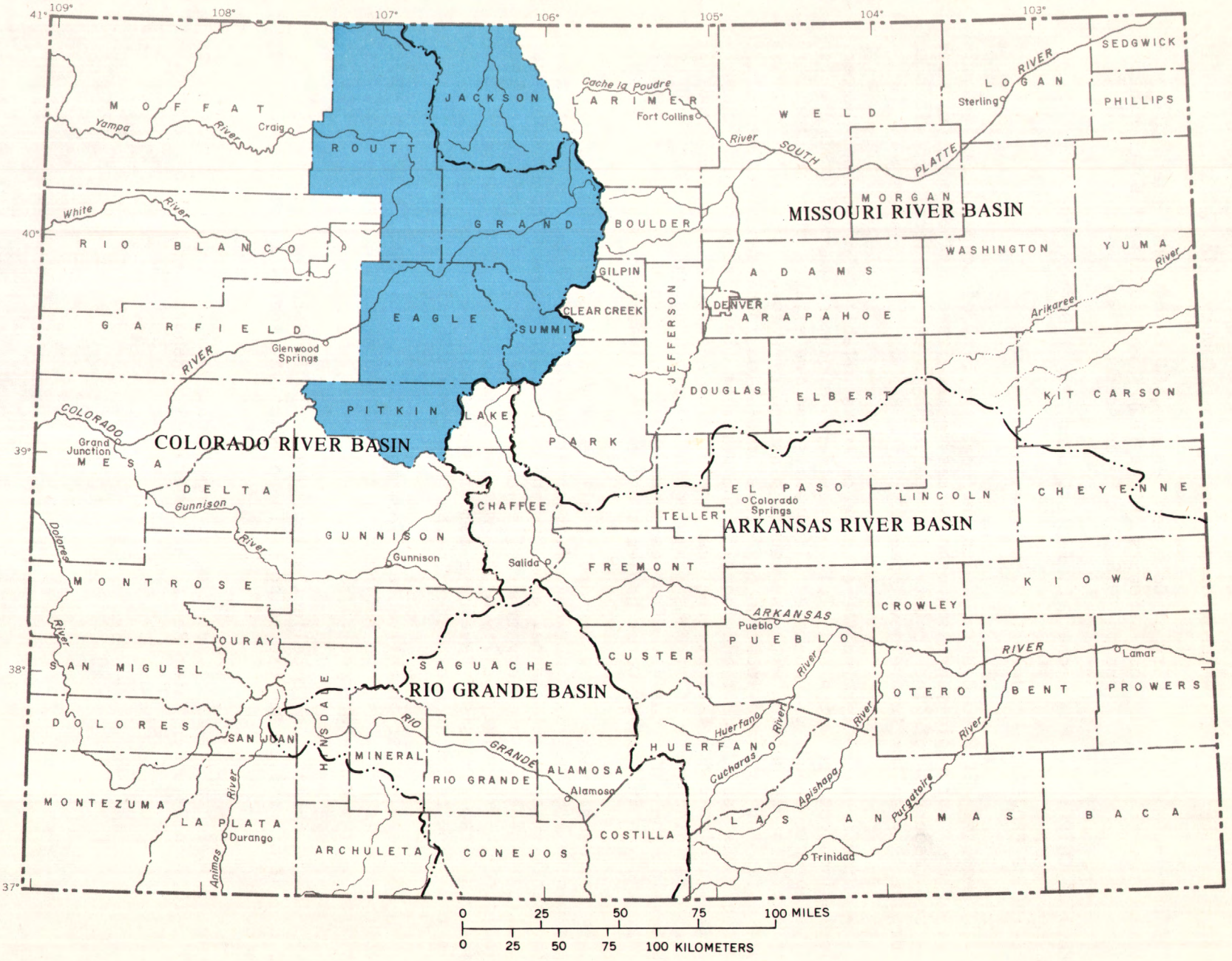

Figure 13.--Location of Eagle, Grand, Jackson, Pitkin, Routt, and Summit Counties.

PROJECT TITLE: Inventory of Water Quality in Eagle, Grand, Jackson, Pitkin, Routt, and Summit Counties (fig. 13)

COOPERATING AGENCY: North West Colorado Council of Governments

PROJECT CHIEF: Linda J. Britton, District Office, Lakewood

PERIOD OF PROJECT: February 1976 to September 1977

Problem.--Section 208 of Public Law 92-500, Federal Water Pollution Control Act, Amendment of 1972, requires that local government agencies be established to identify and eliminate sources of water-quality pollution in urban areas. The North West Colorado Council of Governments has been established to implement those requirements in Eagle, Grand, Jackson, Pitkin, Routt, and Summit Counties. As part of their activities, the North West Colorado Council of Governments requested the U.S. Geological Survey to determine the existing quality of surface water in the six-county area.

Objectives.--Determine the existing quality of surface water. Identify existing water-quality problems resulting from point and nonpoint sources. Identify potential water-quality problems based on data collected during the investigation. Design a water-quality monitoring network for the six-county area.

Approach.--Compile and analyze all existing water-quality data. Based on the analysis, design a sampling program to supplement and update the existing data. The sampling program will include the collection of trace-metals, nutrient, pesticide, bacteriological, and biological data from streams in the vicinity of point-source waste-discharge sites and from streams affected by nonpoint sources, such as agriculture, storm runoff, and recreation areas. Make field determinations of water temperature, pH, specific conductance, dissolved oxygen, and coliform bacteria at all sites.

Progress.--Compilation of existing data has been completed. Field-data collection has been completed.

Plans.--Analyze data and prepare a final report.

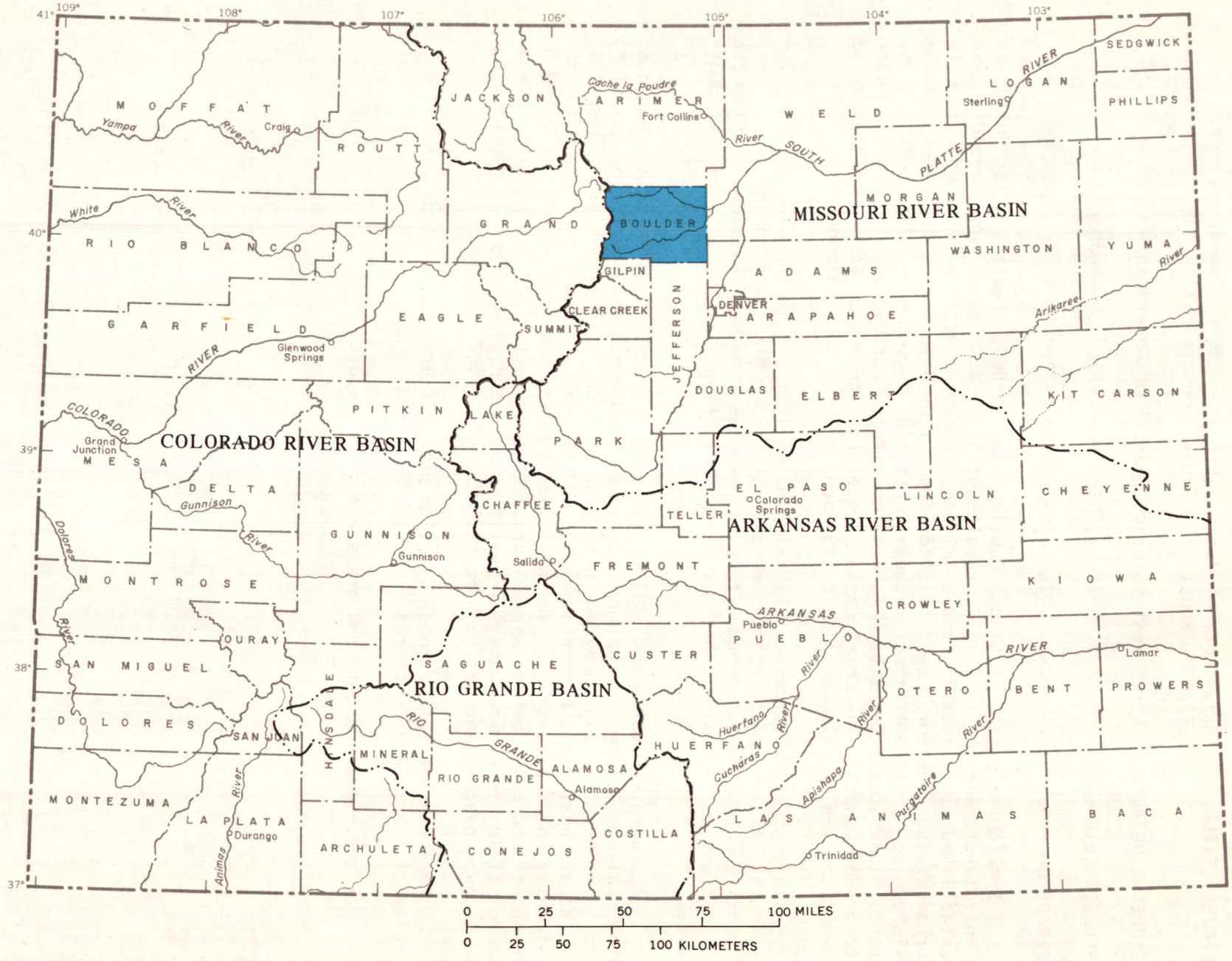

Figure 14.--Location of Boulder County.

PROJECT TITLE: Water Quality and Availability in Boulder County (fig. 14)

COOPERATING AGENCIES: Boulder City and County Health Department and Colorado Department of Natural Resources, Colorado Geological Survey

PROJECT CHIEF: Dennis C. Hall, District Office, Lakewood

PERIOD OF PROJECT: July 1975 to September 1977

Problem.--Urbanization in Boulder County is both increasing the demand for dependable supplies of water with suitable quality for residential, commercial, and industrial uses and degrading the existing water supplies through the addition of increasing amounts of wastes into the hydrologic system. Local officials need to know how the hydrologic system is being affected by urbanization so that they can more effectively manage the water resources in the county.

Objectives.--Determine the quality of water in the county, identify areas where contamination of water supplies is occurring, and determine the severity of the contamination. Develop a water budget for the county to determine the type and volume of water available for development and use.

Approach.--Compile and analyze all existing data relating to the quality and quantity of water. Determine where data need to be collected to supplement or update existing data. Collect samples for water-quality analysis from both surface- and ground-water sources. Identify both point and nonpoint sources of contamination. Compile or determine precipitation and streamflow data and measure water levels in wells completed in each aquifer to obtain the data needed for computing the water budget.

Progress.--All data collection has been completed and analysis of the data is in progress.

Plans.--Complete data analysis and prepare a final report.

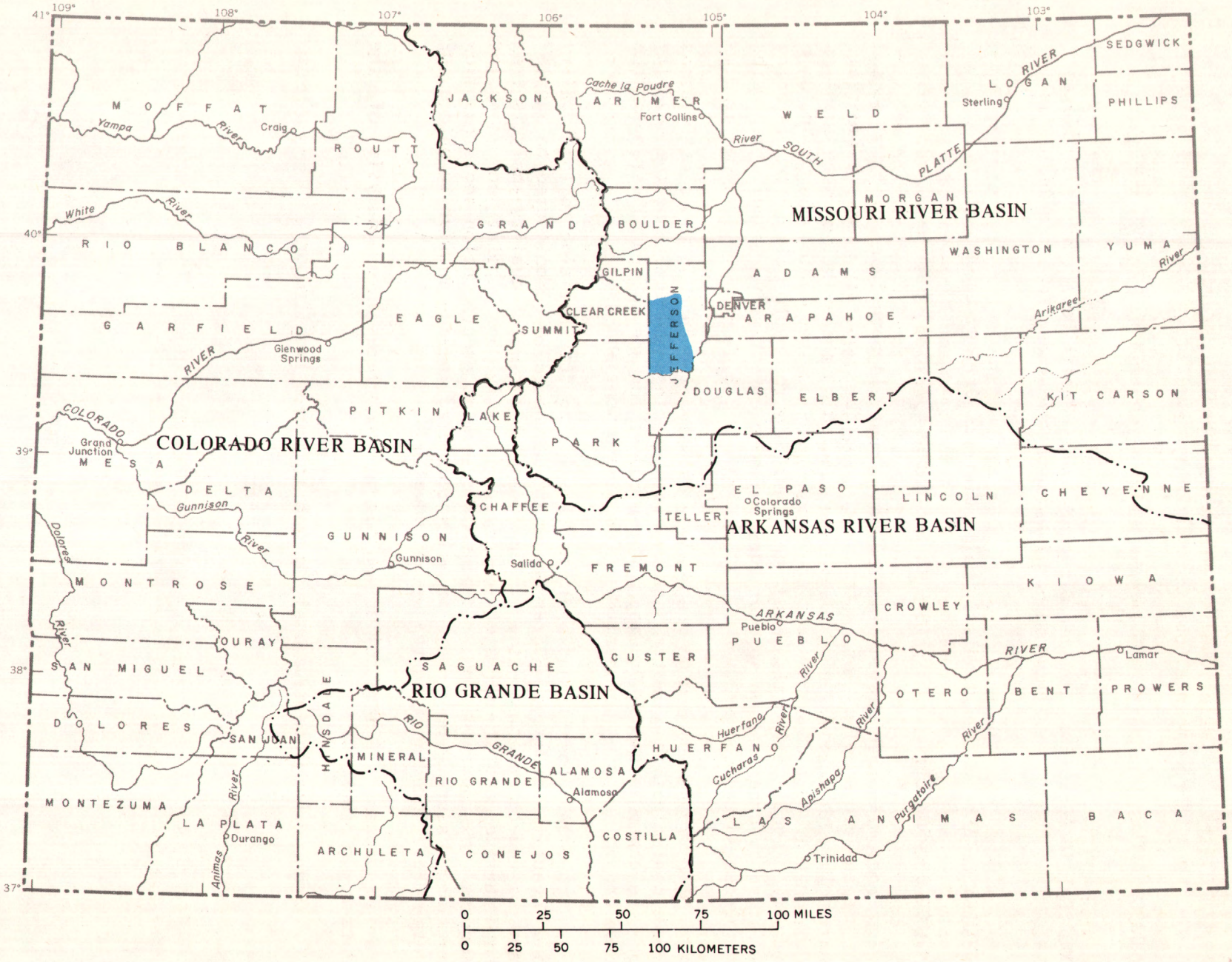

Figure 15.--Location of the mountainous central part of Jefferson County.

PROJECT TITLE: Water Quality and Related Health Hazards in the Mountainous Central Part of Jefferson County (fig. 15)

COOPERATING AGENCY: Jefferson County Health Department

PROJECT CHIEF: Dennis C. Hall, District Office, Lakewood

PERIOD OF PROJECT: March 1975 to September 1977

Problem.--Housing density is increasing in the mountainous part of Jefferson County. Many residents of the area rely on individual wells for water supply and individual systems, such as septic tanks and leach fields, for disposal of household wastes. Ground water in the more densely populated areas is degraded, but the specific factors contributing to the degradation are unknown. Radiochemicals are known to be present in the ground water and trace metals may be present. However, few data are available to determine the concentration of radiochemicals, and no data are available to determine the concentration of trace metals. In sufficient quantities, both radiochemicals and trace metals can constitute a health hazard.

Objectives.--Determine the geohydrologic factors contributing to the degradation of ground water. Compare the water quality of treated effluent from septic-tank leach fields with that from aerobic-treatment systems to determine degradation resulting from the effluent. Determine the concentrations of radiochemicals and trace metals in ground water and determine if concentrations constitute a health hazard. Determine seasonal changes in water-table levels and in the chemical and bacterial quality of ground water.

Approach.--For intensive studies, select three communities with similar geohydrologic settings and waste-treatment systems but with different population densities. Measure depth to water in wells and collect samples for chemical and bacteriological analyses from wells and treatment systems periodically throughout the year within each community. Determine seasonal changes by measuring depth to water and collecting samples for chemical, radiochemical, and trace-metal analyses periodically throughout the year from 2 wells in each community and from 11 additional observation wells throughout the project area.

Progress.--All field data have been collected and analyzed. Final report is in preparation.

Plans.--Complete final report.

Reports published or released during fiscal year 1976.--See reference 10 under Water-Resources Interpretive Reports at back of report.

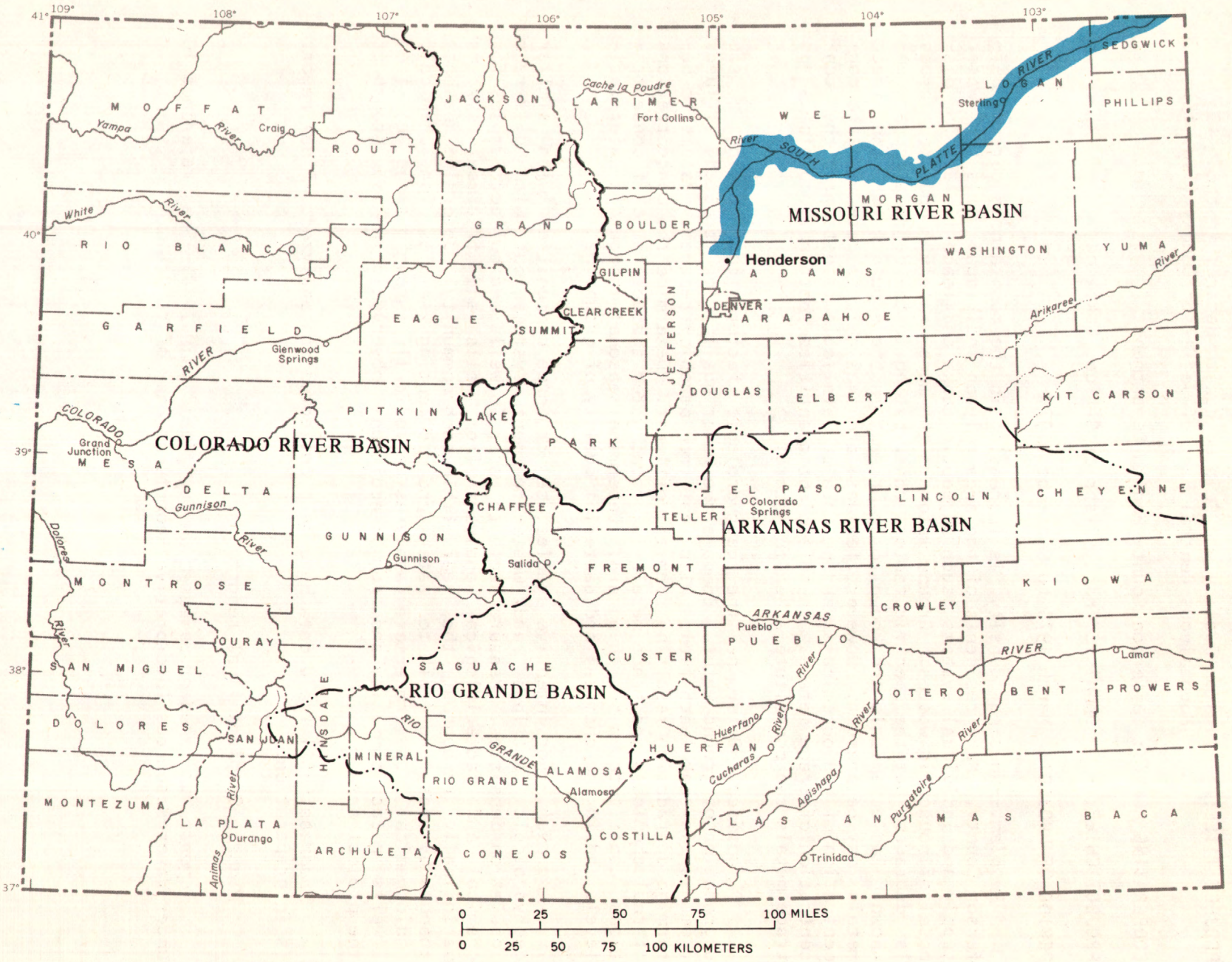

Figure 16.--Location of the South Platte River valley downstream from Henderson.

PROJECT TITLE: Hydrology of the South Platte River Valley Between Henderson and the Colorado-Nebraska State Boundary (fig. 16)

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

PROJECT CHIEF: R. Theodore Hurr, District Office, Lakewood

PERIOD OF PROJECT: Continuous since July 1966

Problem.--State and local agencies are making a concerted effort to improve water-management practices in the major river basins of Colorado. The geohydrology of the river-aquifer system needs to be defined and a computer model developed to determine the potential effects of water-management alternatives on the hydrologic system.

Objectives.--Define the geologic and hydrologic components of the river-aquifer system in the South Platte River valley. Develop a computer model that will be able to simulate the effects of alternative management practices.

Approach.--Collect geologic and hydrologic field data that can be used as the basis for the computer model. Develop and calibrate the computer model and then test the model using a variety of hypothetical management alternatives.

Progress.--Field-data collection has been completed. The computer model has been developed and currently is being calibrated.

Plans.--Finish calibrating the computer model, test the model, and prepare a final report.

Reports published or released during fiscal year 1976.--See references 11 and 13 under Water-Resources Interpretive Reports at back of report.

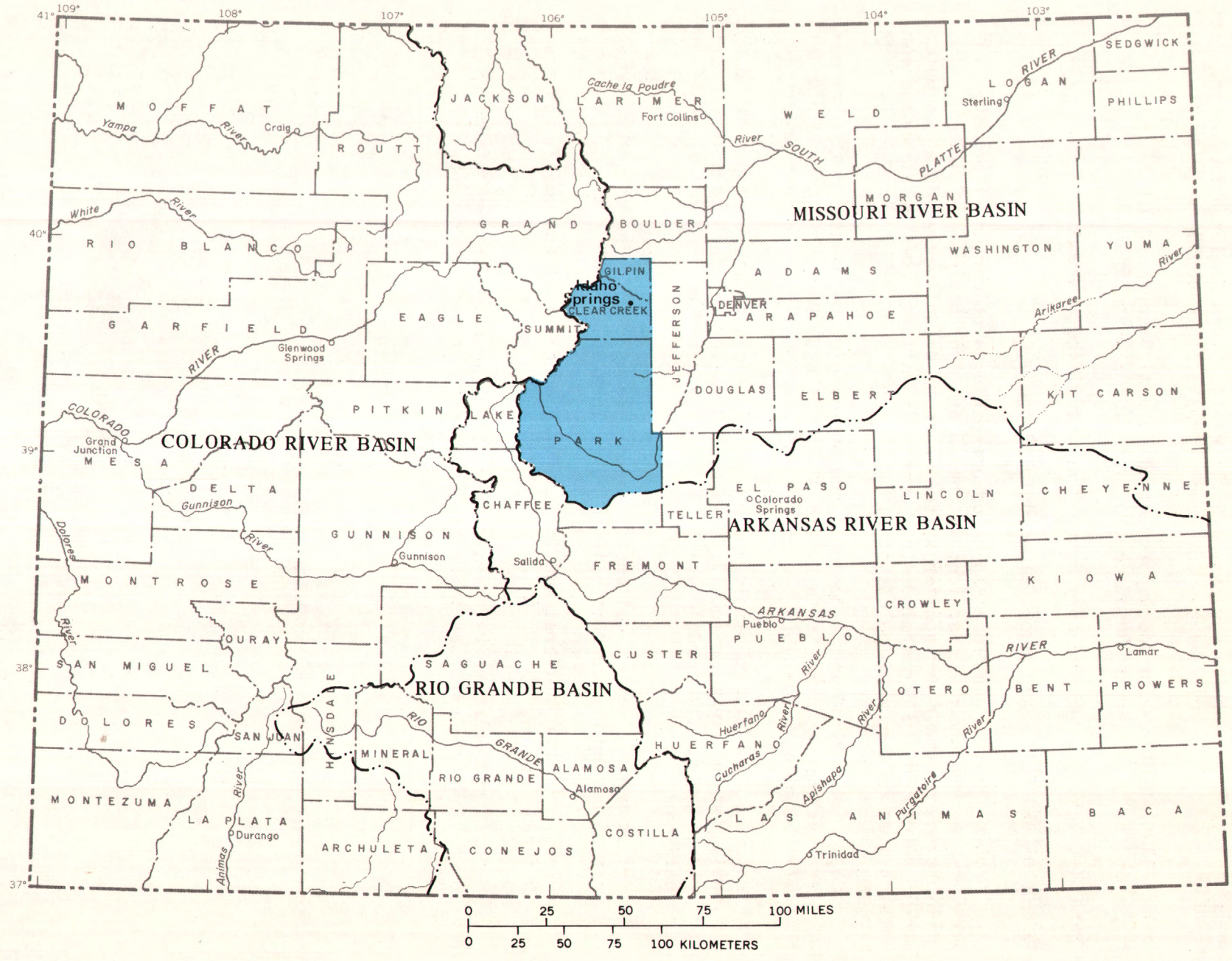

Figure 17.--Location of area for which the chemical quality of drainage from metallic-ore mines is being determined.

PROJECT TITLE: Water Quality of Discharges from Mines and Tailings Piles Containing Metallic Ores (fig. 17)

COOPERATING AGENCY: U.S. Department of the Army, Corps of Engineers

PROJECT CHIEF: Dennis A. Wentz, District Office, Lakewood

PERIOD OF PROJECT: December 1975 to September 1977

Problem.--Approximately 450 miles of streams in 25 areas of Colorado are adversely affected by discharges from mines and tailings piles containing metallic ores. As a result of previous investigations, the affected stream reaches have been determined. However, information is needed on the location, chemical processes of formation, volume, and chemical quality of the discharges to establish criteria for treatment of the discharges.

Objectives.--Locate the sources of mine drainage and determine the chemical quality of the discharges. Determine the chemical processes of mine-drainage formation and monitor the seasonal variations in the volume and chemical quality of the Argo tunnel, one of the major mine-drainage sources in the study area.

Approach.--Compile all existing volume and water-quality data from both active and abandoned mines and tailings piles. Field check the locations of the mines and tailings piles. Install a recorder at the Argo tunnel to obtain a continuous record of volume, water temperature, and specific conductance. Collect water-quality samples on a monthly basis from the selected mine and analyze for pH and trace metals.

Progress.--Compilation of existing data has been completed. Field checking of mine and tailings-piles locations has been completed. Two recorders were installed at the Argo tunnel in Idaho Springs and data collection has been completed.

Plans.--Analyze data and prepare a final report.

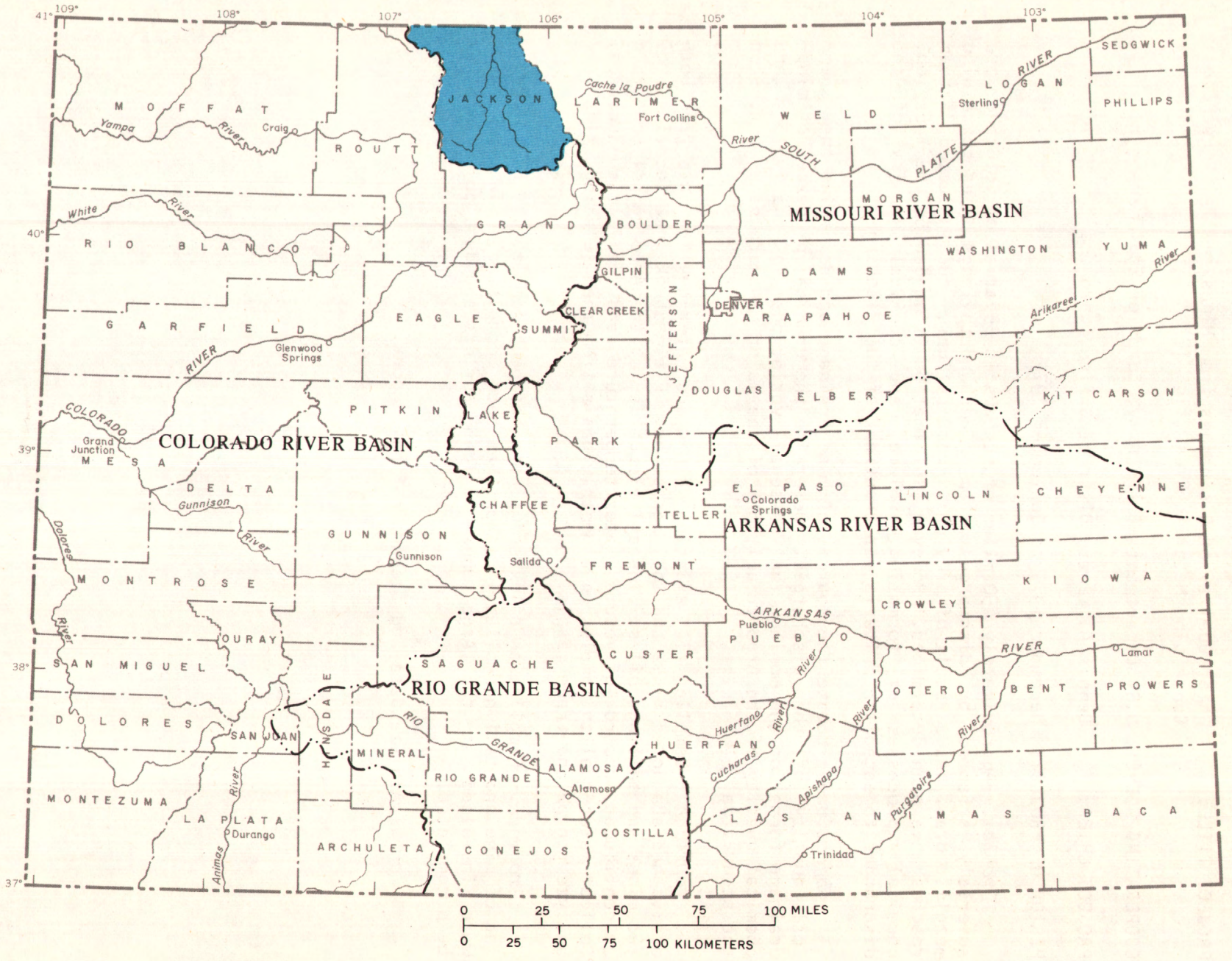

Figure 18.--Location of Jackson County.

PROJECT TITLE: Assessment of Surface Water in Jackson County (fig. 18)

COOPERATING AGENCY: Jackson County

PROJECT CHIEF: Russell K. Livingston, Subdistrict Office, Lakewood

PERIOD OF PROJECT: October 1976 to September 1979

Problem.--The proposed development of coal in Jackson County will affect the streams in the vicinity of the areas of development. A knowledge of the existing stream regime is needed prior to the beginning of coal mining so that the effects of coal mining can be determined.

Objective.--Determine the existing streamflow and water-quality characteristics in the vicinity of the proposed coal-mining area.

Approach.--Install five streamflow-gaging stations in the vicinity of the proposed coal-mining area. Install three stations upstream and two stations downstream from the area. Collect sediment samples on a monthly basis at each station. Collect water samples for chemical analysis on a monthly basis at each station. Make field determinations for water temperature, pH, and specific conductance each time a water sample is collected. Analyze samples for major ions, ammonia, dissolved and suspended organic carbon, kjeldahl nitrogen, and orthophosphate. Collect water samples in May and October at each station for analysis of trace elements. Analyze samples for antimony, arsenic, cadmium, copper, lead, mercury, nickel, selenium, vanadium, and zinc.

Progress.--All data-collection stations have been installed and water-quality sampling is in progress.

Plans.--Continue data collection.

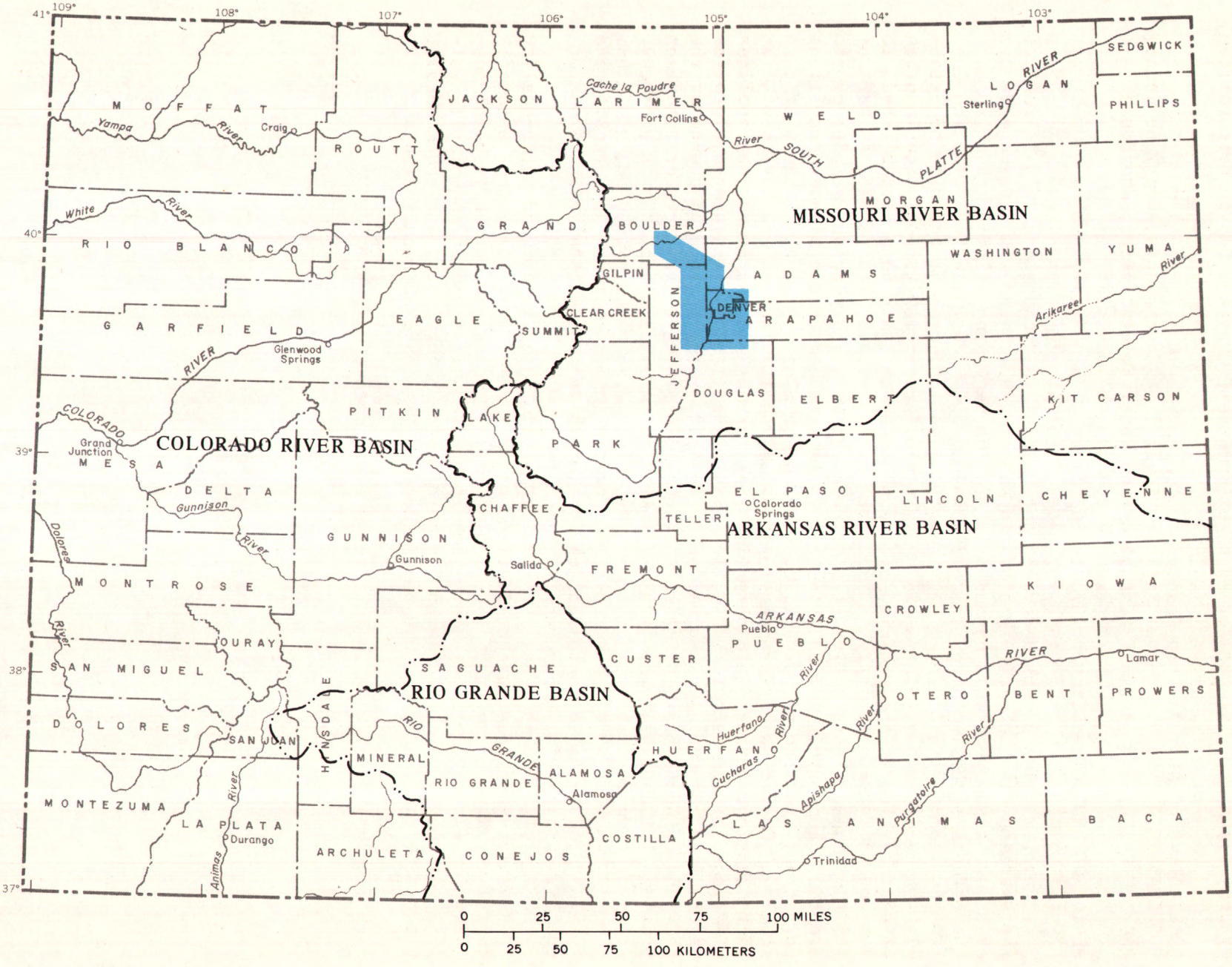

Figure 19.--Location of the Denver–Boulder urban area.

PROJECT TITLE: Monitoring of Storm-Runoff Quality, Denver Metropolitan Area (fig. 19)

COOPERATING AGENCIES: Denver Regional Council of Governments; City and County of Denver, Board of Water Commissioners; and Urban Drainage and Flood Control District

PROJECT CHIEF: Sherman R. Ellis, District Office, Lakewood

PERIOD OF PROJECT: January 1975 to January 1978

Problem.--Section 208 of Public Law 92-500, Federal Water Pollution Control Act, Amendment of 1972, requires that local government agencies be established to identify and eliminate sources of water-quality pollution in urban areas. The Denver Regional Council of Governments has been established to implement those requirements in the Denver metropolitan area. As part of their activities, the cooperators requested the U.S. Geological Survey to determine the magnitude and type of pollution caused by storm-water runoff.

Objectives.--Determine the types, concentration, and behavior of dissolved and suspended material in storm-water runoff in the Denver metropolitan area. In the event that treatment of storm-water runoff is required, provide information needed to evaluate the magnitude of and type and degree of the treatment required. Determine the approximate effect of storm-water runoff on the quality of water in the South Platte River.

Approach.--Install a network of precipitation gages, and runoff and water-quality stations. Obtain samples for water-quality analysis.

Progress.--Seven precipitation gages and three runoff and water-quality stations have been installed. Water-quality samples are collected automatically at varying frequencies during storms. Samples are currently being analyzed for dissolved solids, total nonfilterable solids, total nonvolatile solids, dissolved and suspended organic carbon, nutrients, and trace metals. Biochemical-oxygen-demand and pesticide data also have been collected.

Plans.--Continue to collect and analyze data.

PROJECT TITLE: Flood Frequency in Urban Areas (fig. 19)

COOPERATING AGENCY: Urban Drainage and Flood Control District

PROJECT CHIEF: Russell K. Livingston, Subdistrict Office, Lakewood

PERIOD OF PROJECT: Continuous since December 1967

Problem.--Flood flows are an important aspect in designing urban drainage works. Data are lacking for small watersheds and estimates made from existing data are likely to be substantially in error. Data are needed to define rainfall-runoff relations in small watersheds located in urban areas.

Objectives.--Collect data to define the relations between rainfall intensity, duration, and runoff in small drainage basins in the urban parts of Adams, Arapahoe, Boulder, Denver, Douglas, and Jefferson Counties. Develop techniques for extrapolating the data both in time and space. Develop and test a computer model to predict rainfall-runoff relations for small drainage basins.

Approach.--Collect rainfall-runoff data from 30 basins in the six-county area. Rainfall data to include continuous records supplemented by data from standard rain gages. Runoff data to include continuous records from each basin. Basins to be selected to sample the ranges of the following parameters: (1) Size--40 acres to 2 square miles, (2) vegetative cover--natural to none, (3) drainage by sewers--nonsewered to completely sewered, and (4) urban development--natural to completely urbanized.

Progress.--Data collection is continuing. Basin characteristics have been determined. Computer model being developed and tested.

Plans.--Continue data collection. Complete development of computer model, calibrate model, and begin testing of model.

Reports published or released during fiscal year 1976.--See reference 3 under Water-Resources Data Reports at back of report.

PROJECT TITLE: Rainfall-Runoff Management Model for the Denver Federal Center (fig. 19)

COOPERATING AGENCY: U.S. General Services Administration

PROJECT CHIEF: Robert D. Jarrett, District Office, Lakewood

PERIOD OF PROJECT: Continuous since July 1975

Problem.--Rapid urbanization of the area west of the Denver Federal Center has increased the possibility of flooding on the Federal Center. The magnitude and frequency of floods need to be determined so that appropriate flood-control structures can be constructed on the Federal Center and future facilities located in areas that are not subject to flooding.

Objectives.--Develop a computer model to predict the magnitude and frequency of floods. Prepare a flood-prone-area map of the Federal Center. Determine the physical characteristics of catchment areas on the Federal Center and in upstream tributary areas.

Approach.--Install rain gages on the Federal Center and in the upstream tributary areas west of the Federal Center. Install stream-stage stations to measure inflow to and outflow from the Federal Center. Install stage recorders in nonurbanized and urbanized watersheds to determine runoff characteristics. Make current-meter measurements at all stream-stage locations to define stage-discharge relations. Obtain an orthophotographic base map with 2- and 4-foot contour intervals to determine the physical characteristics of the catchment and tributary areas.

Progress.--Nine recording and seven nonrecording rain gages have been installed on the Federal Center and in the McIntyre Gulch drainage basin. Eight recording and one nonrecording stream-stage stations have been installed within or immediately adjacent to the Federal Center. Stage recorders have been installed in a natural-grass watershed and a storm-sewered area. A contract was awarded to a private firm to prepare the orthophotographic base map. The physical characteristics of the catchment and tributary areas have been determined. The flood-prone-area map has been prepared and three flood-retention ponds constructed on the Federal Center by the General Services Administration. The computer model has been developed but not calibrated because storms have been so infrequent that sufficient data to calibrate the model have not been collected.

Plans.--Continue data collection. Investigate the feasibility of calibrating the computer model using data collected from similar areas in the Denver metropolitan area.

Reports published or released during fiscal year 1976.--See reference 9 under Water-Resources Interpretive Reports at back of report.

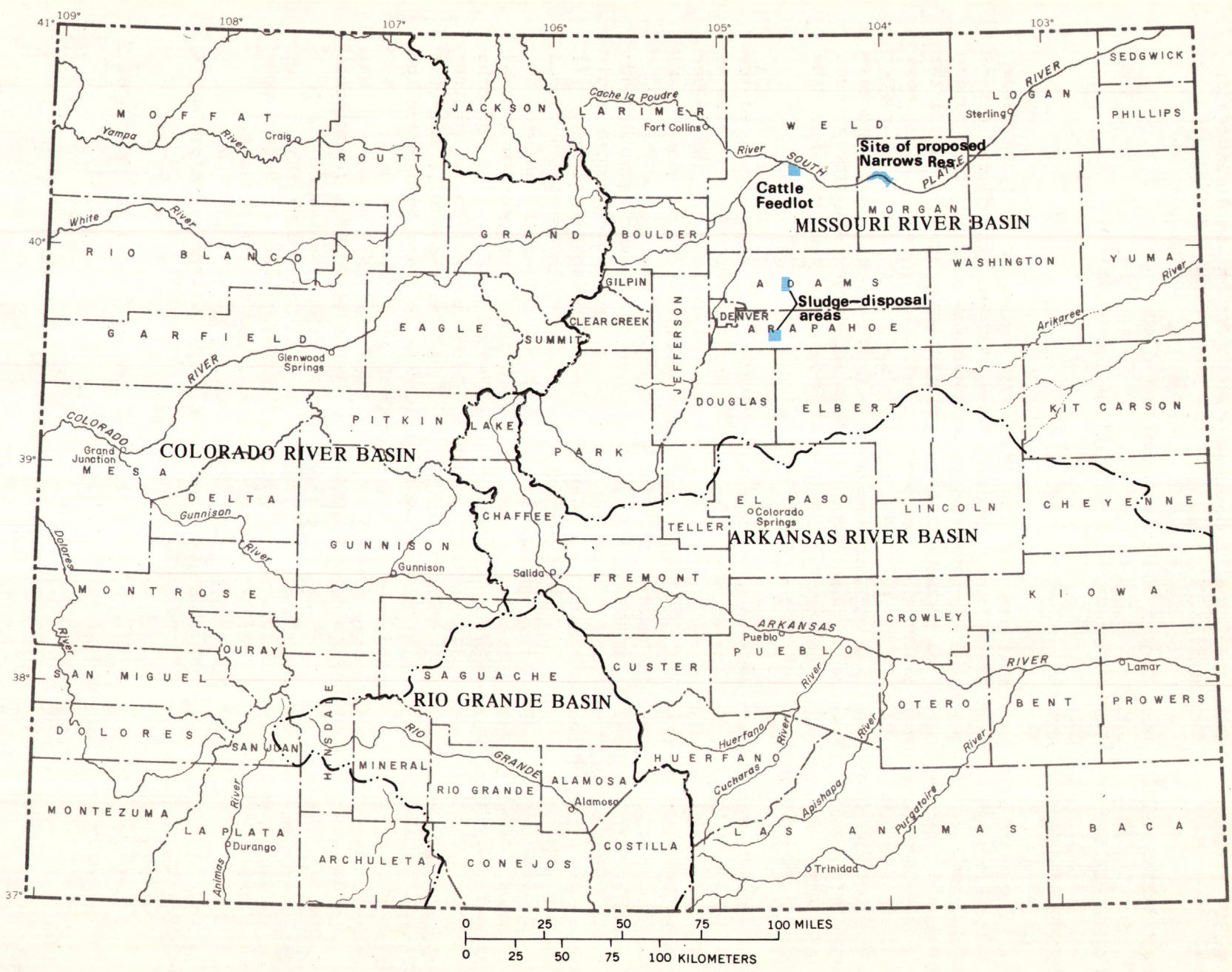

Figure 20.--Location of the proposed Narrows Reservoir, cattle feedlot, and sludge–disposal areas.

PROJECT TITLE: Effects of the Proposed Narrows Reservoir on Ground-Water System (fig. 20)

COOPERATING AGENCY: U.S. Bureau of Reclamation

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

PERIOD OF PROJECT: October 1975 to September 1978

Problem.-Construction of the proposed Narrows Reservoir on the South Platte River will affect the ground-water system in the vicinity of the reservoir. Because of the high degree of hydraulic connection between the reservoir and the alluvial aquifer, water will move into the aquifer during the filling of the reservoir. Once the reservoir is filled, water will move either into the reservoir from the aquifer during periods of declining reservoir storage or into the aquifer from the reservoir during periods of increasing reservoir storage. The effects of gains and losses in bank storage need to be known so that the time required to initially fill the reservoir and the details of operational rules can be determined.

Objectives.--Determine the time required for the aquifer to adjust to the filling of the proposed reservoir. Determine bank-storage seepage rates to and from the reservoir and changes in ground-water discharge to the river downstream from the proposed dam during transient reservoir conditions.

Approach.-Develop and calibrate steady-state and transient computer models to predict the effects of the reservoir filling and operation on the aquifer. Use the transient model to simulate the following situations: (1) Aquifer storage and discharge using a representative time period that includes above-normal, normal, and below-normal streamflows without storage in the reservoir, (2) aquifer storage and discharge using successive years of normal streamflow and operating rules to be used during the initial filling of the reservoir, and (3) aquifer storage and discharge using combinations of historical streamflows and normal reservoir operations. Make a sensitivity analysis of the model to determine what effects possible errors in data will have on different operating rules.

Progress.--The steady-state analysis has been completed and a report published.

Plans.--Develop and calibrate the transient computer model. Begin computer analysis of the filling- and operating-rules phase of the project.

Reports published or released during fiscal year 1976.--See reference 6 under Water-Resources Interpretive Reports at back of report.

PROJECT TITLE: Effects of the Proposed Narrows Reservoir on Surface-Water Quality and Sediment Transport (fig. 20)

COOPERATING AGENCY: U.S. Bureau of Reclamation

PROJECT CHIEF: Donald R. Minges, Subdistrict Office, Lakewood

PERIOD OF PROJECT: March 1977 to September 1980

Problem.--Construction of the proposed Narrows Reservoir on the South Platte River will affect the water-quality and sediment-load characteristics of the river. A knowledge of existing water-quality and sediment-load characteristics is needed so that the effects of the reservoir on water quality and sediment load can be determined both during and following construction.

Objectives.--Determine the existing water-quality and sediment-load characteristics of the South Platte River both upstream and downstream from the proposed reservoir site. Determine both seasonal and annual variations in water quality and sediment load. Determine the streamflow of Bijou Creek, a major tributary of the South Platte River that joins the river about 4 miles downstream from the proposed reservoir site.

Approach.--Install continuous-record streamflow stations on the South Platte River upstream from the reservoir site and on Bijou Creek near the mouth to supplement the records from an existing station on the South Platte River downstream from the reservoir site. Measure gain and loss in streamflow weekly at five sites, including the three streamflow stations. Measure gain and loss in streamflow monthly at 12 sites in addition to the 5 weekly sites. Collect samples for chemical analysis biweekly during the irrigation season (April 1 to October 1) at the three streamflow stations. Collect sediment samples daily during the irrigation season at the streamflow station on the South Platte River downstream from the reservoir site. Collect sediment samples twice a month from 15 irrigation canals; collect sediment samples daily for 5 consecutive days twice during the irrigation season from the 15 irrigation canals.

Progress.--The continuous-record gaging stations have been installed. The gain-and-loss sites have been determined. Data collection is in progress.

Plans.--Continue data collection.

PROJECT TITLE: Effects of Wastes from a Cattle Feedlot on the Chemical Quality of Water in an Alluvial Aquifer (fig. 20)

COOPERATING AGENCY: None

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

PERIOD OF PROJECT: July 1973 to June 1979

Problem.--Because large cattle feedlots may produce wastes on a daily basis comparable in volume to daily wastes produced by a medium-size city, there is a great potential for ground-water contamination due to infiltration of the wastes into aquifers beneath and adjacent to the feedlot. Higher-than-normal concentrations of nitrate and other dissolved ions have been reported in ground water beneath and adjacent to large feedlots. These constituents are a contamination hazard to nearby wells and streams.

Objective.--Monitor and describe any changes that occur in the chemical quality of ground water resulting from the operation of a large cattle feedlot.

Approach.--Establish an observation-well network on and adjacent to the area where a large cattle feedlot is to be constructed. Determine the chemical quality of ground water in both areas prior to construction of the feedlot. After construction, collect samples of ground water for chemical analysis from both the feedlot and the control areas. Determine changes in chemical quality resulting from operation of the feedlot.

Progress.--Water-quality sampling from wells is continuing. A marked change in ground-water quality has not been observed.

Plans.--Continue water-quality sampling.

PROJECT TITLE: Effects of Land Disposal of Sludge and Landfills on Ground-Water Quality (fig. 20)

COOPERATING AGENCY: Metropolitan Denver Sewage Disposal District No. 1

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

PERIOD OF PROJECT: July 1974 to September 1979

Problem.--The Metropolitan Denver Sewage Disposal District No. 1 plans to replace its current sewage-sludge land-disposal facility in Arapahoe County with sludge-drying basins to facilitate sludge disposal and allow use of dried sludge as fertilizer. The new facility will be located in Adams County about 25 miles northeast of Denver. The drying basins will occupy about 600 acres of a 2,000-acre site. About 100 tons of sludge per day will be pumped through pipelines to the drying basins. The Metropolitan Denver Sewage Disposal District, the U.S. Environmental Protection Agency, and local residents are concerned about the effects of the facility on local ground-water quality.

Objectives.--Determine the location of, depth to, and areal extent of alluvial and bedrock aquifers beneath the sludge-drying site and adjacent areas. Determine the direction of ground-water flow and the present quality of the ground water. Determine the quality of the leachate, the rate of movement of the leachate into the aquifers, and the dispersion of the leachate once it enters the aquifers.

Approach.--Establish a ground-water-quality monitoring network within a 28-square-mile area around the sludge-drying site. Locate the existing 20 wells in the study area; measure depth to water and obtain samples for water-quality analysis. Construct potentiometric-surface maps for the alluvial and bedrock aquifers to aid in determining where to drill new observation wells. Drill about 40 new observation wells; 34 in the alluvial aquifer and 6 in the bedrock aquifer. Measure depth to water and obtain samples for water-quality analysis. Install six pan-type lysimeters under selected drying basins to determine the infiltration rate of the leachate and to provide areas for collecting water-quality samples. Collect samples of leachate for water-quality analysis.

Progress.--Final report for area in Arapahoe County is in preparation. Locating existing wells in the Adams County area is in progress.

Plans.--Complete final report for area in Arapahoe County. Inventory existing wells in Adams County; measure depth to water and obtain samples for water-quality analysis.

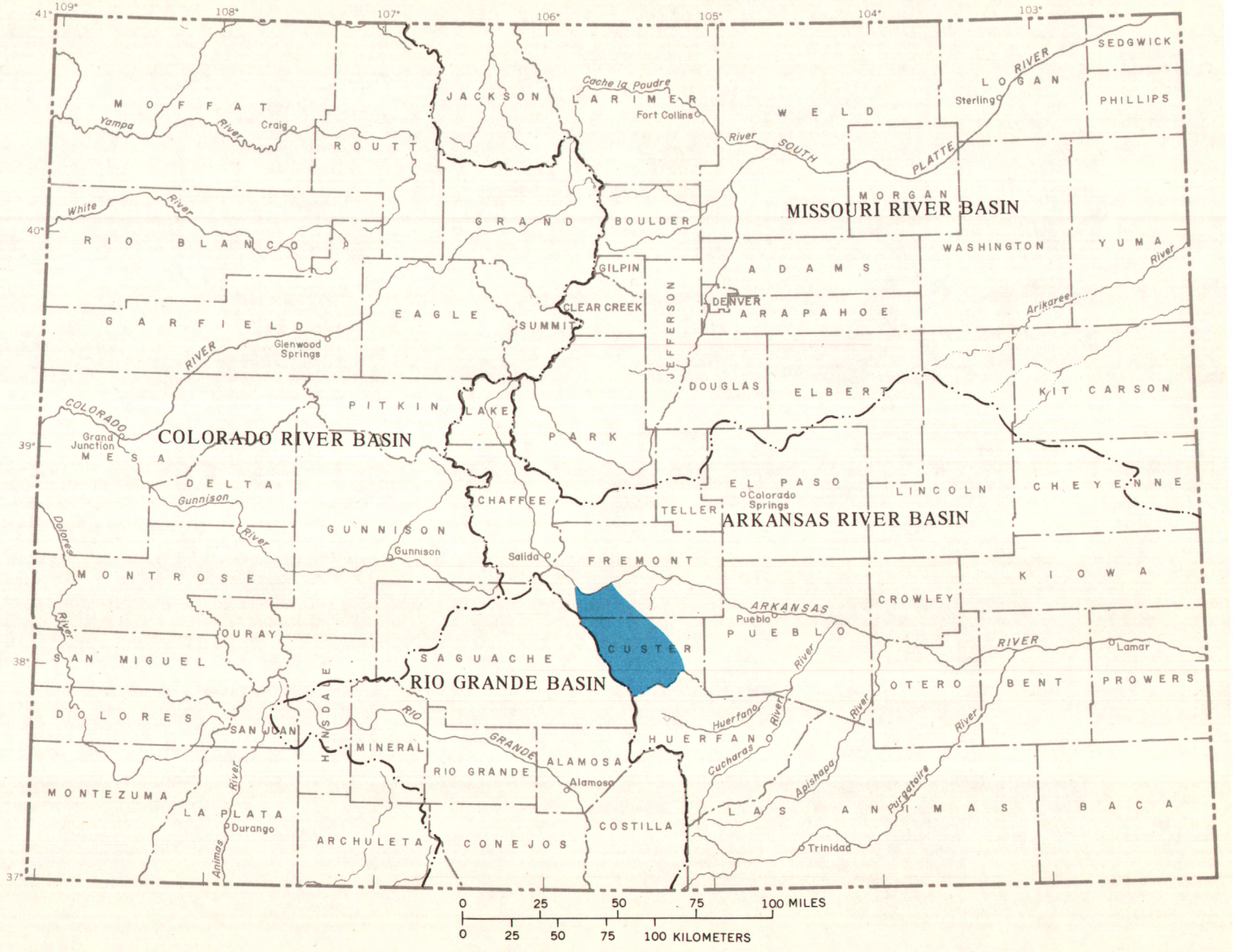

Figure 21.--Location of Wet Mountain Valley.

PROJECT TITLE: Water-Resources Appraisal of the Wet Mountain Valley, Custer and Fremont Counties (fig. 21)

COOPERATING AGENCY: Southeastern Colorado Water Conservancy District

PROJECT CHIEF: Clark J. Londquist, Subdistrict Office, Pueblo

PERIOD OF PROJECT: July 1970 to September 1977

Problem.--Wet Mountain Valley, which presently is sparsely populated and has an economy based on agriculture, has the potential for becoming a popular recreation area. Proposals have been made to construct resort-type homes and a ski resort in the valley. A knowledge of the existing hydrologic system is needed by local officials to determine the effects of development on the hydrologic system and to provide a basis for managing the water resources of the area.

Objective.--Determine the quantity and quality of surface and ground water available in Wet Mountain Valley.

Approach.--Install two continuous-record and four partial-record streamflow stations. Correlate streamflow data with existing records. Estimate streamflow from small ungaged basins. Collect samples from streams for chemical analysis. Make an inventory of existing wells. Measure water levels in the wells bimonthly. Collect water samples for chemical analysis. Make a resistivity survey to determine the thickness of the basin fill. Analyze meteorologic and hydrologic data to determine a water budget for the valley.

Progress.--All data collection and analysis have been completed.

Plans.--Prepare a final report.

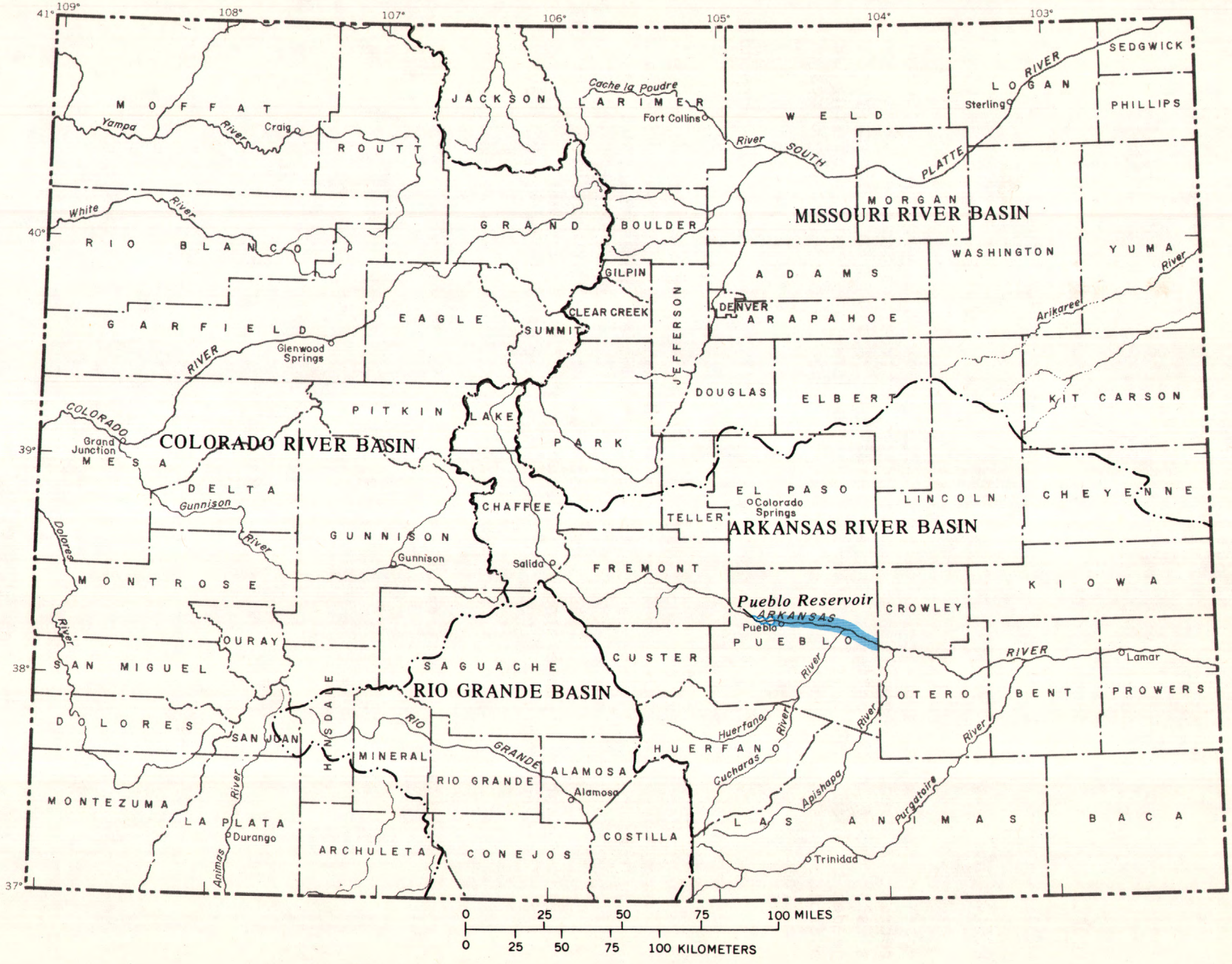

Figure 22.--Location of the reach of the Arkansas River in Pueblo County downstream from Pueblo Reservoir.

PROJECT TITLE: Water-Quality Assessment of the Arkansas River in Pueblo County Downstream from Pueblo Reservoir (fig. 22)

COOPERATING AGENCY: Pueblo Area Council of Governments

PROJECT CHIEF: Kimball E. Goddard, Subdistrict Office, Pueblo

PERIOD OF PROJECT: April 1976 to September 1977

Problem.--Section 208 of Public Law 92-500, Federal Water Pollution Control Act, Amendment of 1972, requires that local government agencies be established to identify and eliminate sources of water-quality pollution in urban areas. The Pueblo Area Council of Governments has been established to implement those requirements in Pueblo County. As part of their activities, the Pueblo Area Council of Governments requested the U.S. Geological Survey to determine the existing water quality of the Arkansas River in Pueblo County downstream from Pueblo Reservoir.

Objectives.--Determine the existing water quality of the Arkansas River downstream from Pueblo Reservoir in Pueblo County. Determine sources of point and nonpoint pollution entering the river.

Approach.--Make monthly discharge measurements at 21 sites. Make monthly field determinations of dissolved oxygen, pH, specific conductance, and water temperature at 21 sites, and chlorine residual at 9 sites. Collect samples monthly at 21 sites for analysis of major ions; ammonia; biochemical oxygen demand; 5-day chemical oxygen demand; dissolved, total, and suspended solids; total kjeldahl nitrogen; total and fecal coliform; and turbidity. Collect samples bimonthly at 12 sites for analysis of aluminum, cadmium, iron, manganese, selenium, silver, and phenols. Collect samples bimonthly at 21 sites for analysis of aluminum, cadmium, iron, manganese, selenium, silver, and phenols; mercury at 13 sites; arsenic, boron, copper, lead, and zinc at 9 sites; MBAS at 7 sites; and cyanide at 5 sites. Conduct an intensive 24-hour sampling program at 28 sites to make field determinations of biochemical oxygen demand, discharge, dissolved oxygen, nitrate, pH, specific conductance, total and fecal coliform, and water temperature.

Progress.--Data collection has been completed.

Plans.--Prepare a final report.

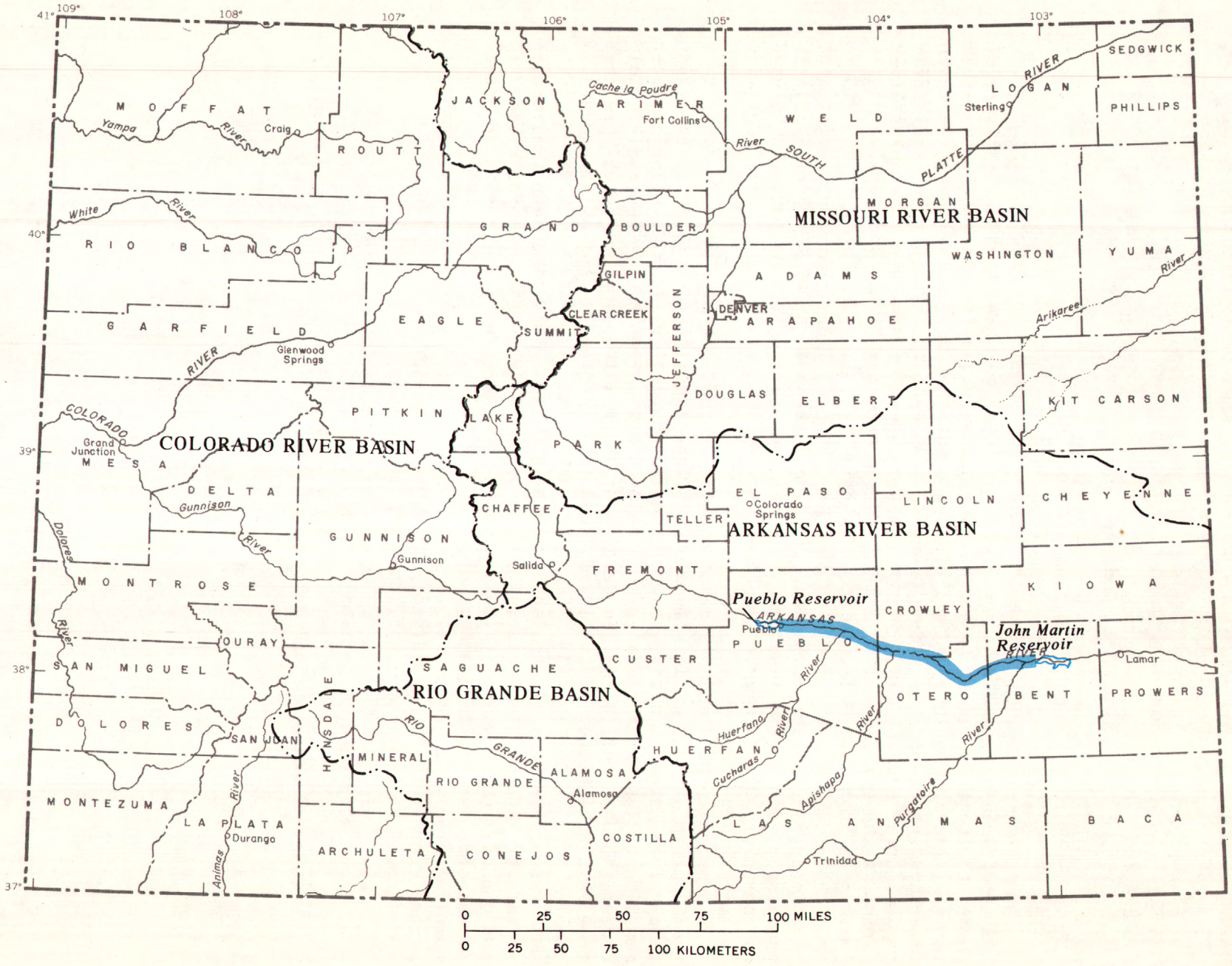

Figure 23.--Location of the reach of the Arkansas River between Pueblo and John Martin Reservoirs.

PROJECT TITLE: Travel Time and Transit Losses of Reservoir Releases, Arkansas River from Pueblo Reservoir to John Martin Reservoir (fig. 23)

COOPERATING AGENCY: Southeastern Colorado Water Conservancy District

PROJECT CHIEF: Russell K. Livingston, Subdistrict Office, Lakewood

PERIOD OF PROJECT: July 1974 to September 1977

Problem.--Optimum management of reservoir releases includes delivery of water to downstream users at specified times and identification of water loss in transit. A knowledge of the time required for reservoir releases to reach diversion points and the loss of water during transit is needed by local officials for the management of the reservoir system in the lower Arkansas River basin.

Objectives.--Develop and calibrate a computer model that can predict the time required for reservoir releases to reach downstream diversion points, that can predict the volume of water lost during transit, and that can be used by appropriate officials to develop management plans that will optimize deliveries and identify transit losses.

Approach.--Collect and analyze all existing streamflow data for the study reach of the river. Use the data to modify and calibrate an existing computer model developed for the Arkansas River upstream from Pueblo Reservoir. Collect field data needed for calibration of the model during an actual release from Pueblo Reservoir if calibration cannot be achieved using existing data.

Progress.--The existing computer model has been modified and calibrated to reflect the hydrologic regime of the study reach of the Arkansas River. It was necessary to collect field data to calibrate the model during an actual release from Pueblo Reservoir.

Plans.--Prepare a final report.

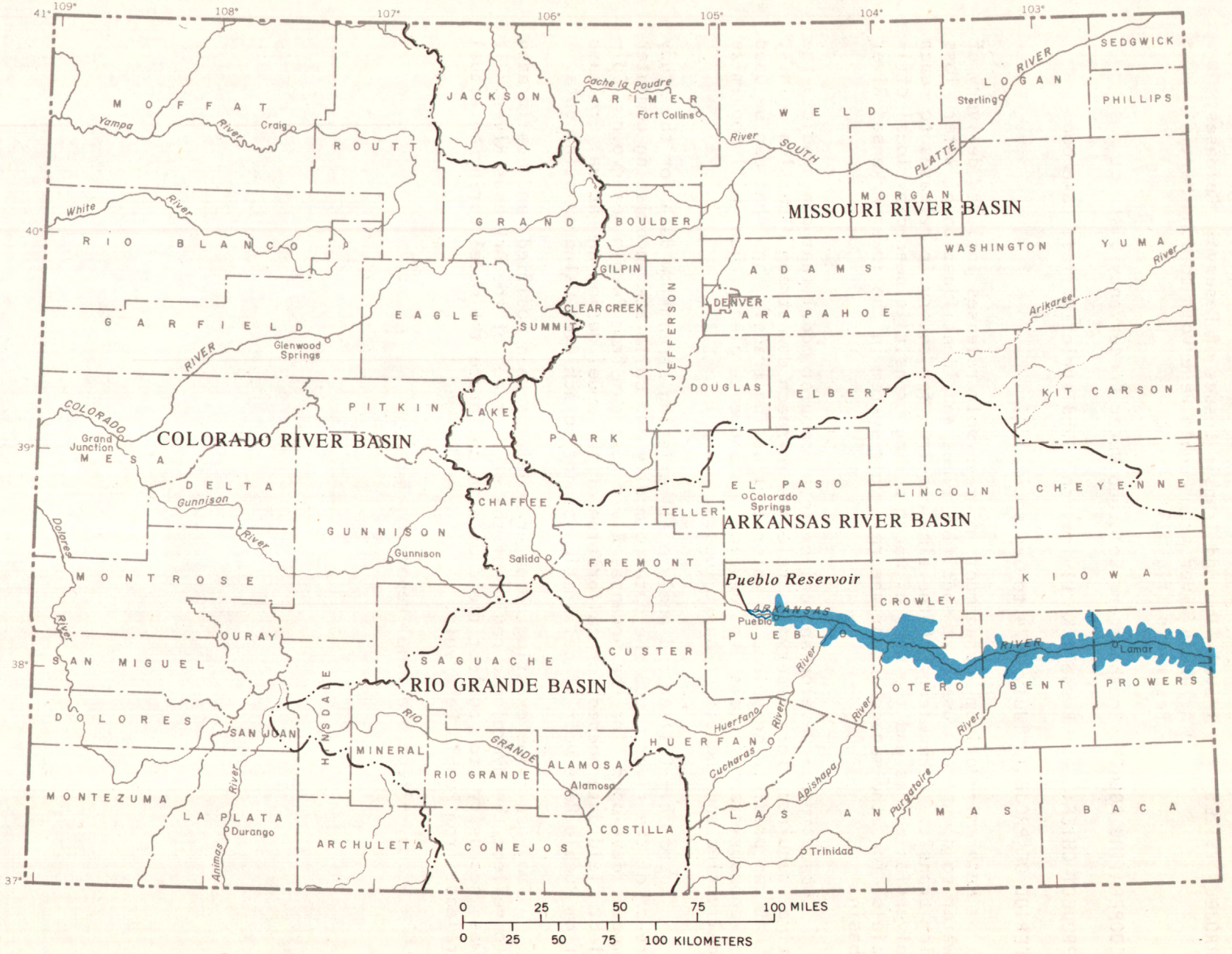

Figure 24.--Location of the Arkansas River valley downstream from Pueblo Reservoir.

PROJECT TITLE: Hydrology of the Arkansas River Valley, Pueblo Reservoir to Colorado-Kansas State Boundary (fig. 24)

COOPERATING AGENCY: Southeastern Colorado Water Conservancy District

PROJECT CHIEF: Richard E. Fidler, Subdistrict Office, Pueblo

PERIOD OF PROJECT: Continuous since July 1961

Problem.--The Arkansas River valley in Colorado, an area of intensive water use, has a variety of water problems. Snowmelt from the mountains provides most of the streamflow. Streamflow is supplemented by water from summer thundershowers and from transmountain diversions. Most of the water inflow occurs upstream from Canon City, but most of the use is downstream from Pueblo. Water in the Arkansas River is over-appropriated and the distribution of water in time and space needs to be known to benefit water users in the valley. Computer models of the valley are needed so that alternative water-management plans involving conjunctive use of surface and ground water can be evaluated.

Objectives.--Collect and analyze hydrologic data needed to define the hydrologic system and to develop and calibrate computer models to be used for planning and administering water use.

Approach.--Provide a continuing inventory of both surface- and ground-water use. Collect data on the natural variations of water availability. Develop and calibrate computer models that will simulate the hydrologic system.

Progress.--The hydrology of the Arkansas River valley has been described and a water-management model of the Arkansas River aquifer system has been developed. Reports have been published on all phases of the study. Water-level data were collected from about 800 wells in the valley.

Plans.--Collect water-level data from wells, evaluate the data, and develop an optimum observation-well network. Update and revise the water-management model as required.

Reports published or released during fiscal year 1976.--See references 17 and 18 under Water-Resources Interpretive Reports at back of report.

PROJECT TITLE: Surface-Water Return Flow from Irrigated Lands to the Arkansas River, Pueblo Reservoir to the Colorado-Kansas State Boundary (fig. 24)

COOPERATING AGENCY: Southeastern Colorado Water Conservancy District

PROJECT CHIEF: Kimball E. Goddard, Subdistrict Office, Pueblo

PERIOD OF PROJECT: October 1976 to September 1977

Problem.--Surface water flowing from irrigated lands to the Arkansas River contains chemical constituents that affect the water quality of the river. A knowledge of the types and quantities of the chemical constituents is needed by local officials to better manage the water resources of the area.

Objectives.--Delineate the areal extent of irrigated lands contributing return flows to the Arkansas River. Determine the volume and water quality of the return flows.

Approach.--Use existing land-use maps and recent aerial photography to delineate the areal extent of irrigated lands. Use records from existing streamflow stations to determine the volume of return flows. Collect samples for chemical analysis; analyze for constituents, such as chloride, nitrate, and pesticides.

Progress.-Delineation of irrigated land and collection of streamflow-discharge and chemical-quality data are in progress.

Plans.-Complete delineation of irrigated lands and data collection. Analyze data and prepare a final report.

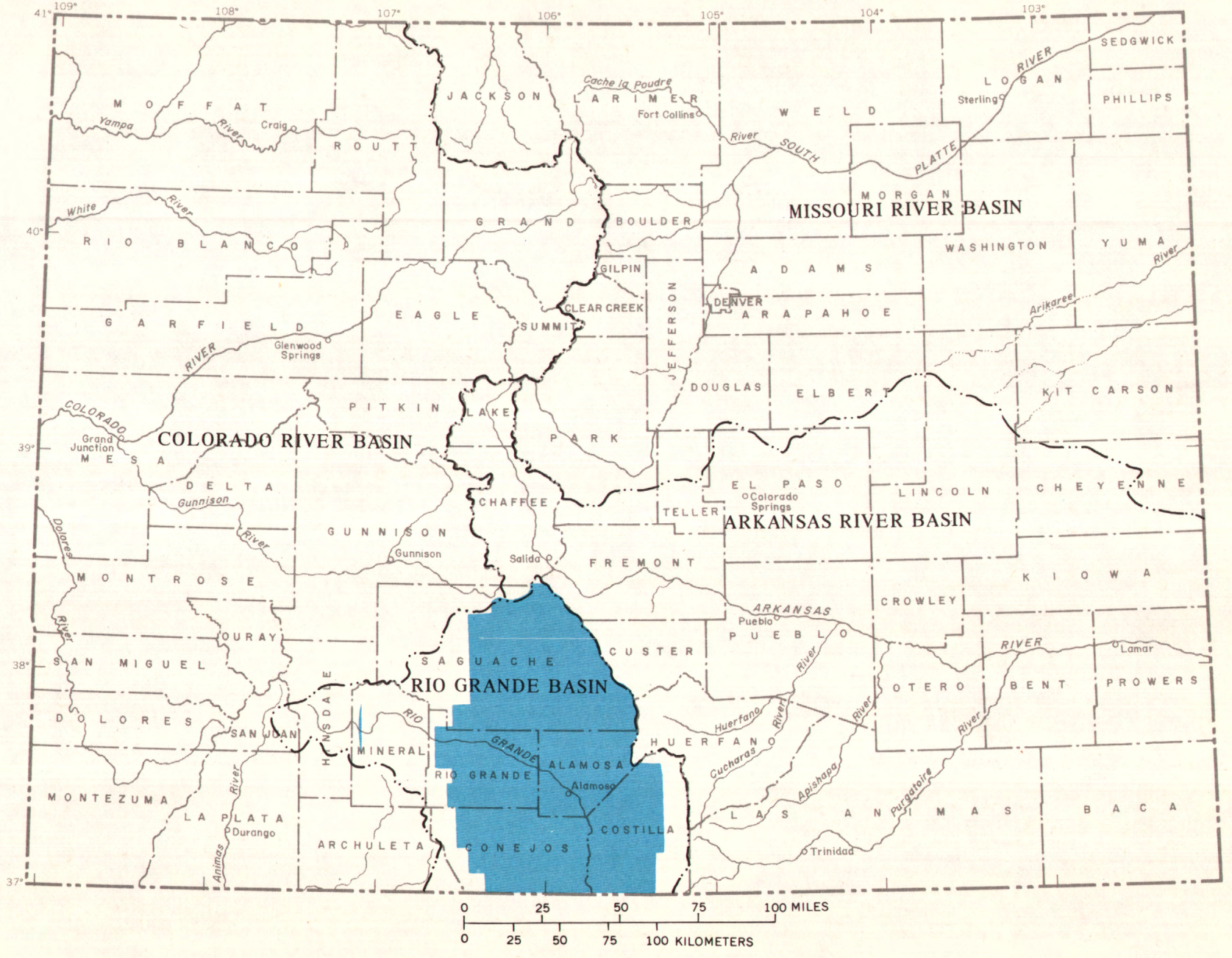

Figure 25.--Location of the San Luis Valley.

PROJECT TITLE: Water Resources of the San Luis Valley in Colorado (fig. 25)

COOPERATING AGENCIES: Rio Grande Water Conservation District and Colorado Department of Natural Resources, Division of Water Resources, Office of the State Engineer

PROJECT CHIEF: Richard E. Fidler, Subdistrict Office, Pueblo

PERIOD OF PROJECT: Continuous since July 1966

Problem.--The San Luis Valley in Colorado is an area of intensive water use. Water problems include increasing competition for existing surface- and ground-water supplies and an alleged deficit in the amount of surface water to be delivered to downstream users in New Mexico and Texas in accordance with the Rio Grande Compact. A knowledge of the hydrologic system of the valley is needed to determine the quantity and quality of the water resources and to provide State and local officials with data that they can use to effectively manage the water resources.

Objectives.--Quantitatively define the hydrologic system. Develop and calibrate models that can be used to predict the effects of alternative water-management proposals provided by State and local officials.

Approach.--Compile existing data and collect additional data to define the hydrologic system. Make a comprehensive inventory of wells and pumpage. Determine stream discharge. Define the areal extent, thickness, and hydrologic properties of the unconfined and confined aquifers. Determine the hydrologic relation between the aquifers. Develop and calibrate hydrologic models.

Progress.--Sufficient data have been collected to define the hydrologic system and to construct and calibrate an electric-analog model. Data collection is continuing for the purpose of refining the predictive capability of the analog model and determining the feasibility of developing a digital-computer model. Reports on all phases of the study have been published.

Plans.--Continue data collection.

Reports published or released during fiscal year 1976.-See reference 4 under Water-Resources Data Reports, and reference 7 under Water-Resources Interpretive Reports at back of report.

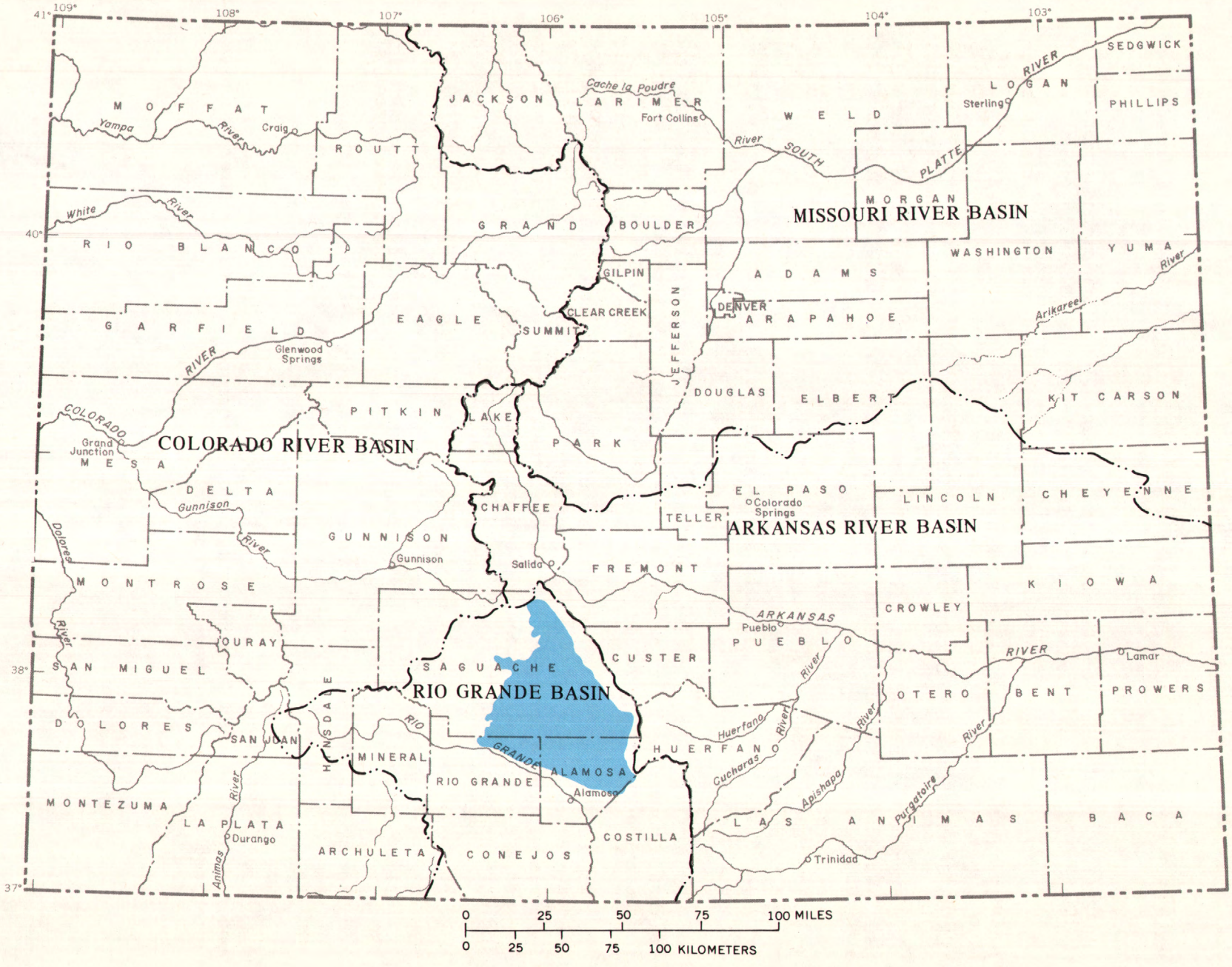

Figure 26.--Location of the closed-basin part of the San Luis Valley.

PROJECT TITLE: Hydrology of the Closed-Basin Part of the San Luis Valley in Colorado (fig. 26)

COOPERATING AGENCY: U.S. Bureau of Reclamation

PROJECT CHIEF: Clark J. Londquist, Subdistrict Office, Pueblo

PERIOD OF PROJECT: Continuous since July 1976

Problem.--Extensive long-term application of water for irrigation has resulted in waterlogging and the accumulation of salts on and near the land surface in many areas of the closed-basin part of the San Luis Valley. Pumping ground water from a series of wells would lower the water table in the closed basin, reduce evaporation losses, and supplement the flow in the Rio Grande. The feasibility of salvaging ground water without adversely affecting the ground-water system in the closed basin and the water quality of the Rio Grande needs to be determined.

Objectives.--Determine the feasibility of salvaging ground water by pumpage from wells. Determine the quality of water pumped from the wells that would be discharged into the Rio Grande. Develop and calibrate flow and chemical-transport computer models of the closed basin.

Approach.--Select areas for installation of wells. Drill test wells in the areas selected. Conduct aquifer tests and geophysical surveys of the test wells. Obtain water samples for chemical analysis from the test wells. Convert suitable test wells to salvage wells. Use the existing electric analog model and existing water-level and water-quality data to develop the computer models. Use existing data and data from the test-well drilling program to calibrate the computer models.

Progress.--Test wells and observation wells have been drilled at two sites by the U.S. Bureau of Reclamation. Vandalism of the wells has prevented the conducting of aquifer tests and geophysical logging by the U.S. Geological Survey.

Plans.--Continue the test-well drilling program. Begin development of the computer models.

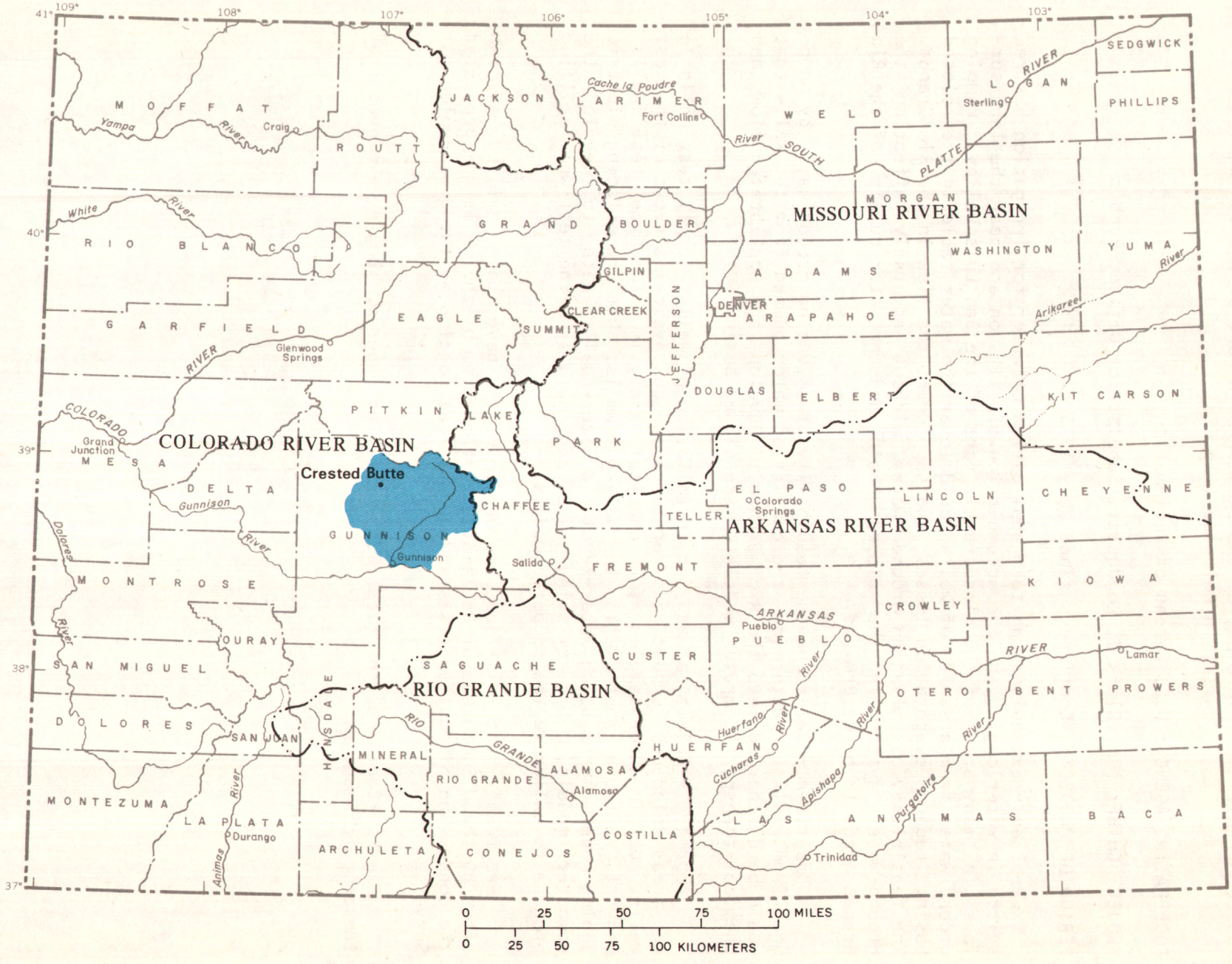

Figure 27.--Location of the Gunnison–Crested Butte area.

PROJECT TITLE: Evaluation of Aquifers, Western Colorado (fig. 27)

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

PROJECT CHIEF: Timothy F. Giles, Subdistrict Office, Grand Junction

PERIOD OF PROJECT: Continuous since October 1974

Problem.--The use of ground water to meet residential, commercial, industrial, recreational, and agricultural needs in western Colorado is increasing because most existing surface-water supplies have been appropriated. To manage the development of the ground-water resources, State and local officials need to know the location and areal extent of the aquifers and the quantity and quality of water found in the aquifers.

Objectives.--Locate and determine the areal extent of aquifers. Determine the quantity and quality of water found in the aquifers.

Approach.--Compile existing geologic and hydrologic data. Determine areas where data collection is needed to establish the geohydrologic characteristics of selected aquifers. Collect and analyze the data required to meet the objectives.

Progress.--Reports describing two areas have been published. Two reports are in preparation. Data collection is in progress for the Gunnison-Crested Butte area.

Plans.--Complete reports in preparation. Complete the study of Gunnison-Crested Butte area and prepare a final report. Select other areas for study in western Colorado.

Reports published or released during fiscal year 1976.--See references 4 and 5 under Water-Resources Interpretive Reports at back of report.

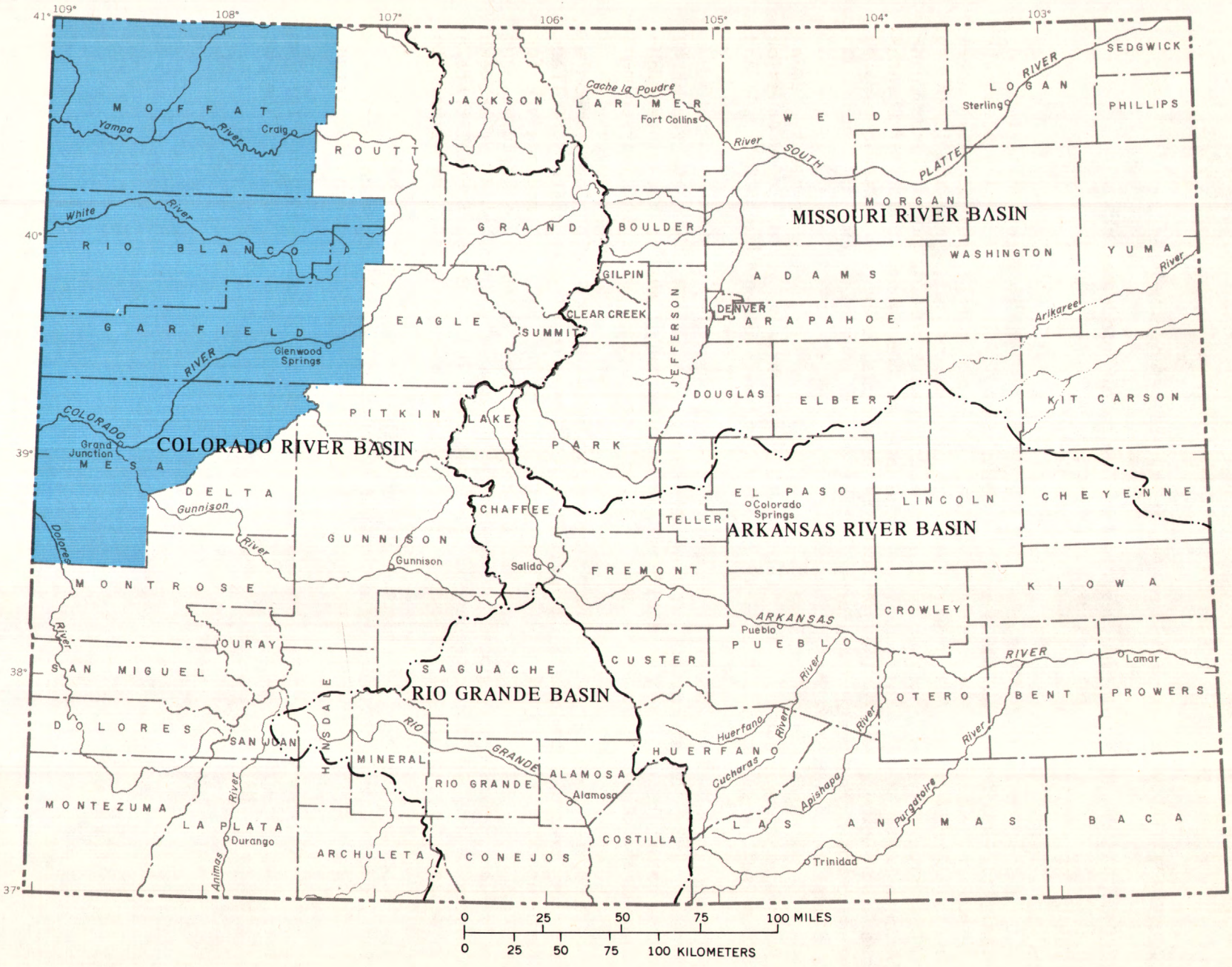

Figure 28.--Location of Garfield, Mesa, Moffat, and Rio Blanco Counties.

PROJECT TITLE: Quality of Streams in Garfield, Mesa, Moffat, and Rio Blanco Counties (fig. 28)

COOPERATING AGENCY: Colorado West Area Council of Governments

PROJECT CHIEF: Thomas R. Ford, Subdistrict Office, Meeker

PERIOD OF PROJECT: August 1976 to September 1978

Problem.--Section 208 of Public Law 92-500, Federal Water Pollution Control Act, Amendment of 1972, requires that local government agencies be established to identify and eliminate sources of water-quality pollution in urban areas. The Colorado West Area Council of Governments has been established to implement those requirements in Garfield, Mesa, Moffat, and Rio Blanco Counties. As part of their activities, the Colorado West Area Council of Governments requested the U.S. Geological Survey to determine the existing quality of streams in the four-county area.

Objectives.--Determine the quality of streams in the four-county area. Determine the capacity of the Colorado River in the vicinity of Grand Junction to assimilate waste loads introduced into the river between Palisade and Fruita.

Approach.--Incorporate water-quality data currently being collected at 47 stream stations in the four-county area into the data base for this investigation. Install five new stations. Collect streamflow and suspended-sediment data on a daily basis at one of the new stations. Collect samples on a monthly basis at all of the new stations and analyze for major ions, ammonia, chemical oxygen demand, Kjeldahl nitrogen, and total phosphate. Collect samples on a quarterly basis at all of the new stations and analyze for arsenic, dissolved organic carbon, iron, lead, manganese, mercury, and selenium. Conduct an intensive 24-hour sampling of the Colorado River between Palisade and Fruita to obtain the data needed to develop and calibrate a computer model that will be able to predict the capacity of the river to assimilate waste loads.

Progress.--Five new stations have been installed and data collection is in progress. The 24-hour sampling of the Colorado River has been completed.

Plans.--Continue data collection. Analyze data obtained during the 24-hour sampling of the Colorado River and begin development and calibration of the waste-assimilative-capacity model.

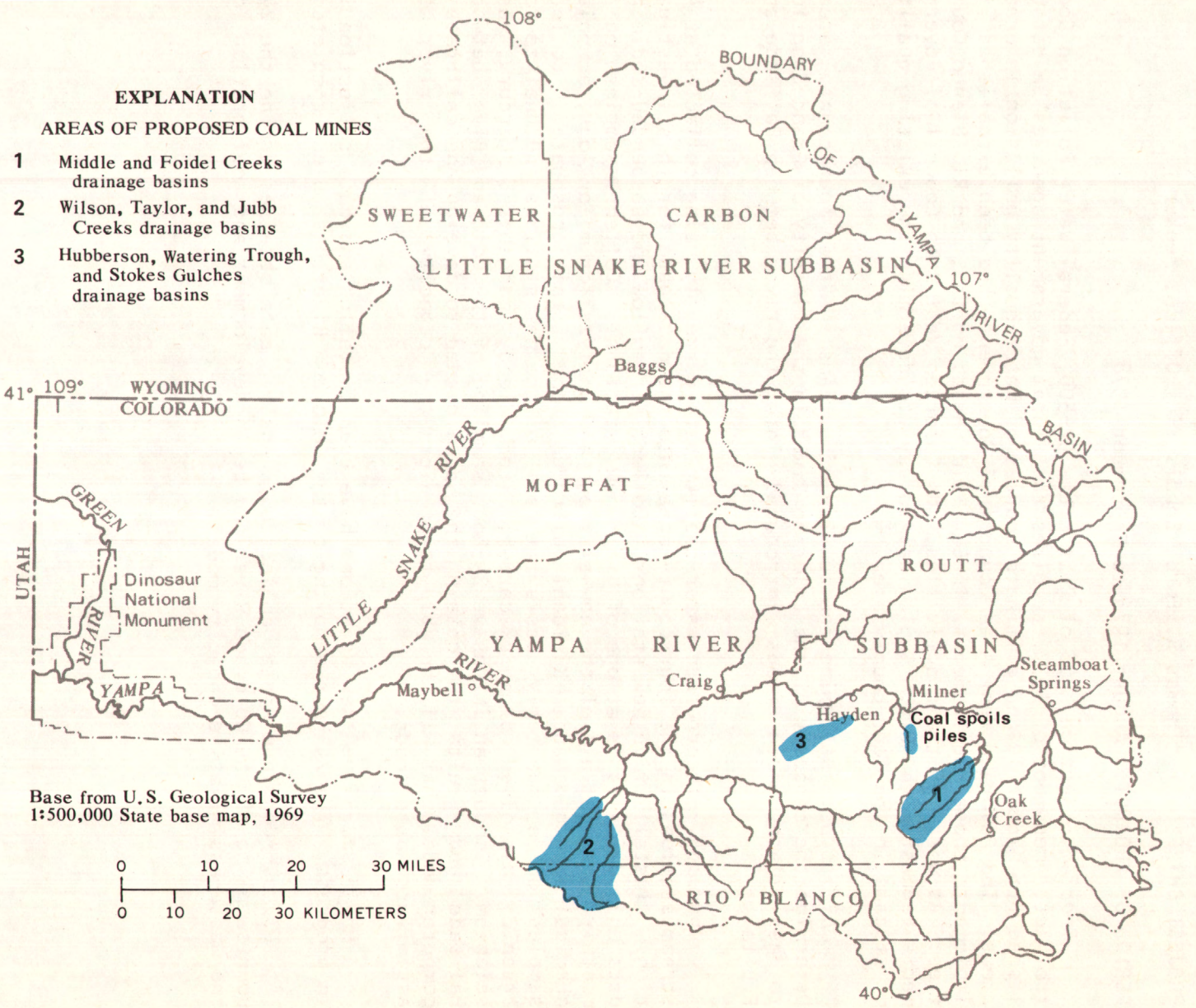

Figure 29.--Location of the Yampa River basin, Colorado–Wyoming, and areas of proposed coal mines and coal-spoils piles.

PROJECT TITLE: Yampa River Basin Assessment Study--An Evaluation of the Effects of Alternative Energy-Development Proposals on the Environment (fig. 29)

COOPERATING AGENCY: None

PROJECT CHIEF: Timothy D. Steele, District Office, Lakewood

PERIOD OF PROJECT: April 1975 to December 1977

Problem.--The imminent expansion of energy-resources development, principally coal, in the Yampa River basin of Colorado and Wyoming will affect both the hydrologic system of the basin and the social and economic conditions of people living in the basin. Evaluations of alternative energy-development proposals need to be made prior to the anticipated large-scale expansion to determine the effects of the proposals on the environment and people of the basin.

Objectives.--Determine the existing hydrologic, social, and economic conditions in the basin. Develop and calibrate computer models to determine the effects of alternative energy-development proposals. Convey the results of the computer analyses to Federal, State, and local officials who will determine, based in part on the analyses, the method or methods of energy-resources development to be used in the basin.

Approach.--Collect and analyze hydrologic data needed to define the existing hydrologic system. Collect and analyze data related to social and economic conditions. Use both the hydrologic and nonhydrologic data to develop and calibrate the computer models.

Progress.--Field-data collection has been completed. Contracts have been awarded to private firms to determine water rights and diversions within the basin, institutional constraints, and social and economic aspects. Development of a salinity computer model and a waste-load assimilative-capacity computer model has been started.

Plans.--Complete all data analysis and computer-model development. Prepare final reports.

Reports published or released during fiscal year 1976.--See references 22 and 23 under Water-Resources Interpretive Reports at back of report.

PROJECT TITLE: Hydrology of Proposed Coal-Mining Areas, Moffat, Rio Blanco, and Routt Counties (fig. 29)

COOPERATING AGENCY: U.S. Bureau of Land Management

PROJECT CHIEF: George H. Leavesley, District Office, Lakewood

PERIOD OF PROJECT: July 1974 to September 1977

Problem.--To evaluate the impact of coal mining in the Yampa River basin, the hydrologic system of proposed coal-mining areas needs to be defined prior to the start of mining activities. Because it will not be possible to directly determine the hydrologic system of every proposed coal-mining area, a method of evaluation needs to be developed that can be easily adapted to areas for which detailed studies of the hydrologic system are not planned.

Objectives.--Determine the existing quantity and quality of surface- and ground-water resources and predict the effects of coal mining on the hydrologic system. Develop and calibrate a computer model that can be used to predict the effects of coal mining on the hydrology in areas for which intensive studies are not planned.

Approach.--Select areas for intensive study. Install streamflow-gaging stations and two-parameter water-quality monitors in each area. Collect water samples on a monthly basis for analysis of major chemical constituents. Collect water samples on a quarterly basis for analysis of trace elements. Install one climatological station and several precipitation gages in each area. Drill test wells in each area. Test all wells to determine the hydraulic characteristics of the alluvial and bedrock aquifers. After aquifer testing is completed, convert the wells to observation wells and measure water levels on a periodic basis. Collect water samples for chemical analysis.

Progress.--Three areas have been selected; area 1--drainage basins of Middle and Foidel Creeks, area 2--drainage basins of Wilson, Taylor, and Jubb Creeks, and area 3--drainage basins of Hubberson, Watering Trough, and Stokes Gulches. All data-collection instruments have been installed in areas 1 and 2. Test wells have been drilled, aquifer tests made, and test wells converted to observation wells. Collection of water-quality data is in progress.

Plans.--Complete installation of equipment and continue to collect surface- and ground-water data. Begin development and calibration of computer model.

PROJECT TITLE: Hydrology and Reclamation Potential of Coal-Spoils Piles (fig. 29)

COOPERATING AGENCIES: U.S. Bureau of Land Management and the U.S. Environmental Protection Agency

PROJECT CHIEF: George H. Leavesley, District Office, Lakewood

PERIOD OF PROJECT: July 1975 to September 1977

Problem.--Coal mining will create large areas of spoils piles. The hydrology and reclamation potential of the piles need to be known so that the effects of the piles on the hydrologic system beneath and adjacent to the piles can be determined. Because it will not be possible to directly determine the hydrology and reclamation potential of all spoils piles, a method of evaluation needs to be developed that can be easily adapted to spoils piles for which detailed studies are not planned.

Objectives.--Determine the hydrologic characteristics of coal-spoils piles. Determine changes in chemical quality as water moves through the piles. Determine the effects of various reclamation procedures on the hydrology of the piles. Determine the effects of the piles on the hydrologic system beneath and adjacent to the piles. Develop and calibrate a computer model that can be used to predict the hydrology and reclamation potential of the piles and the effects of the piles on the hydrologic system beneath and adjacent to the piles in areas for which intensive studies are not planned.

Approach.--Install five lysimeters, three in a spoils area and two in an unmined area. Use rainfall simulators to produce runoff into two lysimeters in the spoils area and one lysimeter in the unmined area. Determine the quantity and quality of water percolating into the lysimeters. Drill observation wells adjacent to the lysimeters to determine soil-moisture regimes. Apply various reclamation treatments to the surface of the spoils areas. Use rainfall simulators to stress the treated areas. Drill six wells of equivalent depth in the spoils and unmined areas. Measure water levels in and collect water samples for chemical analysis from all the wells. Use the drill cuttings from the wells to construct laboratory columns; percolate water through the columns and collect water samples for chemical analysis at predetermined times. Correlate water-quality analyses from the lysimeters, observation wells, and laboratory columns. Develop and calibrate a computer model.

Progress.--The five lysimeters have been installed.

Plans.--Drill the observation wells. Begin data collection.

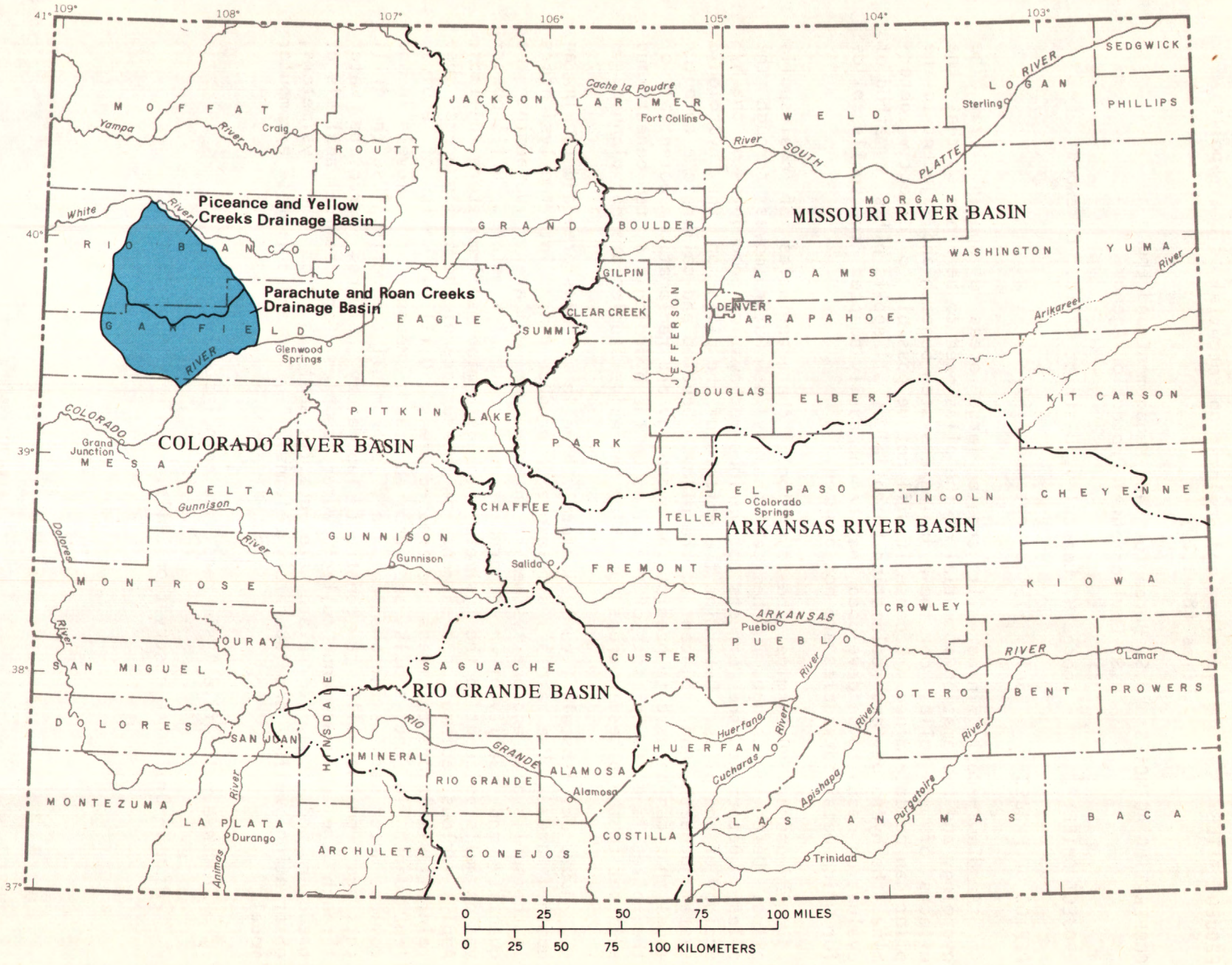

Figure 30.--Location of Piceance and Yellow Creeks and Parachute and Roan Creeks drainage basins.

PROJECT TITLE: Hydraulic Research of Springs, Piceance Creek and Yellow Creek Drainage Basins (fig. 30)

COOPERATING AGENCY: None

PROJECT CHIEF: George J. Saulnier, Jr., Subdistrict Office, Meeker

PERIOD OF PROJECT: July 1974 to September 1977

Problem.--Aquifer dewatering resulting from oil-shale mining will reduce ground-water discharge to many springs that are used as a water supply for livestock and irrigation. Water quality also may be affected by aquifer dewatering. The geologic source, water quality, and hydraulics of the springs need to be known prior to the beginning of oil-shale mining so that the effects of aquifer dewatering on the springs can be determined.

Objectives.--Locate and determine the geologic source of major springs, determine their water quality and flow characteristics, and determine the effects of aquifer dewatering on water quality and discharge.

Approach.--Use infrared aerial photography and thermal imagery to locate the springs. Use concentrations of dissolved fluoride and chloride and water temperature to aid in determining the geologic source of the springs. Install flumes at about 90 springs to measure discharge.

Progress.--All springs have been located and field checked. A grant was awarded to the Colorado Department of Natural Resources, Division of Water Resources, Office of the State Engineer, for the purpose of collecting water-quality samples and discharge measurements. Water-quality and discharge data have been collected from 89 springs. Data collection has been completed.

Plans.--Analyze data and prepare reports. Plan for continued collection of water-quality and discharge data throughout the prototype phase of oil-shale development.

PROJECT TITLE: Observation-Well Drilling and Potentiometric-Surface Mapping, Piceance Creek and Yellow Creek Drainage Basins (fig. 30)

COOPERATING AGENCY: None

PROJECT CHIEF: Frank A. Welder, Subdistrict Office, Meeker

PERIOD OF PROJECT: July 1974 to September 1977

Problem.--Aquifer dewatering resulting from oil-shale mining will alter the existing steady-state conditions of the ground-water system. The existing steady-state conditions need to be known prior to the beginning of oil-shale mining so that the effects of aquifer dewatering on the ground-water system can be determined.

Objectives.--Determine the predevelopment potentiometric surfaces for the two bedrock aquifers in the basin. Use the data to improve the predictive capability of the existing computer model of the ground-water system.

Approach.--Drill 22 observation wells and convert existing core holes to observation wells to supplement the existing observation-well network. Complete 12 of the new observation wells in each of the aquifers. Collect water-quality and discharge data from each well during drilling. Determine geophysical characteristics of each well after drilling is completed. Install continuous water-level recorders on seven existing observation wells. Measure water levels periodically in all observation wells. Construct a potentiometric-surface map for each aquifer. Use the data to improve the calibration of the computer model.

Progress.--A drilling contract was awarded to a private firm; 25,092 feet were drilled. Water-temperature and specific-conductance data, water samples for chemical analysis, and discharge-rate measurements have been collected during the drilling. Geophysical logging has been completed. Water levels have been measured in 58 wells. Data collection has been completed.

Plans.--Analyze data and prepare reports. Plan for continued collection of water-level data throughout the prototype phase of oil-shale development.

PROJECT TITLE: Aquifer Testing, Piceance Creek and Yellow Creek Drainage Basins (fig. 30)

COOPERATING AGENCY: None

PROJECT CHIEF: Frank A. Welder, Subdistrict Office, Meeker

PERIOD OF PROJECT: July 1974 to September 1977

Problem.--The effects of aquifer dewatering resulting from oil-shale mining can be predicted using a computer model. However, the accuracy of the model depends on the definition of the transmissive and storage properties of the two aquifers and of the vertical-hydraulic conductivity of the confining layer that separates the aquifers. Existing data are inadequate to reliably define the regional variations in aquifer properties. The vertical-hydraulic conductivity of the confining layer has been only estimated.

Objectives.--Determine the regional variations in aquifer properties and the vertical-hydraulic conductivity of the confining layer. Use the data to improve the predictive capability of the existing computer model.

Approach.--Select eight aquifer-test sites based on the data obtained from the observation-well drilling and potentiometric-surface mapping project. Drill one test hole for use as the production well at each site. The test holes will penetrate both aquifers and the confining layer. Use the observation wells mentioned above for the aquifer tests. Conduct the aquifer tests. Analyze the aquifer-test data using the leaky-aquifer theory. Use the data to improve the calibration of the computer model.

Progress.--Based upon the results of the three tests and aquifer tests made by lessees of the oil-shale tracts, it was determined that leaky-aquifer tests cannot provide conclusive results within reasonable testing time and cost. Therefore, no additional tests were completed. A contract was awarded to a private firm to rehabilitate eight existing wells to prevent flow between aquifers in the well bores; the contract has been completed.

Plans.--Determine the feasibility of conducting conventional aquifer tests. Prepare a contract to rehabilitate additional existing wells.

PROJECT TITLE: Geochemical Investigation, Piceance Creek and Yellow Creek Drainage Basins (fig. 30)

COOPERATING AGENCY: None

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

PERIOD OF PROJECT: July 1974 to September 1977

Problem.--Aquifer dewatering resulting from oil-shale mining will induce recharge to the two bedrock aquifers and change existing flow patterns within the aquifers. The existing chemical equilibrium may be altered, resulting in the solution of minerals and increased dissolved-solids concentrations. Presently, the dissolved-solids concentrations range from a few hundred to more than 60,000 milligrams per liter. The discharge of the very saline water into springs and streams could result in a serious pollution problem. The existing chemical equilibrium needs to be known prior to the beginning of oil-shale mining so that the effects of aquifer dewatering on the chemical equilibrium can be determined.

Objectives.--Determine the present water quality in the aquifers. Develop a solute-transport computer model that can be coupled with the existing ground-water flow computer model to predict the effects of aquifer dewatering on water quality.

Approach.--Collect samples for chemical analysis from wells and springs. Develop a three-dimensional solute-transport model that will be able to predict water-quality changes both within and between the aquifers. Use the water-quality data collected from wells and springs to calibrate the model.

Progress.--Collection of water-quality data has been completed. Development and calibration of a solute-transport model is in progress.

Plans.--Complete development and calibration of the solute-transport model. Analyze data and prepare reports.

PROJECT TITLE: Sediment Yield of Streams, Piceance Creek and Yellow Creek Drainage Basins (fig. 30)

COOPERATING AGENCY: None

PROJECT CHIEF: Vernon W. Norman, Subdistrict Office, Meeker

PERIOD OF PROJECT: July 1974 to September 1977

Problem.--Prototype oil-shale development will involve the mining, processing, and disposal of an estimated 150,000 tons of oil shale per day. Handling and disposal of this quantity of material may increase the sediment load in streams. Increases in sediment yield alters channel geometry and morphology and reduces the conveyance capacity of streams. The existing sediment yield of streams needs to be known prior to the beginning of oil-shale mining so that the effects of the mining on sediment yield of streams can be determined.

Objectives.--Determine the present sediment yield of streams draining the basin. Determine the erosion potential of the lands that are to be mined.

Approach.--Install automatic suspended-sediment samplers and automatic turbidity monitors on streams. Maintain and monitor channel cross sections and hillslope erosion transects established during a previous project.

Progress.--Twenty-seven automatic suspended-sediment samplers and two automatic turbidity monitors have been installed. Fifty-two channel cross sections and 35 hillslope erosion transects have been resurveyed periodically. Data collection has been completed.

Plans.--Analyze data and prepare reports. Plan for continued collection of sediment data throughout the prototype phase of oil-shale development.

Reports published or released during fiscal year 1976.--See reference 8 under Water-Resources Interpretive Reports at back of report.

PROJECT TITLE: Occurrence of Benthic Invertebrates, Piceance Creek Drainage Basin (fig. 30)

COOPERATING AGENCY: None

PROJECT CHIEF: Kenneth J. Covay, Subdistrict Office, Meeker

PERIOD OF PROJECT: October 1976 to September 1979

Problem.--Oil-shale mining may adversely affect the water quality in Piceance Creek. Because of their sensitivity to slight changes in water quality, benthic invertebrates can be used to determine the effects of mining on the water quality of the creek. However, it is necessary to know the types and numbers of benthic invertebrates living in the creek prior to the beginning of mining before they can be used as an indicator of changes in water quality.

Objectives.--Determine the types and numbers of benthic invertebrates living in the creek. Relate the populations of benthic invertebrates to the physical and chemical properties of the water. Determine which physical and chemical properties of the water are limiting factors for the various populations. Determine the influence of habitat on populations. After collection and removal of benthic invertebrates, determine the rate of recolonization at the collection sites.

Approach.--Collect benthic invertebrates at six sites on a monthly basis--four sites on Piceance Creek and two sites on tributaries. Use a Surber sampler when possible, otherwise use a hand-operated Eckman dredge. Install 2 to 5 artificial substrates at each site. Identify populations to the species level.

Progress.--Artificial substrates have been installed at all the sites. Benthic invertebrates are being collected at all sites.

Plans.--Continue data collection.

PROJECT TITLE: Hydrologic Reconnaissance of Parachute Creek and Roan Creek Drainage Basins (fig. 30)

COOPERATING AGENCY: None

PROJECT CHIEF: D. Briane Adams, Subdistrict Office, Grand Junction

PERIOD OF PROJECT: July 1974 to September 1977

Problem.--Parachute Creek and Roan Creek drainage basins are sites of potential oil-shale development on privately owned lands. Previous investigations of the hydrology of the Piceance structural basin have not included an intensive hydrologic appraisal of these drainage basins. Both streams are tributary to the Colorado River, whose water-quality characteristics are of national and international interest. The present hydrologic conditions need to be known prior to the beginning of oil-shale mining so that the effects of the mining on the water quality of the Colorado River can be determined.

Objective.--Determine the present hydrologic conditions in the two basins.

Approach.--Install hydrologic monitoring stations to collect stream-discharge and sediment-yield data. Collect water-quality data from the streams. Locate springs and collect discharge and water-quality data. Contact land owners to determine the types of hydrologic data they are collecting and to obtain permission to establish an observation-well network using their existing wells.

Progress.--Four continuous-record surface-water stations have been established. Two of the stations are equipped with automatic suspended-sediment samplers and two-parameter water-quality monitors. Twelve surface-water stations are maintained by land owners; records from these stations will be made available to the U.S. Geological Survey. Discharge and water-quality data have been collected at 25 springs. An observation-well network of 11 shallow and 3 deep wells has been established. Water-quality data have been collected from the wells.

Plans.--Continue to collect data at present stations. Locate and collect data at additional springs. Expand observation-well network. Plan for continued collection of hydrologic data throughout the prototype phase of oil-shale development. Coordinate project activities with the activities of the project that is to determine the hydrologic conditions on the U.S. Naval Oil Shale Reserve No. 1, which is located in the Parachute Creek drainage basin.

PROJECT TITLE: Hydrologic Reconnaissance of the U.S. Naval Oil Shale Reserve No. 1, Parachute Creek Drainage Basin (fig. 30)

COOPERATING AGENCY: U.S. Department of the Navy

PROJECT CHIEF: D. L. Collins, Subdistrict Office, Grand Junction

PERIOD OF PROJECT: October 1976 to September 1979

Problem.--The U.S. Naval Oil Shale Reserve No. 1 is a site of potential oil-shale development. Previous investigations of the hydrology of the Piceance structural basin have not included an intensive hydrologic appraisal of the reserve. Streams draining the reserve are tributary to the Colorado River, whose water-quality characteristics are of national and international interest. The present hydrologic conditions of the reserve need to be known prior to the beginning of oil-shale mining so that the effects of the mining on the water quality of the Colorado River can be determined.

Objective.--Determine the present hydrologic conditions of the reserve.

Approach.--Install hydrologic monitoring stations to collect precipitation, stream-discharge, and sediment-yield data. Collect water-quality data from the streams. Locate springs and collect discharge and water-quality data. Drill a minimum of 10 test holes. Collect geologic, discharge, and water-quality data during the drilling of the test holes. After drilling is completed, collect geophysical data from each test hole and conduct one to three aquifer tests in each test hole. Locate existing wells and collect water-level and water-quality data.

Progress.--A data-collection network consisting of five streamflow stations, two automatic sediment samplers, three precipitation gages, and one weather station has been established. A preliminary drilling contract has been prepared.

Plans.--Continue to collect data at present stations. Finalize and award drilling contract. Coordinate project activities with the activities of the project that is to determine the hydrologic conditions in the Parachute Creek and Roan Creek basins.

REPORTS PUBLISHED OR RELEASED DURING FISCAL YEAR 1976

Reports published or released during fiscal year 1976 may be purchased or inspected as follows:

U.S. GEOLOGICAL SURVEY: MISCELLANEOUS INVESTIGATIONS MAPS--May be purchased over the counter or by mail from:

U.S. Geological Survey, Branch of Distribution
Box 25286, Building 41
Denver Federal Center
Denver, Colorado 80225

U.S. GEOLOGICAL SURVEY: WATER-RESOURCES INVESTIGATIONS, OPEN-FILE REPORTS, AND WATER-RESOURCES DATA REPORTS--May be inspected at the following locations:

U.S. Geological Survey, Colorado District Office
Room H-2103, Building 53
Denver Federal Center
Denver, Colorado 80225

U.S. Geological Survey, Library
1526 Cole Blvd. at West Colfax Ave.
Golden, Colorado
(Mail address: Box 25046, Mail Stop 914,
Denver Federal Center
Denver, Colorado 80225)

U.S. Geological Survey, Public Inquiries Office
Room 1012, Federal Building
1961 Stout Street
Denver, Colorado 80294

COLORADO WATER CONSERVATION BOARD: WATER-RESOURCES CIRCULARS AND BASIC-DATA RELEASES--May be purchased from:

Colorado Water Conservation Board
1313 Sherman Street
Denver, Colorado 80203

COLORADO GEOLOGICAL SURVEY: BULLETINS--May be purchased from:

Colorado Geological Survey
1313 Sherman Street
Denver, Colorado 80203

Water-Resources Data Reports

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2. _____1976, Lakes in the Colorado Springs-Castle Rock area, Front Range urban corridor, Colorado: U.S. Geol. Survey Miscellaneous Inv. Map I-857-E, 1 sheet.
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4. Brogden, R. E., and Giles, T. F., 1976, Availability and chemical characteristics of ground water in central La Plata County, Colorado: Lakewood Colo., U.S. Geol. Survey Water-Resources Inv. 76-69, map, 1 sheet.
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6. Burns, A. W., and Weeks, J. B., Simulated effects of the proposed Narrows Reservoir on the water-table aquifer, Morgan County, Colorado: U.S. Geol. Survey Open-File Rept. 76-379, 15 p.

7. Emery, P. A., Patten, E. P., Jr., and Moore, J. E., 1975, Analog model study of the hydrology of the San Luis Valley, south-central Colorado: Colorado Water Conserv. Board Water Resources Circ. 29, 21 p.
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19. McCain, J. F., and Hotchkiss, W. R., 1975, Map showing flood-prone areas, Greater Denver area, Front Range urban corridor, Colorado: U.S. Geol. Survey Miscellaneous Inv. Map I-856-D, 1 sheet.
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