WATER-RESOURCES INVESTIGATIONS
OF THE U.S. GEOLOGICAL SURVEY
IN COLORADO--Fiscal Year 1981

Compiled by William E. Price, Jr.

U.S. GEOLOGICAL SURVEY

Open-File Report 81-150

Lakewood, Colorado

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UNITED STATES DEPARTMENT OF THE INTERIOR

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GEOLOGICAL SURVEY

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CONTENTS

ILLUSTRATIONS

CONTENTS--Continued

CONTENTS--Continued

TABLE

METRIC CONVERSION FACTORS

Multiply	*By*	*To obtain*
foot	0.3048	meter
mile	1.609	kilometer
acre	0.4047	hectare
square mile	2.590	square kilometer
gallon per minute	0.06309	liter per second
acre-foot	0.001233	cubic hectometer
ton	0.9072	metric ton

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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 1981 fiscal year (October 1, 1980, to September 30, 1981).

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

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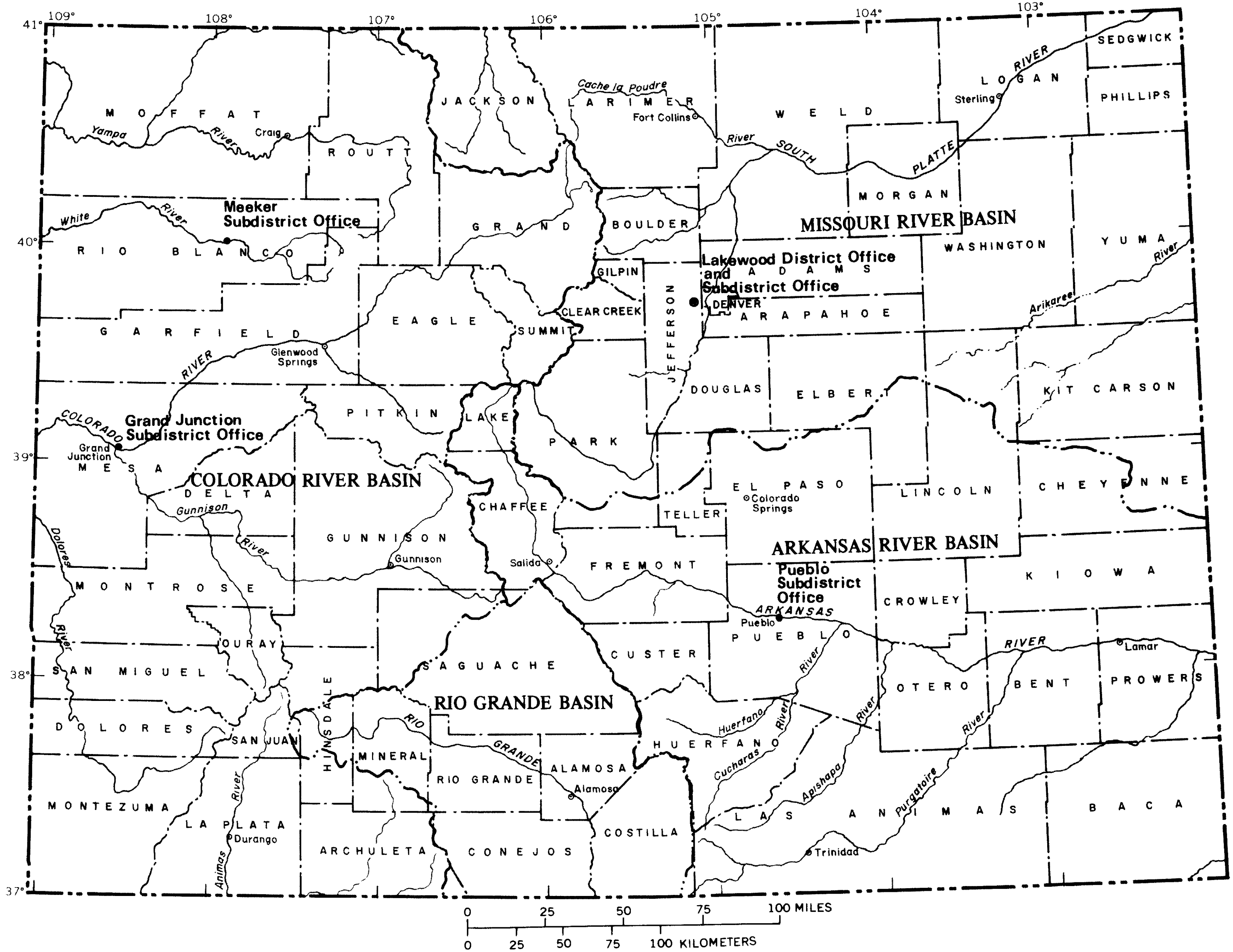

Figure 1.--Location of major river basins and offices of the U. S. Geological Survey's Colorado District.

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COOPERATING AGENCIES

In Colorado, some of the water-resources data-collection activities and interpretive hydrologic investigations are conducted in cooperation with Federal, State, and local agencies. Those agencies cooperating with the U.S. Geological Survey during fiscal year 1981 are:

Adams County Board of Commissioners
Arapahoe County
Arkansas River Compact Administration
Central Yuma Groundwater Management District
Cherokee Water District
City of Aspen
City of Aurora
City of Colorado Springs, Department of Public Utilities
City of Colorado Springs, Office of the City Manager
City and County of Denver, Board of Water Commissioners
City of Glenwood Springs
Colorado Department of Highways
Colorado Department of Natural Resources
Colorado Water Conservation Board
Division of Water Resources,
Office of the State Engineer
Division of Wildlife
Colorado River Water Conservation District
Denver Regional Council of Governments
Eagle County Board of Commissioners
El Paso County Board of Commissioners
Frenchman Groundwater Management District
Larimer-Weld Regional Council of Governments
Marks Butte Groundwater Management District
Metropolitan Denver Sewage Disposal District No. 1
Mineral County

Northern Colorado Water Conservancy District
Pitkin County Board of County Commissioners
City of Pueblo
Pueblo Area Council of Governments
Purgatoire River Water Conservancy District
Rio Grande Water Conservation District
Sand Hills Groundwater Management District
Southeastern Colorado Water Conservancy District
Southwestern Water Conservation District
St. Vrain and Left Hand Water Conservancy District
Trinchera Conservancy District
Uncompaghre Valley Water Users Association
Upper Arkansas River Water Conservancy District
Urban Drainage and Flood Control District
White River Soil Conservation District
U.S. Air Force Academy
U.S. Department of the Army
- Corps of Engineers
- Fort Carson

U.S. Department of Energy
U.S. Department of the Interior
- Bureau of Indian Affairs
- Bureau of Land Management
- Bureau of Mines
- Water and Power Resources Service

U.S. Environmental Protection Agency
U.S. General Services Administration
U.S. Office of Surface Mining

COLLECTION OF WATER-RESOURCES DATA

Hydrologic-data stations are maintained at selected locations throughout Colorado and constitute a water-resources-data network for obtaining records on stream discharge and stage, reservoir and lake storage, ground-water levels, well and spring discharge, and the quality of surface and ground water. Every year some stations are added and others are terminated; thus, the U.S. Geological Survey has both a current and a historical file of hydrologic data. Most water-resources data are stored in the U.S. Geological Survey's 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, 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 stations given below.

Station classification	*Number of stations*	
Stream stations	471	
Continuous record		450
Partial record		21
Lake and reservoir stations	32	
Total	503	

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 143 of the surface-water stations listed above and also at 18 other 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. Not listed in table 1 are 291 stations at which miscellaneous measurements of temperature and specific conductance are made and 87 stations at which miscellaneous measurements of temperature only are made.

The types of data determined at all of 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	539		
Water temperature		539	
Daily			77
Monthly			111
Quarterly			24
Intermittently			404
Specific conductance		452	
Daily			75
Monthly			111
Quarterly			24
Intermittently			336
pH		157	
Daily			5
Monthly			111
Quarterly			24
Intermittently			22
Dissolved oxygen		157	
Daily			5
Monthly			111
Quarterly			24
Intermittently			22
Suspended-sediment data	87		
Daily			40
Monthly			47
Chemical data			
Inorganic constituents		157	
Monthly			111
Quarterly			24
Semiannually			1
Intermittently			21
Pesticides		25	
Monthly			2
Quarterly			11
Semiannually			8
Annually			4
Radiochemical data	31		
Monthly			1
Quarterly			13
Semiannually			15
Annually			2
Bacteriological data	45		
Monthly			26
Quarterly			13
Semiannually			6
Biological data	20		
Monthly			19
Quarterly			0
Annually			1

In addition to the water-quality data collected at the 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 55 observation wells (pl. 1) is maintained in Colorado by the U.S. Geological Survey. In addition, a network of about 1,151 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*
Continuous	40
Monthly	100
Bimonthly	52
Semiannually	273
Annually	2,193
Intermittently	600
Total	3,258

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

Sixty-seven interpretive hydrologic investigations are being conducted during fiscal year 1981. These include 12 statewide investigations, 6 regional investigations, 9 investigations in the Missouri River basin, 8 investigations in the Arkansas River basin, 6 investigations in the Rio Grande basin, 21 investigations in the Colorado River basin, and 5 multistate investigations. 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 operating on October 1, 1980, by county*

County	Surface-water stations				Ground-water stations
	Continuous record	Partial record	Lake and reservoir	Water quality	Wells
Adams----------	3	0	0	0	54
Alamosa--------	0	0	0	0	85
Arapahoe-------	3	0	1	3	25
Archuleta------	8	0	0	0	15
Baca-----------	0	0	0	0	45
Bent-----------	4	0	1	1	127
Boulder--------	6	2	0	2	47
Chaffee--------	5	1	0	0	6
Cheyenne-------	0	0	0	0	57
Clear Creek----	2	0	0	0	0
Conejos--------	8	0	4	1	25
Costilla-------	6	0	0	0	44
Crowley--------	0	0	0	0	37
Custer---------	1	0	0	0	18
Delta----------	13	0	0	0	17
Denver---------	3	1	0	1	7
Dolores--------	2	0	0	0	1
Douglas--------	2	0	2	2	19
Eagle----------	27	2	1	3	10
Elbert---------	0	0	0	0	24
El Paso--------	18	0	0	6	125
Fremont--------	5	0	0	1	7
Garfield-------	20	1	0	9	15
Gilpin---------	1	0	0	0	0
Grand----------	24	0	3	3	14
Gunnison-------	12	0	1	2	17
Hinsdale-------	5	0	0	0	2
Huerfano-------	2	0	0	0	8
Jackson--------	11	0	0	5	12
Jefferson------	7	7	1	5	15
Kiowa----------	0	0	0	0	20
Kit Carson-----	0	0	0	0	209

Table 1.--*Water-resources data-collection stations operating on October 1, 1980, by county*--Continued

County	Surface-water stations				Ground-water stations
	Continuous record	Partial record	Lake and reservoir	Water quality	Wells
Lake------------	8	0	1	2	3
La Plata--------	11	1	1	2	23
Larimer---------	12	3	2	13	15
Las Animas------	12	0	2	9	6
Lincoln---------	0	0	0	0	33
Logan-----------	0	0	0	0	41
Mesa------------	28	0	1	16	12
Mineral---------	6	0	0	0	0
Moffat----------	9	0	0	12	27
Montezuma-------	8	0	0	3	9
Montrose--------	10	1	2	8	9
Morgan----------	2	0	0	1	59
Otero-----------	6	0	0	0	176
Ouray-----------	3	0	0	0	1
Park------------	9	0	1	1	14
Phillips--------	0	0	0	0	48
Pitkin----------	27	0	0	0	8
Prowers---------	3	0	0	0	200
Pueblo----------	9	1	2	3	90
Rio Blanco------	39	0	0	30	59
Rio Grande------	3	0	0	0	38
Routt-----------	13	1	0	8	40
Saguache--------	8	0	3	2	40
San Juan--------	1	0	0	0	1
San Miguel------	2	0	0	1	8
Sedgwick--------	1	0	0	1	21
Summit----------	14	0	2	0	5
Teller----------	0	0	0	0	0
Washington------	0	0	0	0	121
Weld------------	7	0	0	5	179
Yuma------------	1	0	1	0	265
Totals---	450	21	32	161	2,658

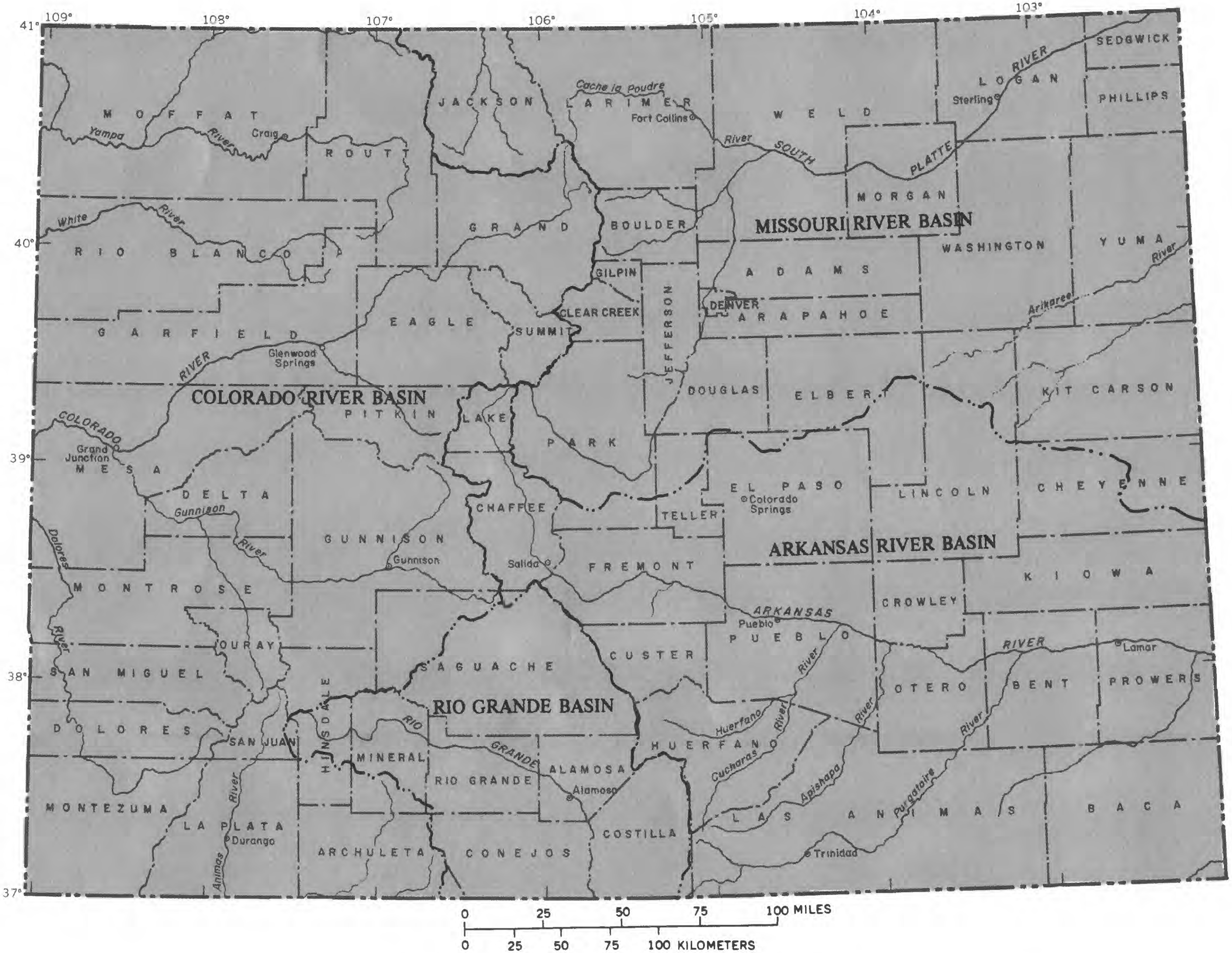

Figure 2.-- Location of area included in water-use inventory.

STATEWIDE

PROJECT TITLE: Statewide Water-Use Inventory (fig. 2)

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 October 1977

Problem.--Water-use data in Colorado are not complete and detailed enough for planning purposes and implementation of a State Water Plan. The sources of water supplies, where and for what purposes water is being used, and the volume of water being consumed or available for multiple use need to be documented so that State and local managers and planners may be better able to make decisions regarding development of the State's water resources.

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

Approach.--Obtain water-use data by contacting users either in person or by mail, soliciting their cooperation, and determining what data they are collecting. If they are already collecting water-use data, ask them to complete a questionnaire in which water-use data are tabulated. If they are not collecting water-use data, devise techniques for converting available data into water equivalent water-use data or suggest techniques for collecting water-use data.

Progress.--A State data base has been created for storage and retrieval of water-use data. Data accumulated include: Water-rights tabulation; surface-water distribution maps; irrigated-acreage tabulation; and total yields of wells by county, township, irrigation district, and State water division. All major municipalities in the State have agreed to provide water-use and Standard Industrial Classification data. Thirty-one utility companies having irrigation accounts have agreed to provide energy-consumption data for use in estimating ground-water withdrawals. These data have been aggregated by irrigation method and by township. Data have been collected on the quantity of energy consumed to produce water from several hundred wells. The data will be employed to determine the amount of ground water pumped when the energy consumption is known.

Plans.--Collection of data will continue on municipal-water use and on surface-water diversions and ground-water pumpage for irrigation. A data base will be made operational at the State level. Data-collection programs will be set up for other water-use categories.

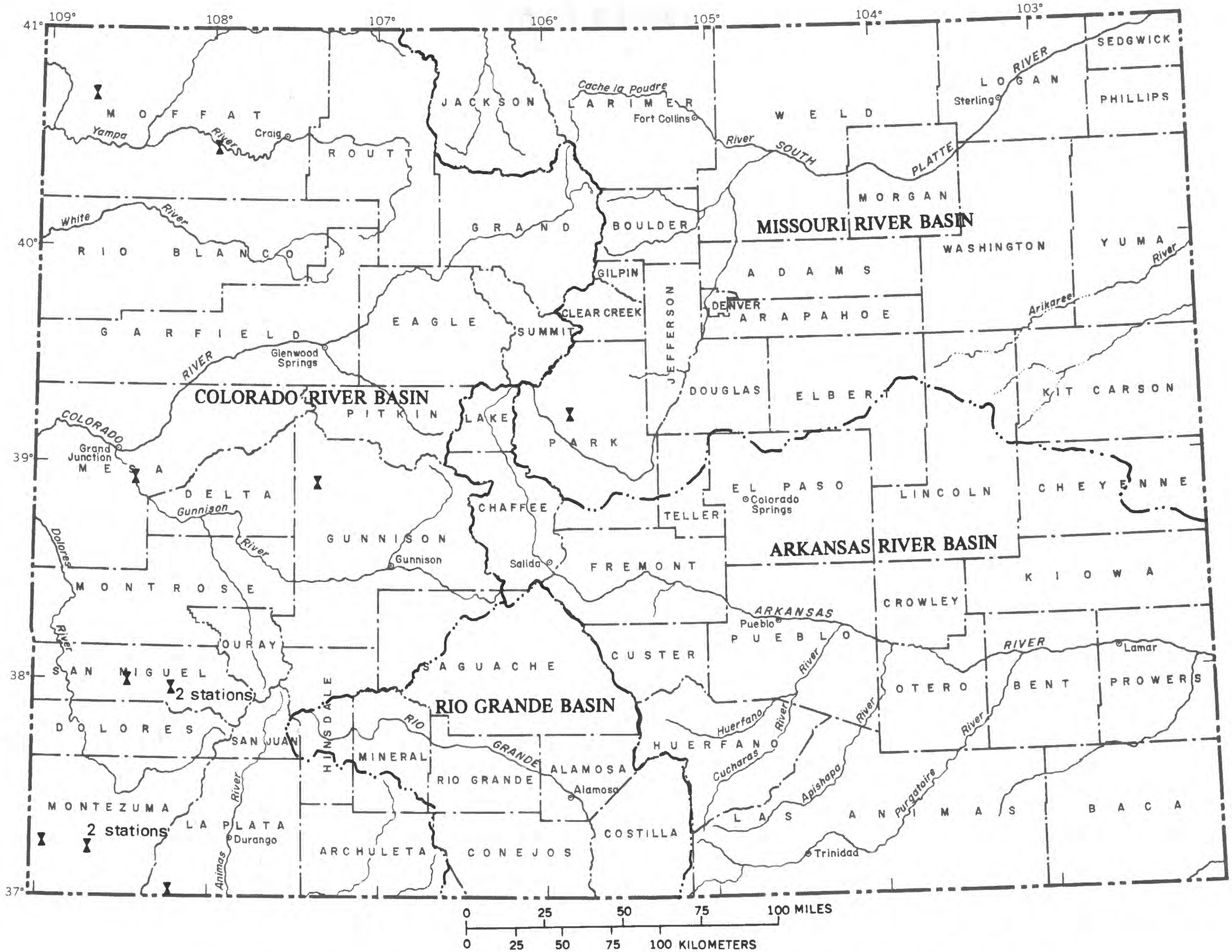

Figure 3.--Location of stations monitoring surface-water flow and quality in coal-mining areas.

PROJECT TITLE: Monitoring of Surface-Water Flow and Quality in Coal-Mining Areas (fig. 3)

COOPERATING AGENCY: None

PROJECT CHIEF: Theron R. Dosch, District Office, Lakewood

PERIOD OF PROJECT: Continuous since February 1977

Problem.--Coal mining may have adverse effects on surface-water resources in the vicinity of and downstream from mine areas. Mine dewatering, changes in land use, disposal of wastes, stream channel realinement, and withdrawal of water for industrial and related uses may alter existing surface-water resources, limit available supplies, and cause deterioration of water quality.

Objectives.--Develop a surface-water-monitoring network. Monitor surface-water flow and quality prior to, during, and after coal mining to determine the effects on surface-water resources.

Approach.--Evaluate existing surface-water stations for inclusion in monitoring network. Establish monitoring network by installing new stations or modifying existing stations.

Progress.--A monitoring network of 12 stations has been established. A contract has been awarded to the Colorado Department of Natural Resources, Division of Water Resources, Office of the State Engineer, to operate the stations and to collect streamflow data. The U.S. Geological Survey has collected monthly water-quality and sediment data. Data interpretation has begun.

Plans.--Continue data collection and interpretation. Publish basic data in annual State report.

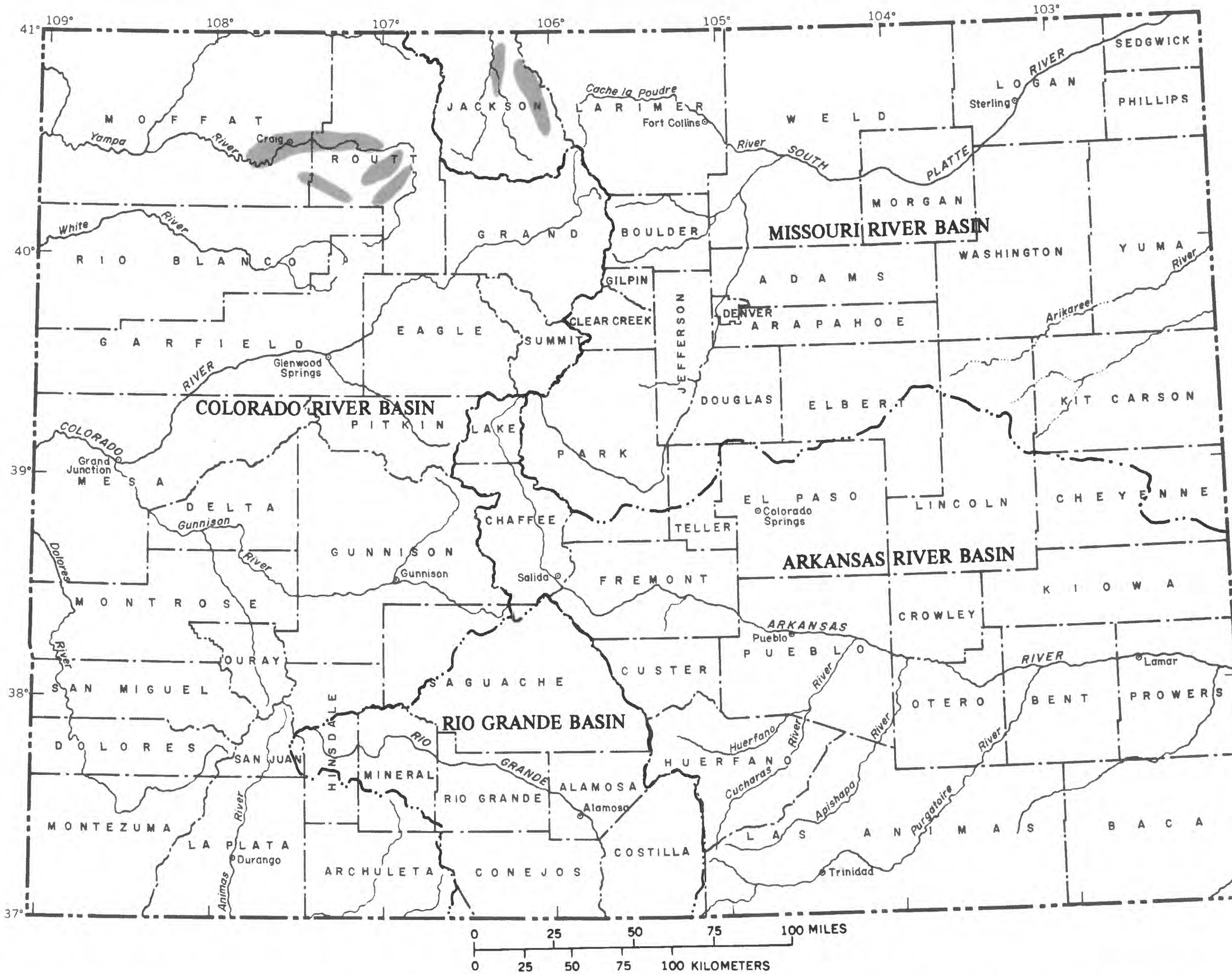

Figure 4.--Location of stream reaches along which traveltime and reaeration studies are being made in coal-producing areas.

PROJECT TITLE: A Study of Traveltime and Reaeration in Streams in Coal-Producing Areas

COOPERATING AGENCY: None

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

PERIOD OF PROJECT: February 1980 to September 1982

Problem.--The large population growth associated with the mining of energy resources generally results in an increase in the amount of waste water introduced into streams. A traveltime and reaeration study is therefore needed to provide information on the capacities of the streams to assimilate municipal organic wastes.

Objectives.--Provide planners and managers with information on the waste-load assimilative capacities of certain stream reaches. This information can be used to determine alternatives for the design and operation of future wastewater treatment plants. Other objectives are to predict the arrival time and concentration of soluble contaminants spilled in a stream, to determine the length of stream affected by a municipal wastewater-treatment-plant discharge, and to calculate the time required for a reservoir release to travel a given distance downstream.

Approach.--Determine traveltime by injecting a fluorescent-type dye into a stream reach and sampling the dye as it moves downstream. Use a mathematical model to predict traveltimes for other flow conditions. Determine the reaeration rate by injecting tracer gas into the stream and computing a desorption coefficient from measurements downstream. Convert these data into a reaeration rate for oxygen. In addition, collect benthic organisms at selected sites to assess the relation between waste-load assimilative capacity and the stability and composition of benthic communities.

Progress.--A year of fieldwork, which has included dye and reaeration tests and biological and water-quality-data collection, has been completed.

Plans.--Collate and analyze data and prepare a report.

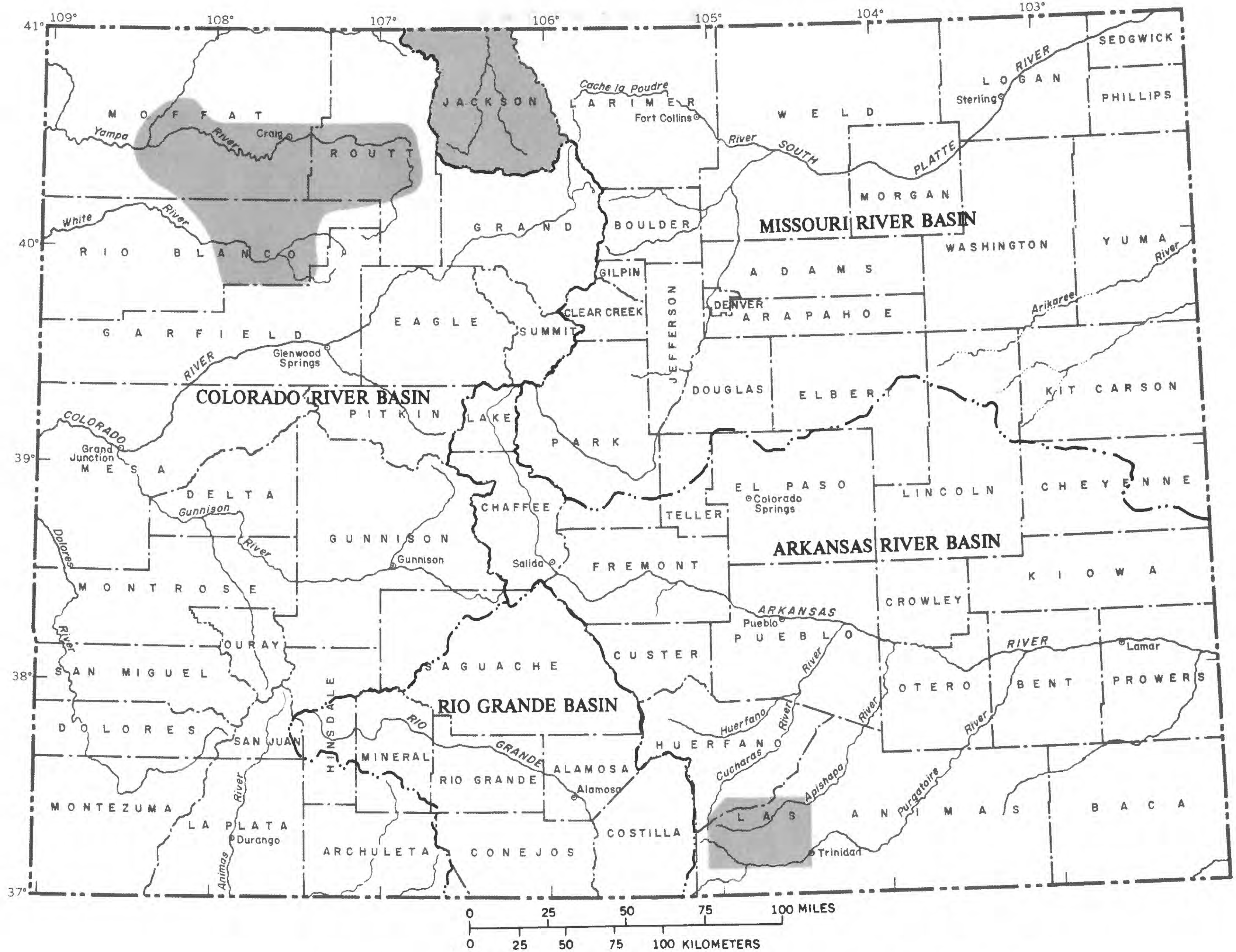

Figure 5.-- Location of coal-mining areas where ground-water studies are in progress.

PROJECT TITLE: Ground-Water Studies in Coal-Mining Areas (fig. 5)

COOPERATING AGENCY: U.S. Bureau of Land Management

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

PERIOD OF PROJECT: October 1978 to September 1982

Problem.--Coal mining may have adverse effects on ground-water resources in the vicinity of and downgradient from mine areas. Mine dewatering, changes in land use, disposal of wastes, and withdrawal of water for industrial and related uses may alter existing ground-water systems, limit available supplies, and cause deterioration of water quality. Few data are available for the ground-water systems containing coal beds.

Objectives.--Determine the potentiometric surface and subsequent changes in the surface for each ground-water system containing coal beds. Determine the spatial distribution of the geohydrologic characteristics of the aquifers.

Approach.--Establish an observation-well network to determine the potentiometric surfaces and to monitor water-level changes. Install continuous water-level recorders on some wells. Conduct aquifer tests and use geophysical logs to determine the geohydrologic characteristics. Collect water samples for chemical analysis.

Progress.--Observation wells have been established in Las Animas, Huerfano, Jackson, Routt, Moffat, Delta, and Mesa Counties. Selected wells are being monitored for water levels and water quality. Single-well aquifer tests were performed on 30 wells in the Williams Fork Mountains near Hayden, Colo. Water samples also were obtained from these wells for chemical analysis. Forty wells have been drilled in alluvial valley floors at various sites from the McCallum area near Hayden, Colo., to the Collom Gulch area south of Craig, Colo. Both geological and geophysical logs have been taken at the alluvial sites. Additionally, water levels are being measured at the alluvial sites.

Plans.--Approximately 30 wells will be drilled in the alluvium along valley floors. Ten wells will be drilled in undisturbed areas near active or potential mine sites. Initially, water levels will be measured in all of the wells, but measurements will be continued in only a few of them. Water-quality samples will be taken from about 25 percent of the new wells. Sampling will be continued at established monitoring sites.

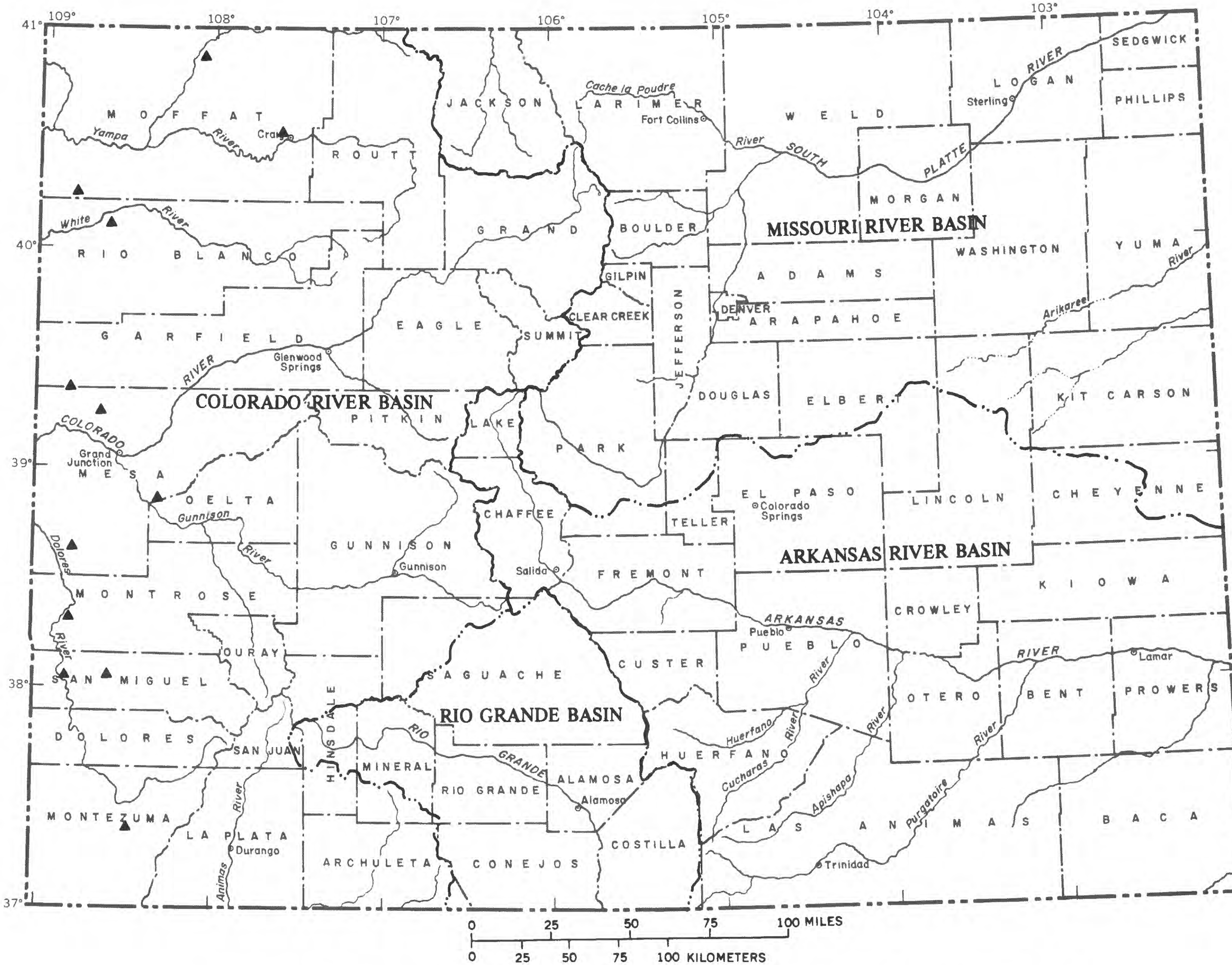

Figure 6.--Location of rainfall-runoff stations in small watersheds crossed by State highways.

PROJECT TITLE: Peak Discharge and Frequency of Floods in Small Watersheds (fig. 6)

COOPERATING AGENCY: Colorado Department of Highways

PROJECT CHIEF: Donald R. Minges, 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, especially those 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 according to its hydrologic and physical characteristics.

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

Progress.--Rainfall-runoff data are being collected at 12 sites in western Colorado. Computer models have been developed for selected watersheds and calibrated where sufficient data are available. Data analysis and model calibrations are being continued for sites in the South Platte River basin.

Plans.--The sites in western Colorado will be discontinued. Data analysis and calibration of the models in the South Platte River basin and western Colorado will be completed. Peak flow and volume relations will be derived from observed and synthetic data obtained from the South Platte River basin. Data to be included in the 1978-80 rainfall-runoff report will be organized. A final interpretive report will be started for the State.

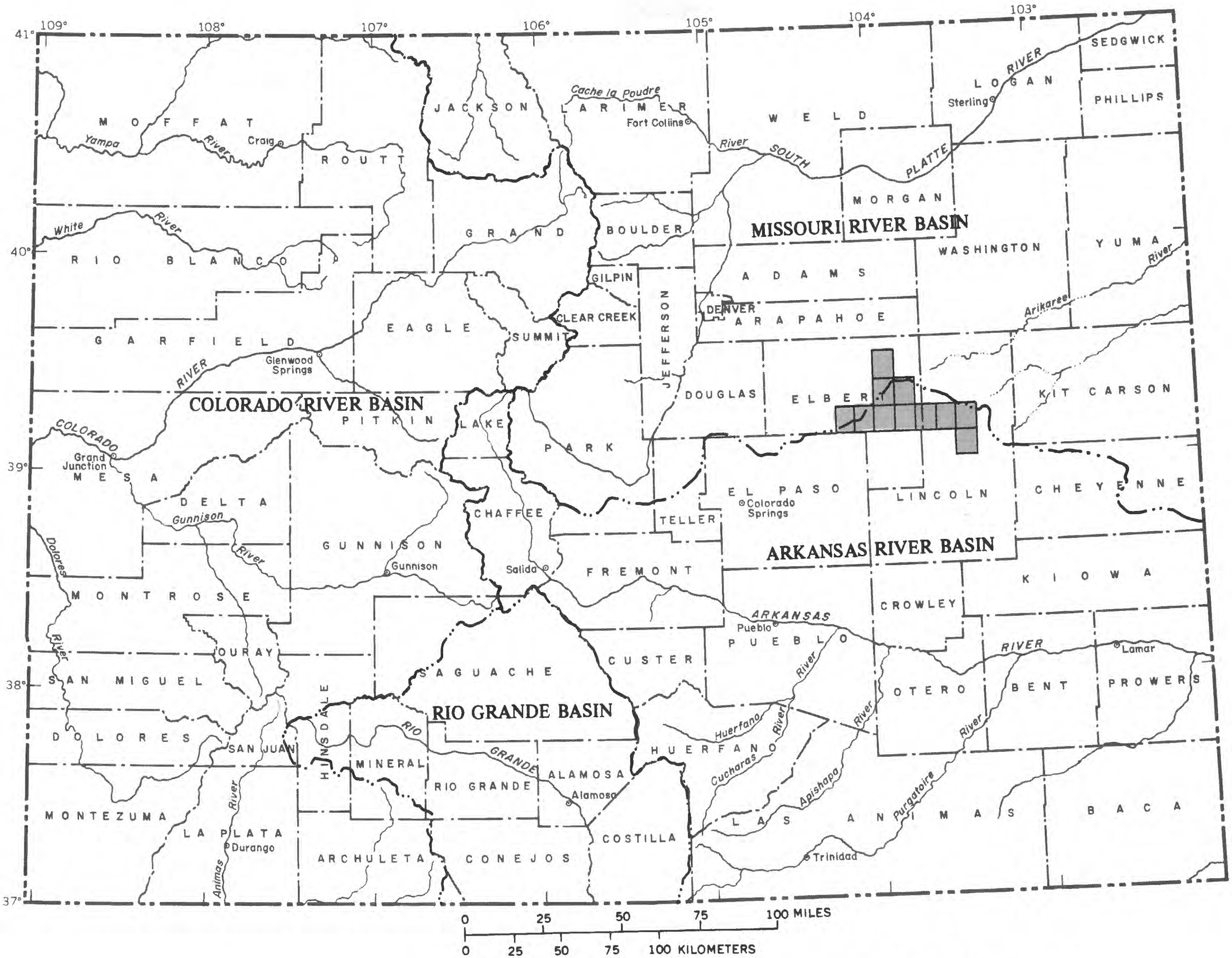

Figure 7.-- Location of topographic quadrangles for which flood-prone areas are being delineated.

PROJECT TITLE: Flood-Hazard Mapping (fig. 7)

COOPERATING AGENCY: None

PROJECT CHIEF: Theron R. Dosch, 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 in counties in which flood-insurance studies will not be contracted by the Federal Emergency Management Administration.

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.--Two hundred and seventeen maps were completed prior to fiscal year 1981.

Plans.--No work scheduled this year.

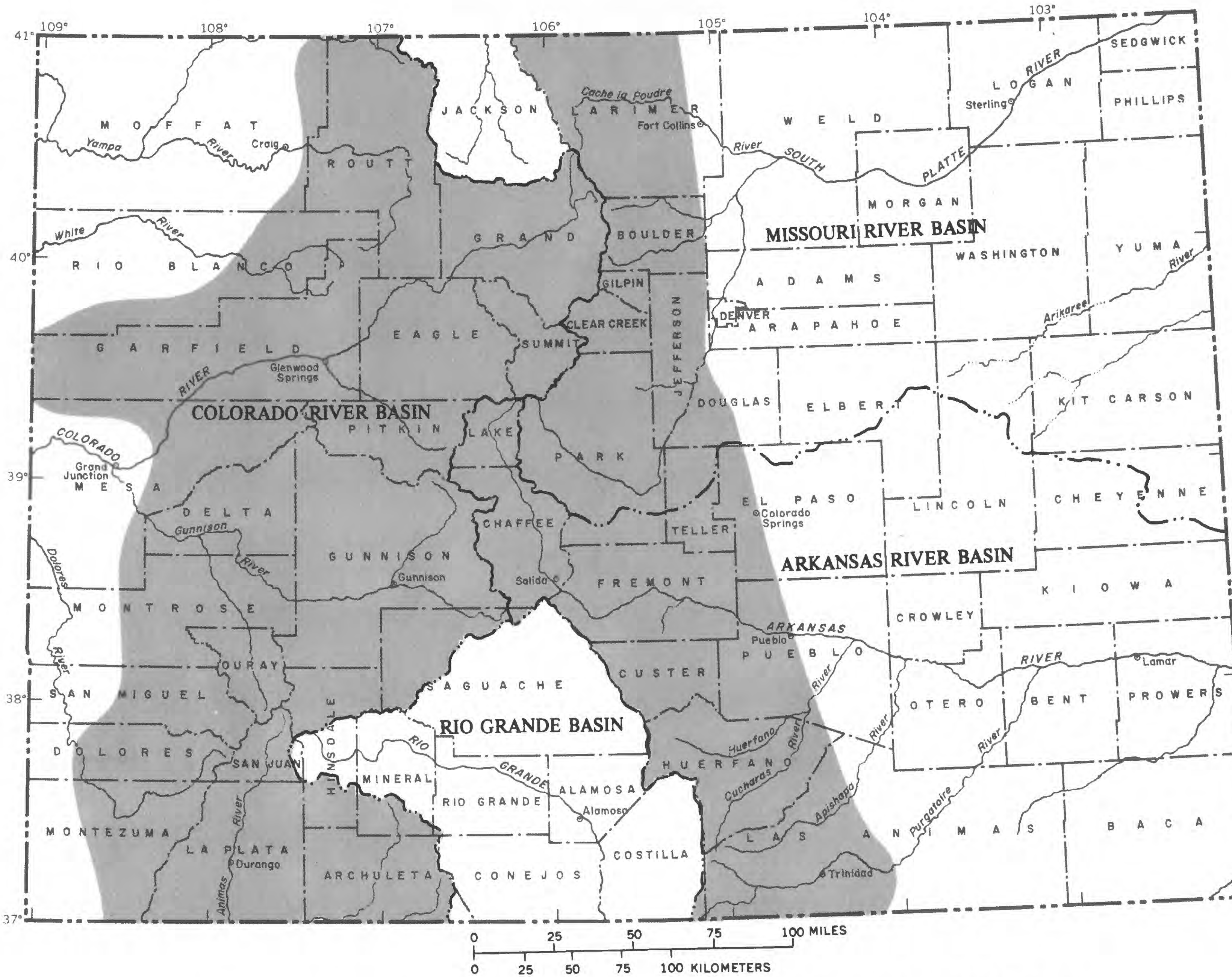

Figure 8.--Location of area for which flood hydrology of foothill streams is being determined.

PROJECT TITLE: Flood Hydrology of Foothill Streams in Colorado (fig. 8)

COOPERATING AGENCIES: Colorado Department of Natural Resources, Colorado Water Conservation Board; Urban Drainage and Flood Control District; U.S. Army Corps of Engineers; and the U.S. Water and Power Resources Service

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

PERIOD OF PROJECT: October 1977 to September 1983

Problem.--More than three-fourths of the people in Colorado live along or near the base of high mountains. Streams along the foothills are subject to 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 data on these floods belong to mixed statistical populations, standard techniques of flood-frequency analysis are inadequate. In addition, the data available are insufficient.

Objectives.--Develop methods for determining flood frequencies from records of mixed-population floods and for estimating flood characteristics at ungaged sites on streams where mixed-population floods occur.

Approach.--Tabulate and evaluate existing flood and precipitation data. Develop methods for identifying and analyzing mixed-population floods using historical flood records. Develop techniques for estimating flood characteristics at ungaged sites using physical and climatical characteristics of foothill basins. Design and test hydrologic model for application in foothill basins. Determine what additional hydrologic data are needed and develop a network to collect these data.

Progress.--A literature search and review has been completed. Studies using geomorphic and botanic data and channel-geometry data to develop techniques for estimating flood characteristics at ungaged sites are in progress. Twenty crest-stage gages have been installed and data are being collected. Methods are being developed for identifying and analyzing mixed-population floods. Records from an additional 30 gaging stations were used to separate snowmelt from rainfall floods, bringing the total number of separations to 60. A preliminary statistical analysis of mixed-population flood records indicates that rainfall-produced floods are less prevalent at higher elevations than expected. A paper on debris flows was submitted to the Association of Engineering Geologists for publication in their bulletin. A project-planning report was distributed to the cooperators and others interested in the study.

Plans.--Work will continue on identifying annual snowmelt and rainfall flood peaks and on studying the relation of the geomorphology and geometry of channels to the flood characteristics of basins in the Colorado River drainage. Work will be completed on techniques for analyzing mixed-population flood records and on techniques which will permit transferring flood information from gaged to ungaged sites. Both basic data and interpretive reports will be prepared.

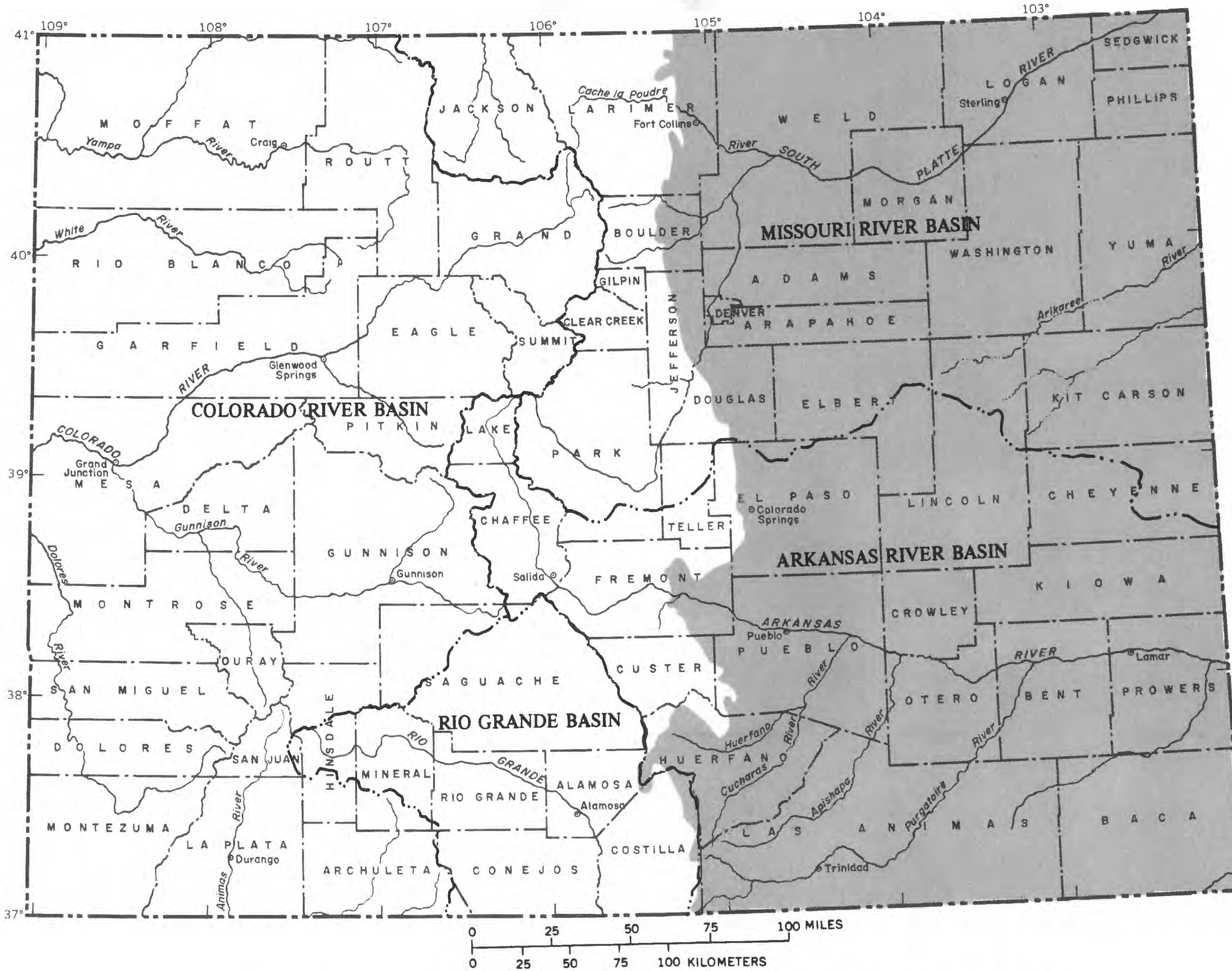

Figure 9.-- Location of the Colorado part of the Central Midwest Regional Aquifer Study.

PROJECT TITLE: Colorado Part of the Central Midwest Regional Aquifer Study (fig. 9)

COOPERATING AGENCIES: None

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

PERIOD OF PROJECT: October 1980 to September 1985

Problem.--Large volumes of ground water are contained in under-utilized bedrock aquifers of Mesozoic and Paleozoic age extending from eastern Colorado to Missouri. Development of these sources of water is hindered by a lack of knowledge of the depth and permeability of the aquifers and the quality of water.

Objectives.--Learn more about the geologic structure and hydrologic characteristics of the most promising of these aquifers. The Colorado part of the study will deal with four aquifers that extend from the Front Range of the Rocky Mountains into Kansas, Nebraska, and Oklahoma.

Approach.--Compute and analyze existing geologic and geophysical data to define the geologic structure of the aquifers. Use the structural data to select wells that will provide information on the hydrologic characteristics of each aquifer. Use digital models of the aquifers to check the validity of the interpretations.

Progress.--None--new project.

Plans.--Complete literature search and compile geologic and geophysical data. Analyze data and prepare structural maps of the aquifers.

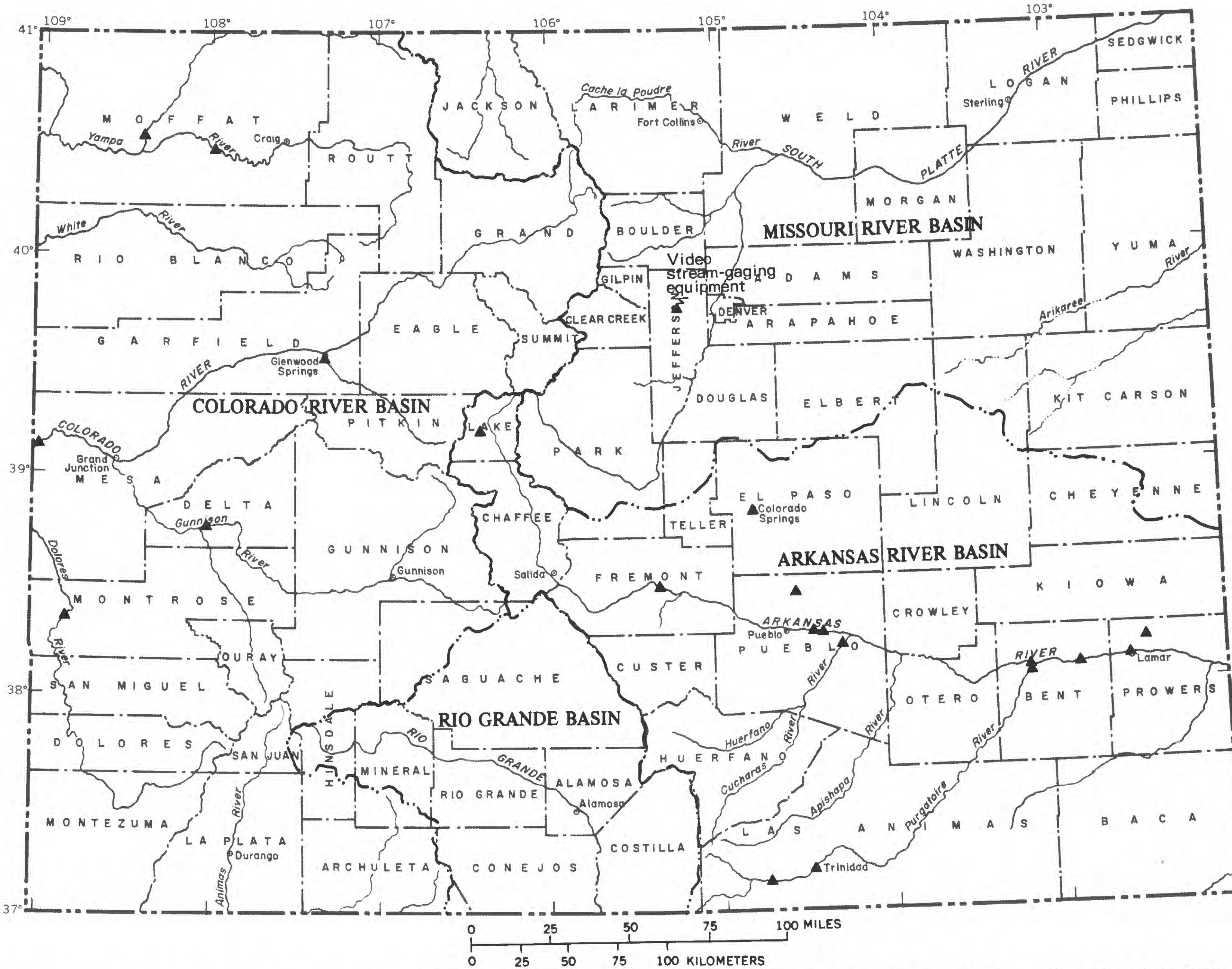

Figure 10.--Location of stations selected for evaluation of the COMSAT General pilot program and the station at which remote video stream-gaging equipment is installed.

PROJECT TITLE: Evaluation of a COMSAT General Pilot Program Providing for Real-Time Data Collection from Gaging Stations in Colorado (fig. 10)

COOPERATING AGENCIES: None

PROJECT CHIEF: Larry L. Jones, District Office, Lakewood

PERIOD OF PROJECT: March 1980 to January 1982

Problem.--Although the Water-Resources Division has a genuine need for real-time hydrologic data telemetered from remote data-collection sites, limitations on personnel and rapid changes in technology make it impractical for the Division to set up and operate a nationwide real-time data-collection network.

Objectives.--Evaluate the ability of COMSAT General to provide hydrologic information under contract 14-08-0001-17548 from 20 sites in Colorado, beginning in December 1980 and ending in January 1982.

Approach.--The contractor will acquire and operate the sensors, data-collection platforms, and associated hardware. The U.S. Geological Survey will provide shelf space and a clear path to the water surface or Geological Survey recorder sprocket. The contractor will deliver the data to the Geological Survey Reston Honeywell computer in real time, where it will be available to the Colorado District Office for retrieval and analysis. Data will be compared with that obtained by standard methods and results will be reported to the Chief, Data Relay Project, Reston, Virginia.

Progress.--All 20 sites have been selected and approved. COMSAT General will begin work in Colorado on October 20, 1980. All platforms will be operational by December 1, 1980.

Plans.--Install the equipment and make it operational. Begin collecting data and submit quarterly reports to the Chief, Data Relay Project, Reston, Virginia.

PROJECT TITLE: Evaluation of Remote Video Stream-Gaging Equipment (fig. 10)

COOPERATING AGENCIES: None

PROJECT CHIEF: Larry L. Jones, District Office, Lakewood

PERIOD OF PROJECT: June 1980 to October 1981

Problem.--Streamflow monitoring in arid and semiarid basins is often complicated by flash floods. The flow cannot be measured accurately because the discharge and stage vary extremely rapidly and the water contains huge amounts of salt and debris.

Objectives.--Collect remote video data (surface velocitites of floating objects recorded and timed on film) at U.S. Geological Survey stream-gaging station 06720500, South Platte River at Henderson, Colo. Evaluate the data after 1 year to determine if the technique is worth further study.

Approach.--Process tapes of film segments by using a video-tape reader with stop action and a TV monitor. Calculate the average surface velocity of an object during a 3-minute run. Analyze and compare the results with "ground truth" obtained from continuous streamflow records collected at the same site.

Progress.--After a test at Henderson, the video equipment was temporarily transferred to gaging station 06719505 on Clear Creek at Golden, Colo. The Golden site more nearly meets the stream-size limitations of the equipment. The site also provides a more stable streambed, which is essential for the development of velocity curves and profiles. These data are used in relating surface velocities to total discharge.

Plans.--Reinstall the video equipment at Golden prior to the spring runoff. Collect video data and plot velocity curves. Analyze and report results.

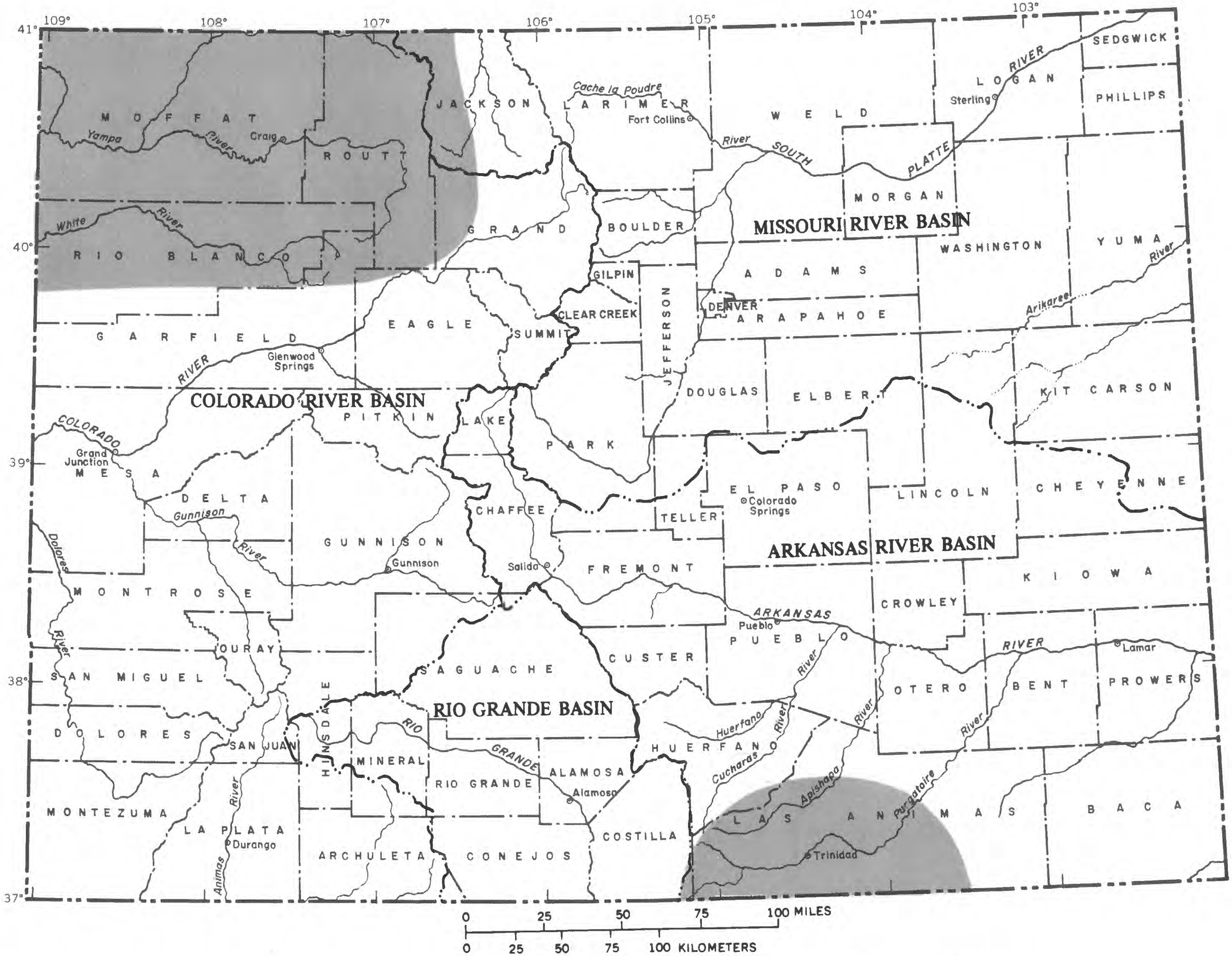

Figure 11.--Location of surface-mining sites in sediment-chemistry study.

PROJECT TITLE: Sediment Chemistry at Prospective Surface-Mining Sites (fig. 11)

COOPERATING AGENCY: None

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

PERIOD OF PROJECT: July 1979 to September 1982

Problem.--Surface mining of coal can affect stream chemistry by changing the chemical composition of suspended sediment transported by the stream. Spoil-pile leachate may deposit chemical coatings on soils and stream-bottom materials or dissolve coatings. Material washed from spoil piles may be of a different composition than native-soil material. Data do not exist that can be used to define the present chemistry of soil and stream-bottom material at prospective surface-mining sites in Colorado.

Objectives.--Define the present composition of soil and stream-bottom material in selected basins in Colorado. Interpret the chemistry of suspended material in the streams, and provide a data base against which to evaluate changes in soil and bottom-material chemistry following surface mining of coal.

Approach.--Seive composited-soil and bottom-material samples from areas and streams within the basins. Determine the chemistry of insoluble materials for the minus 80-mesh fraction. Compare data within and among basins. Compare ratios of chemical concentration to suspended sediment during periods of peak discharge.

Progress.--Sampling of the Energy Mineral Rehabilitation Inventory and Analysis (EMRIA) sites in Colorado has almost been completed.

Plans.--Complete sampling of the EMRIA sites and sample additional sites in northwestern Colorado. Prepare a report on the results of the sampling.

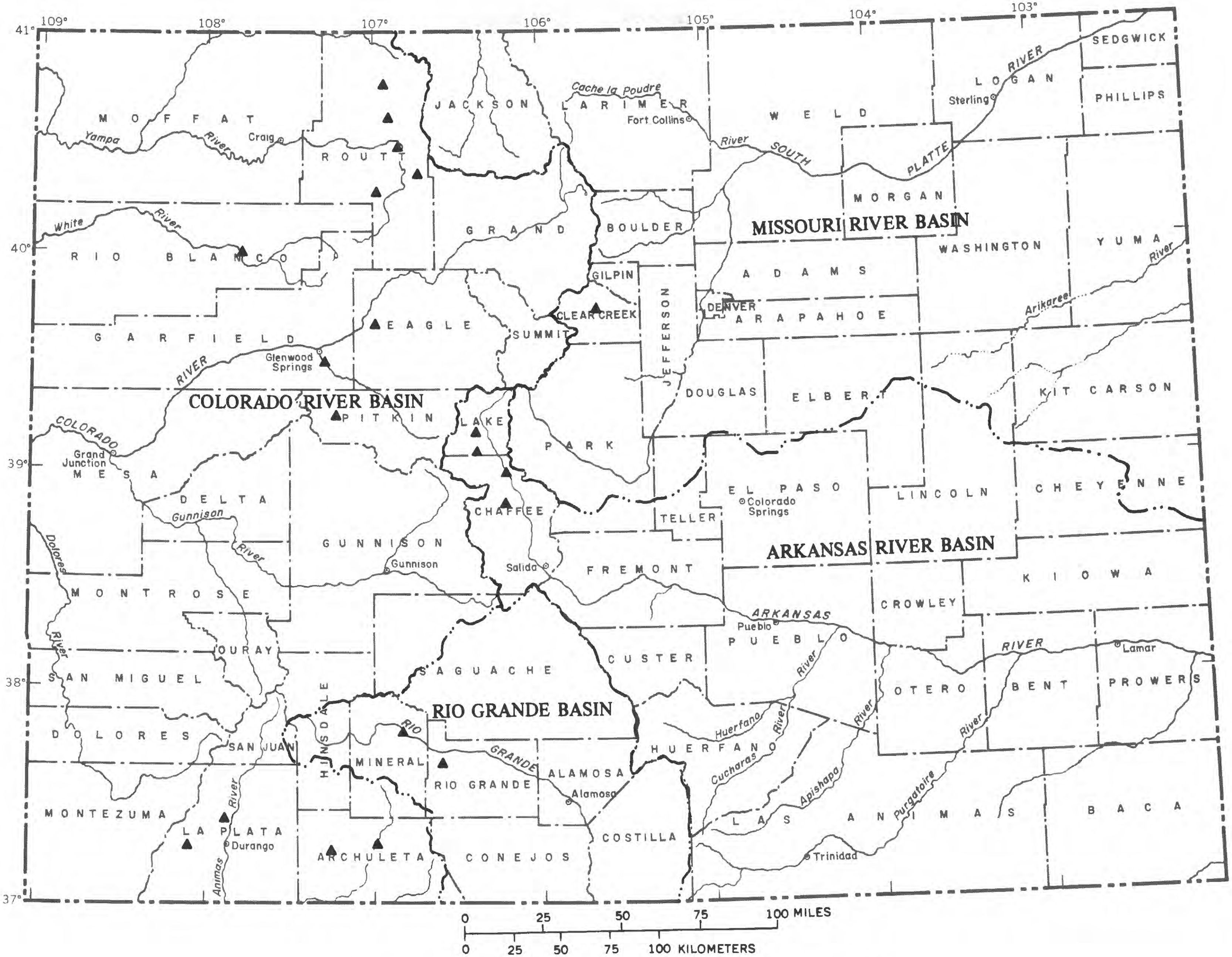

Figure 12.--Location of sites for flow-resistance study.

PROJECT TITLE: Flow Resistance in Steep-Mountain and Ephemeral Streams in Colorado (fig. 12)

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

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

PERIOD OF PROJECT: May 1979 to September 1982

Problem.--Recent legislative actions involving land-use planning and flood-insurance programs have greatly increased the demand for detailed flood studies. Hydraulic computations for these studies are largely based on the Manning equations, which require the selection of a roughness coefficient (n value) to represent flow resistance along a stream channel. Although guidelines are available to aid in the selection of roughness coefficients for many types of channels, insufficient data exist for the range of hydraulic conditions found in steep-mountain and ephemeral streams in Colorado.

Objectives.--Verify Manning's roughness coefficients for selected reaches on steep mountain and ephemeral streams to provide guidelines for the selection of n for flow regimes in Colorado. Evaluate existing guidelines for the selection of roughness coefficients and compile a manual presenting the selection criteria and photographs of representative-channel types. Use study results as a basis for design of a more comprehensive project if evidence indicates selection guidelines for roughness coefficients are not valid for the types of streams being studied.

Approach.--Collect data at selected sites to compute roughness coefficients. Data will include discharge measurements at high stages, color stereo-slides during each measurement and at low stream stage, channel cross-sections, water-surface elevations, and selected roughness coefficients. Use the data to verify the roughness coefficients. Compare the roughness values selected and the verified values to evaluate the present roughness-coefficient guidelines.

Progress.--The collection of streamflow data for various flow depths has been completed at 20 sites typical of steep-gradient streams in Colorado. Analysis of the data indicates that the roughness coefficient, n, changes significantly with depth during flood flows on steep gradient streams that have very coarse bed material. A standard step-backwater analysis generally shows that the flow is supercritical in streams in which the slope exceeds about 1.5 percent; however, the data indicate that flow is subcritical in streams in which the slope exceeds 3 percent.

Plans.--Prepare a technical manual in cooperation with the Colorado Water Conservation Board that presents the criteria used in selecting representative channel types and photographs of these types.

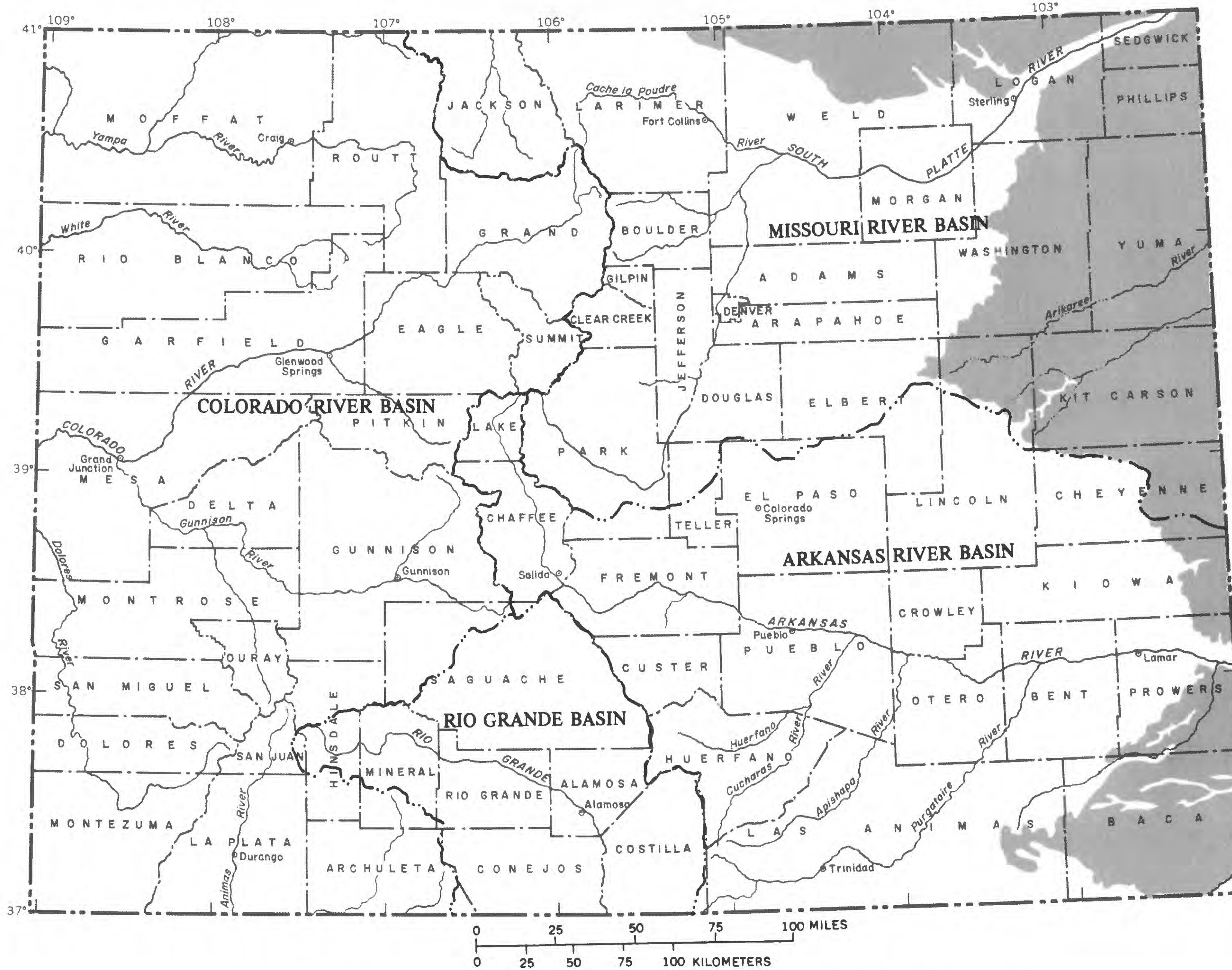

Figure 13.-- Location of the areas of the High Plains regional aquifer in Colorado.

REGIONAL

PROJECT TITLE: Hydrology of the High Plains Regional Aquifer System (fig. 13)

COOPERATING AGENCY: None

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

PERIOD OF PROJECT: October 1977 to September 1982

Problem.--Water levels are declining in many areas of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming because pumpage from the Ogallala aquifer, principally for irrigation, is exceeding recharge to the aquifer. In some areas, including Colorado, the magnitude of the declines may limit continued use of the aquifer as a source of supply for wells yielding more than 100 gallons per minute of water.

Objective.--Develop a computer model of the entire aquifer system that can be used to evaluate long-term effects of various water-management alternatives.

Approach.--Expand and refine the present data base in Colorado by collecting and analyzing additional water-level, well-yield, and water-quality data, especially for areas north of the South Platte River and south of the Arkansas River. Prepare maps showing hydrogeologic characteristics of the aquifer system.

Progress.--Data collection has begun. About 2,500 wells have been inventoried; discharge was measured from about 100 wells. Maps showing bedrock topography and geology and the altitude and configuration of the water table during 1975 have been completed. Water levels were measured in about 650 wells from January to March 1980.

Plans.--Continue measuring water levels in about 650 wells. Modify the observation-well network to provide better coverage. Continue data analysis, initiate model development, and begin preparation of a report.

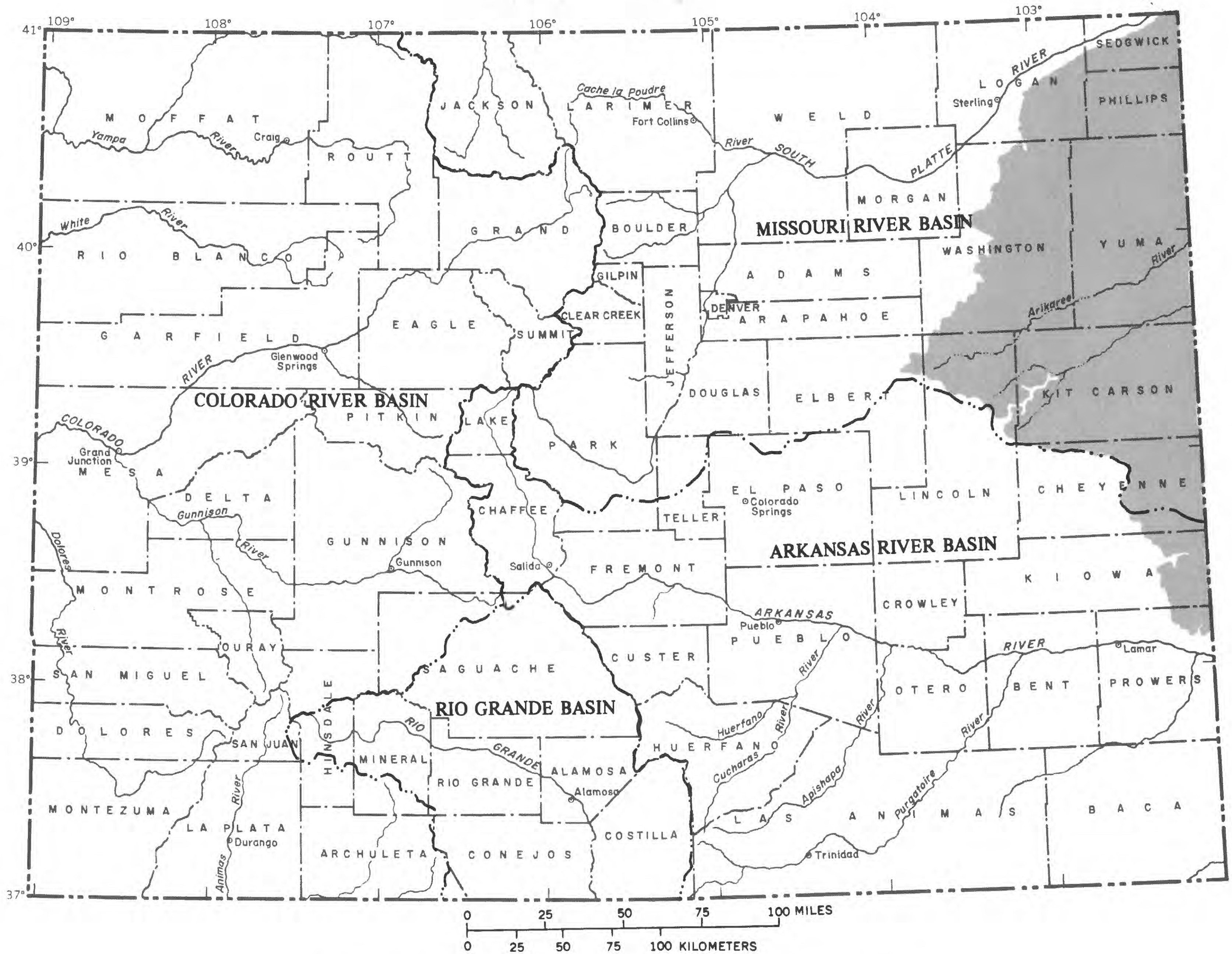

Figure 14.--Location of the Northern High Plains of Colorado.

PROJECT TITLE: Water-Management Study of the Northern High Plains of Colorado (fig. 14)

COOPERATING AGENCY: Colorado Department of Natural Resources, Division of Water Resources, Office of the State Engineer, and the Central Yuma, Frenchman, Marks Butte, and Sand Hills Ground Water Management Districts

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

PERIOD OF PROJECT: Continuous since July 1968

Problem.--State and local water-management agencies are managing the ground-water supply in the Northern 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. Monitor long-term water-level trends.

Approach.--Locate and obtain hydrologic data from all wells that pump more than 100 gallons per minute. Using 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.

Progress.--Data have been collected from about 3,800 wells. Data from about 1,000 wells have been coded for entry into the computer, and about 200 computer records were updated. About 110 well-discharge measurements have been made on 65 wells. A monitoring network of about 650 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 Northern High Plains. Water-table maps have been prepared to show predevelopment conditions in the Northern High Plains of Colorado in 1960, 1965, 1970, 1975, and 1980. Similar water-table maps have been started for the Southern High Plains. Maps were begun showing the distribution of hydraulic conductivity and specific yield.

Plans.--Complete all water-table maps and maps of aquifer properties. Revise map of the base of the aquifer in the northern High Plains of Colorado. Finish well inventory and continue entering data into the computer system. Begin preparation of map reports.

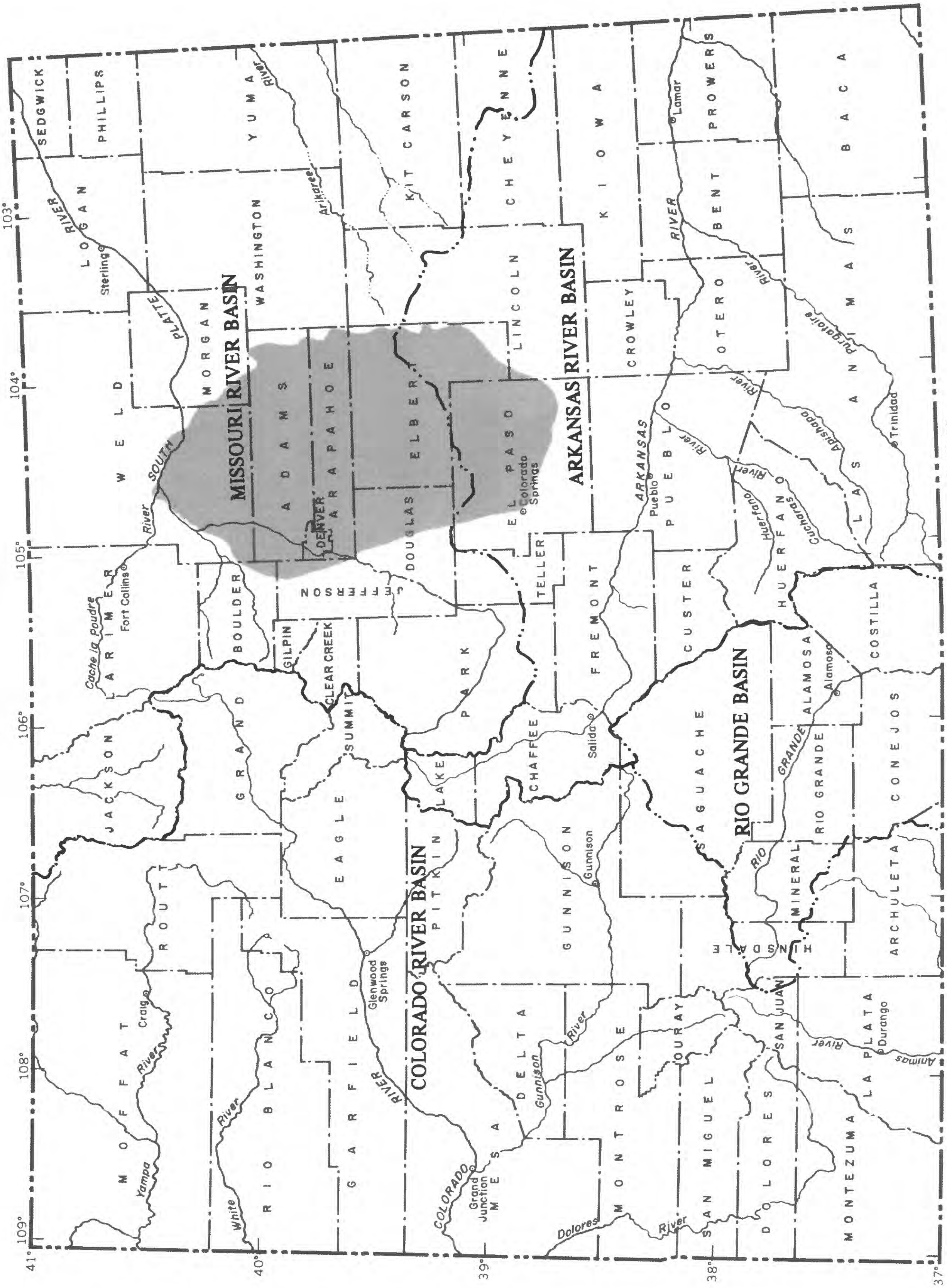

Figure 15.-- Location of the Denver Basin.

PROJECT TITLE: Ground-Water Resources of the Denver Basin (fig. 15)

COOPERATING AGENCIES: Adams County Board of Commissioners; Arapahoe County; City and County of Denver, Board of Water Commissioners; Colorado Department of Natural Resources, Division of Water Resources, Office of the State Engineer; Elbert County Planning Department; and the El Paso County Board of Commissioners

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

PERIOD OF PROJECT: July 1975 to September 1984

Problem.--The Denver Basin is underlain by four major bedrock 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 because 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.--Collect and interpret geohydrologic data needed to develop a computer model of the ground-water-flow system. Collect and interpret ground-water-quality data to better evaluate the water-supply potential of the bedrock aquifers. Develop a computer model of the ground-water flow system that can be used to evaluate long-term effects of various water-management alternatives.

Approach.--Collect and interpret geohydrologic data from wells completed in each aquifer. Establish an observation-well network to monitor water levels in each aquifer. Collect and interpret water-quality data from each aquifer. Determine coefficients of storage and hydraulic conductivity for each aquifer. Prepare maps summarizing all data collected. Develop a computer model of the ground-water-flow system.

Progress.--Geohydrologic data have been obtained from about 700 wells. Selected water-quality data have been obtained from about 500 wells; comprehensive water-quality data have been obtained from about 100 wells. Aquifer tests have been run on 80 bedrock wells, and data have been compiled for an additional 150 aquifer tests. Collection of pumpage data and analysis of well data have begun. Four hydrologic atlases showing the extent, thickness, structure, sand content, and water quality of the four bedrock aquifers have been prepared or are in the process of publication.

Plans.--Complete the aquifer testing and pumpage estimates. Estimate recharge and discharge. Begin construction of a digital model. Prepare a hydrologic-data report.

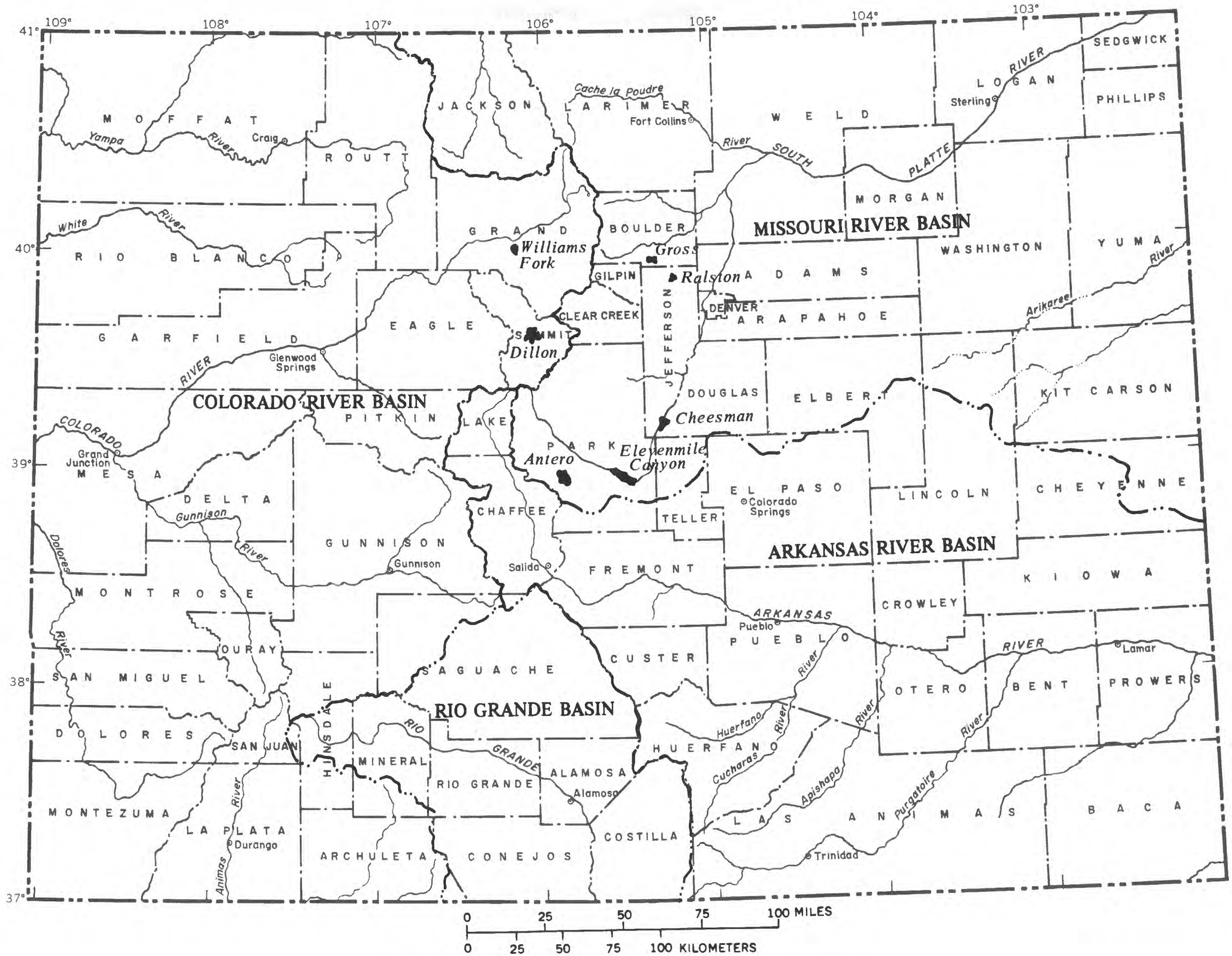

Figure 16.-- Location of water-supply reservoirs.

PROJECT TITLE: Determination of Evaporation and Thermal Regime of Selected Reservoirs and Lakes (fig. 16)

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

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

PERIOD OF PROJECT: May 1972 through May 1982

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-rights 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.

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.

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 have been completed for all reservoirs except the Williams Fork Reservoir. Energy-budget data have been collected at the Williams Fork Reservoir. A climatic study in South Park has been completed.

Plans.--Complete data collection in December 1980. Prepare a report covering data collection from 1974 to 1980.

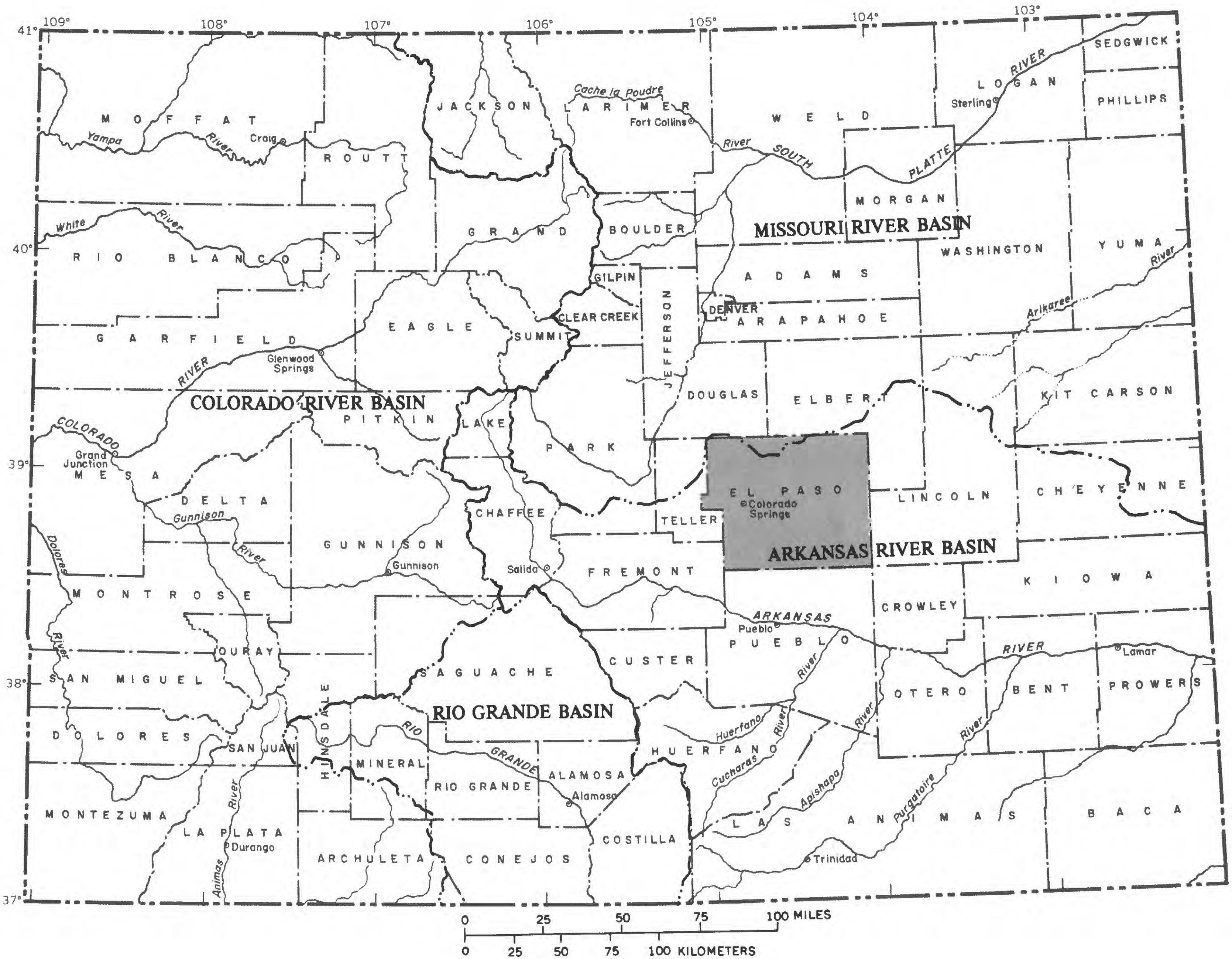

Figure 17.--Location of El Paso County.

PROJECT TITLE: Water Resources of El Paso County (fig. 17)

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

PROJECT CHIEF: Jerry L. Hughes, Subdistrict Office, Pueblo

PERIOD OF PROJECT: July 1972 to December 1984

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 on-site measurements 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 half of the county.

Progress.--Data currently are being collected to improve the predictive capability of the computer model. Gain-loss studies have been conducted on two streams.

Plans.--Continue to collect selected hydrologic data to improve the predictive capability of the computer model. Place the data in computer storage and evaluate the long- and short-term trends in ground-water levels and water-quality conditions. Expand project to define urban impacts on quantity and quality of streamflow in Fountain Creek below Colorado Springs and on ground water in the Widefield aquifer adjacent to the creek.

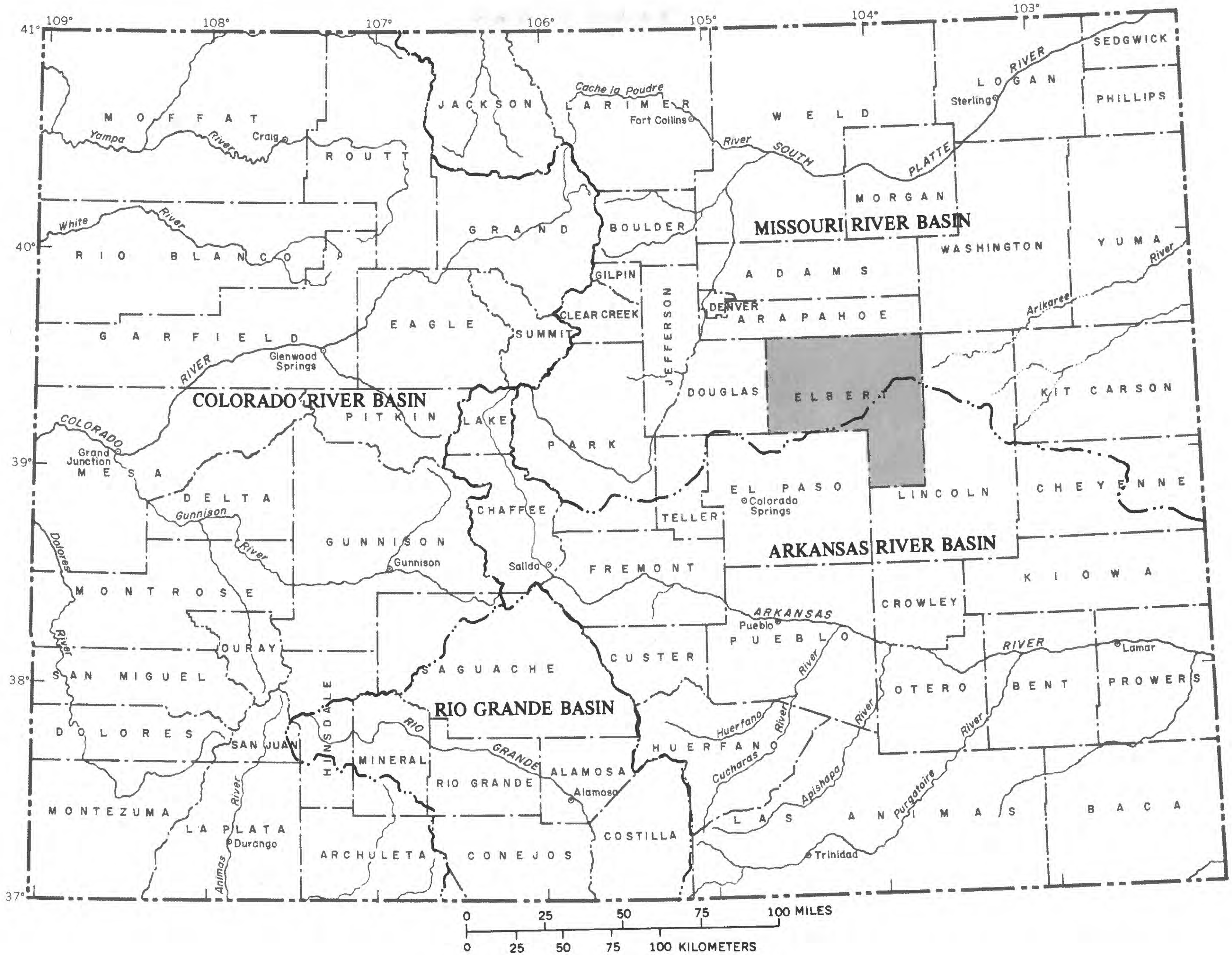

Figure 18.-- Location of Elbert County.

PROJECT TITLE: Flood Study of Elbert County (fig. 18)

COOPERATING AGENCIES: Colorado Department of Natural Resources, Colorado Water Conservation Board; and Elbert County Planning Department

PROJECT CHIEF: Theron R. Dosch, District Office, Lakewood

PERIOD OF PROJECT: January 1979 to September 1981

Problem.--Elbert County, located southeast of Denver and northeast of Colorado Springs, is undergoing rapid residential development without benefit of flood-plain regulations. County officials need flood-plain information that is more accurate than that provided by flood-prone area maps, but detailed flood studies would be too expensive. An intermediate type of study will provide satisfactory information about flood hazards in the county.

Objectives.--Provide flood information, including discharges, flood-plain widths, flood depths, and average flood velocities at selected sites on streams where the width of inundation during a 100-year flood would exceed 60 feet. County officials can use the information to evaluate development proposals and establish flood-plain regulations.

Approach.--Compile existing hydraulic and hydrologic data including historical-flood information. Collect additional data as needed. Compile data on 1:12,000-scale quarter-quadrangle maps made from 1:24,000-scale U.S. Geological Survey topographic quadrangles. Provide a set of map positives to Elbert County officials for duplication as needed.

Progress.--Cross-section characteristics and 100-year flood levels were computed for 93 stream sites in the western one-third of the county. Maps at a 1:12,000 scale showing 100-year flood information were completed for 35 quarter-quadrangles.

Plans.--Complete maps for the western 40 percent of the county, which requires an additional 14 quarter-quadrangles. Provide aerial photographs to Elbert County to complement the older topographic maps. Complete the text for the maps; the text will explain the causes and effects of cloudburst flooding in this normally arid region.

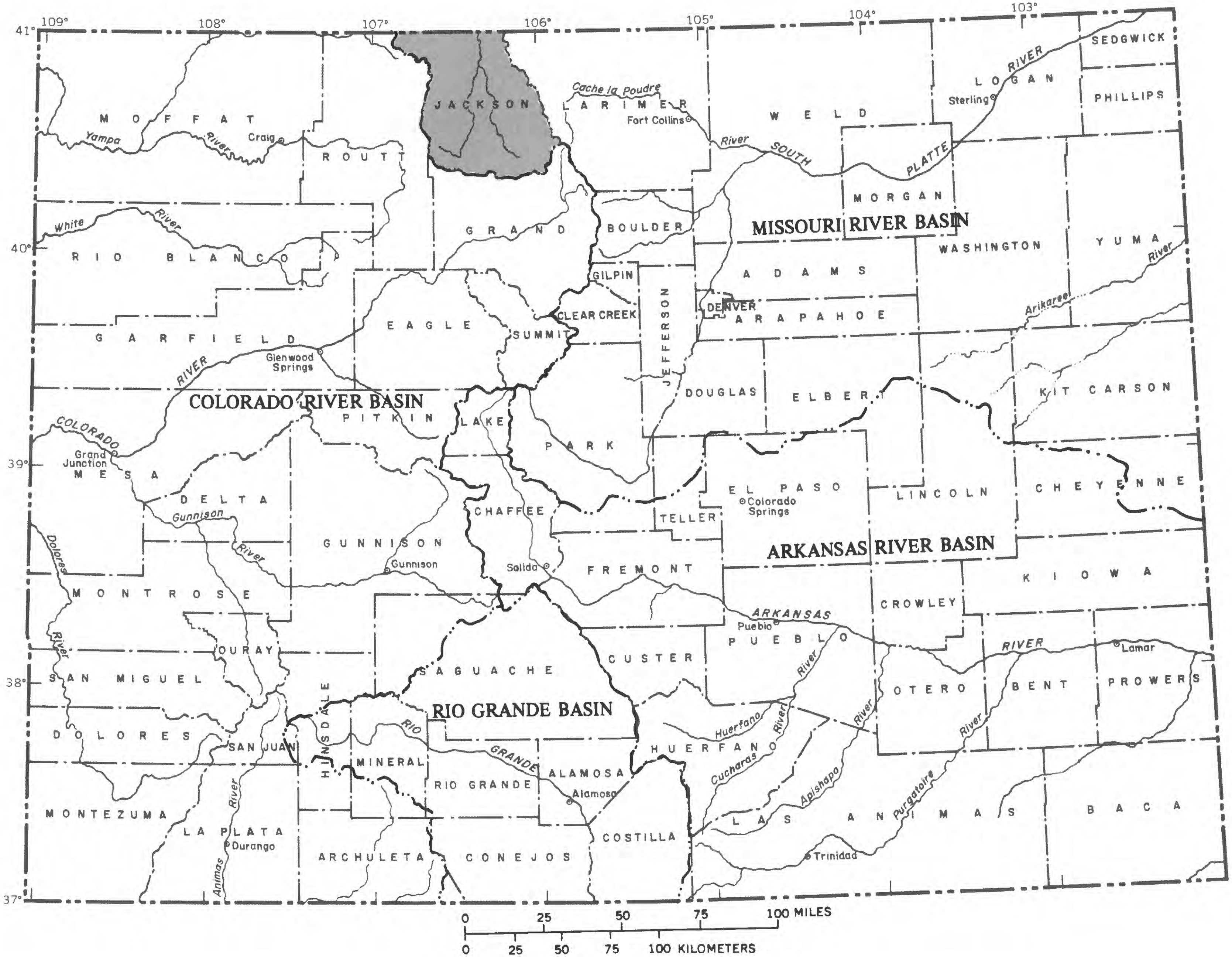

Figure 19.--Location of Jackson County.

MISSOURI RIVER BASIN

PROJECT TITLE: Monitoring of the Hydrologic System in North Park, Jackson County (fig. 19)

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

PROJECT CHIEF: Gerhard Kuhn, Subdistrict Office, Lakewood

PERIOD OF PROJECT: October 1978 to September 1982

Problem.--The proposed development of coal in Jackson County may have adverse effects on the hydrologic system in the county. A knowledge of the existing hydrologic system is needed prior to the beginning of coal mining so that the effects of mining can be determined.

Objective.--Define the hydrologic system of the area; determine the relations between climatic conditions, surface water, and ground water.

Approach.--Continue to collect surface-water-flow and quality data at seven existing stations. Continue to collect rainfall data at three existing recording rain gages. Install a new climatological station in the Canadian River drainage basin. Obtain ground-water data from personnel working on the project, "Ground-Water Studies in Coal-Mining Areas" (p. 17).

Progress.--Data collection has been continuing in the Canadian River basin. Operating are two continuous-record streamflow stations, each of which is equipped with an automatic sediment sampler and water-quality monitor; two partial-record rainfall-runoff stations; and five additional precipitation gages. A climatological station also has been installed to monitor air temperature, wind, and solar radiation. A report has been completed on the Williams Draw basin.

Plans.--Analyze existing data and begin preparation of report.

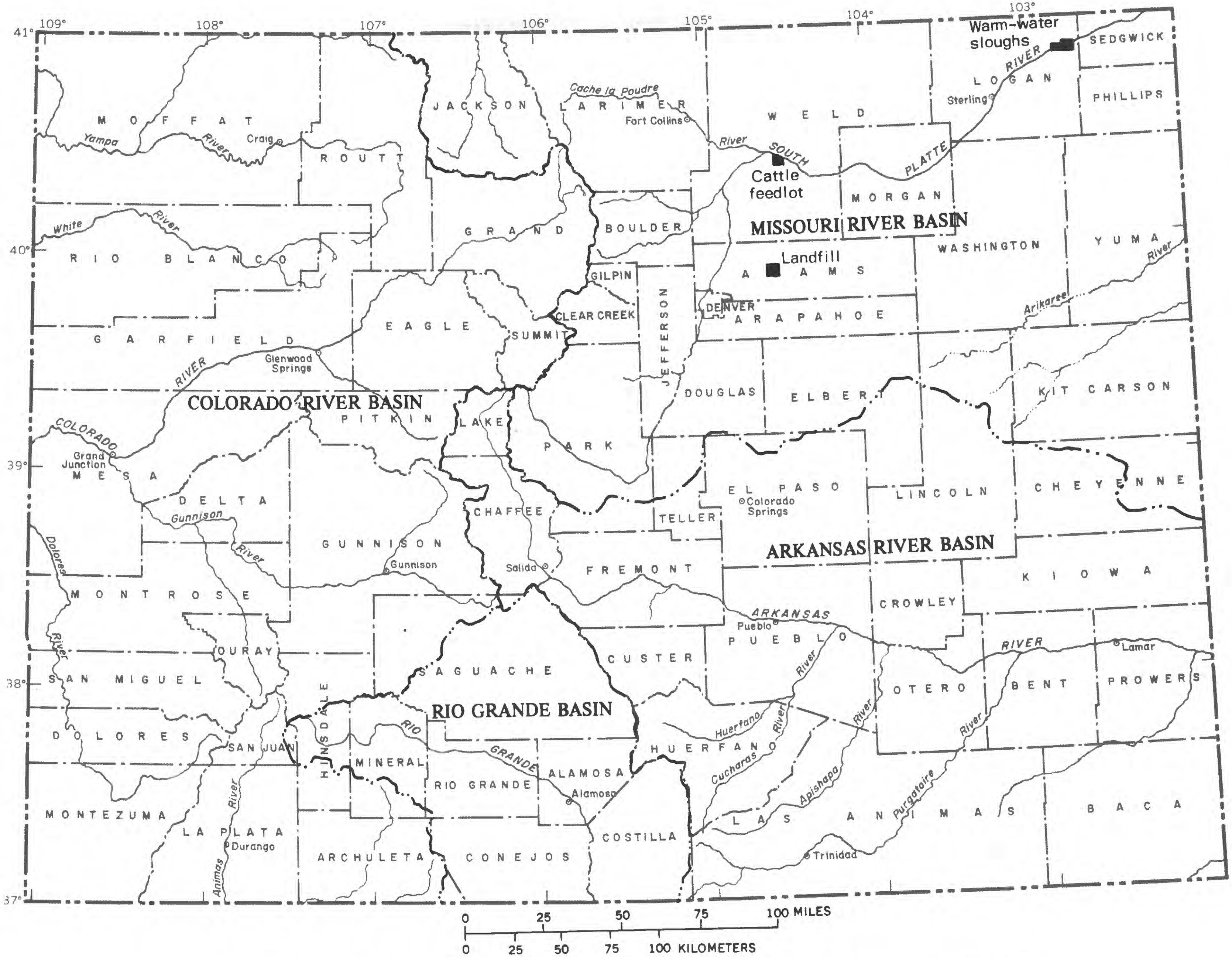

Figure 20.--Location of the cattle feedlot, warm-water sloughs, and proposed landfill.

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: Neville G. Gaggiani, Subdistrict Office, Lakewood

PERIOD OF PROJECT: July 1973 to October 1982

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. Greater-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.--Three wells have been installed near the sump northeast of the feedlot, and two lysimeters have been installed near the sump southeast of the feedlot. High concentrations of manganese have been found in the observation wells near the sumps. Quality of water samples have been taken from 19 observation wells in December, March, June, and September. A progress report is in press.

Plans.--Two observation wells will be installed southwest of the feedlot beside a swamp. Quality of water samples will be taken from at least 19 observation wells in December, March, June, and September.

PROJECT TITLE: Hydrologic Analysis of Warm-Water Sloughs along the South Platte River in Logan County (fig. 20)

COOPERATING AGENCY: Colorado Department of Natural Resources, Division of Wildlife

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

PERIOD OF PROJECT: February 1979 to September 1981

Problem.--The Colorado Division of Wildlife maintains and operates Tamarack Ranch, a wildlife management area along the South Platte River in northeastern Logan County. A primary feature of this area is the warm-water sloughs within the flood plain of the river. Because of the sensitivity of these unique waterfowl habitats to water-management changes, the Colorado Division of Wildlife needs to understand the hydrologic regime of these sloughs so it may better evaluate proposed water-management changes.

Objective.--Determine the hydrologic conditions of warm-water sloughs. Specifically evaluate the possible effects of upstream diversions, upgradient artificial recharge, and increased ground-water pumpage on the water levels and temperatures of selected sloughs.

Approach.--Use aerial photography to delineate warm-water sloughs from Greeley to Julesburg in the South Platte River valley. Within Tamarack Ranch, collect water levels and temperature data from the river, sloughs, and wells. Use a harmonic-temperature model for the river, develop a ground-water flow model and a mass-balance, energy-balance model of selected sloughs.

Progress.--Observation wells have been drilled and data collected on aquifer characteristics. Water levels and specific conductance are being measured monthly. Streamflow data (discharge, temperature, and specific conductance) are being collected. A week-long aquifer test has been conducted and a 4-month artificial recharge experiment monitored on a nearby property. A short report describing the experiment and results is being written. An analysis has been made of streamflow and water-temperature data obtained from gaging-station records. Water temperatures have been measured over a 24-hour period at five sites to supplement monthly measurements. Thermal images of the entire river from Kersey to Julesburg have been taken from an airplane.

Plans.--Conduct a combination discharge-recharge test. Check water-level data and put into the model. Use the model to analyze different management alternatives. Prepare a data report and interpretive reports.

PROJECT TITLE: Effects of Sludge-Drying Basins 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: May 1977 to September 1982

Problem.--The Metropolitan Denver Sewage District (MDSDD) No. 1 plans to replace the current sewage-sludge land-disposal facility in Arapahoe County with sludge-drying basins to facilitate sludge disposal and to permit use of dried sludge as a fertilizer. The new facility will be in Adams County about 25 miles northeast of Denver. The MDSDD, the U.S. Environmental Protection Agency and local residents are concerned about the effects of the facility on the local ground-water quality.

Objective.--Determine the location of, depth to, and areal extent of alluvial and bedrock aquifers beneath the proposed sludge-drying site and adjacent area. Determine the direction of ground-water flow and the present quality of 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 existing wells in the study area; measure depth to water, and obtain samples for water-quality analysis. Construct potentiometric-surface maps of the alluvial and bedrock aquifers to aid in determining where to drill new observation wells. Drill 40 observation wells, 34 in the alluvium and 6 in the bedrock. Measure the depth to water and obtain samples for water-quality analysis. Install six pan-type lysimeters under selected drying basins to determine infiltration rates of the leachate and to provide receptacles for the collection of water-quality samples. Collect samples of the leachate for analysis.

Progress.--Water levels and water quality are being monitored in 12 existing wells near the proposed drying site.

Plans.--Sample the wells annually to obtain background water-quality data.

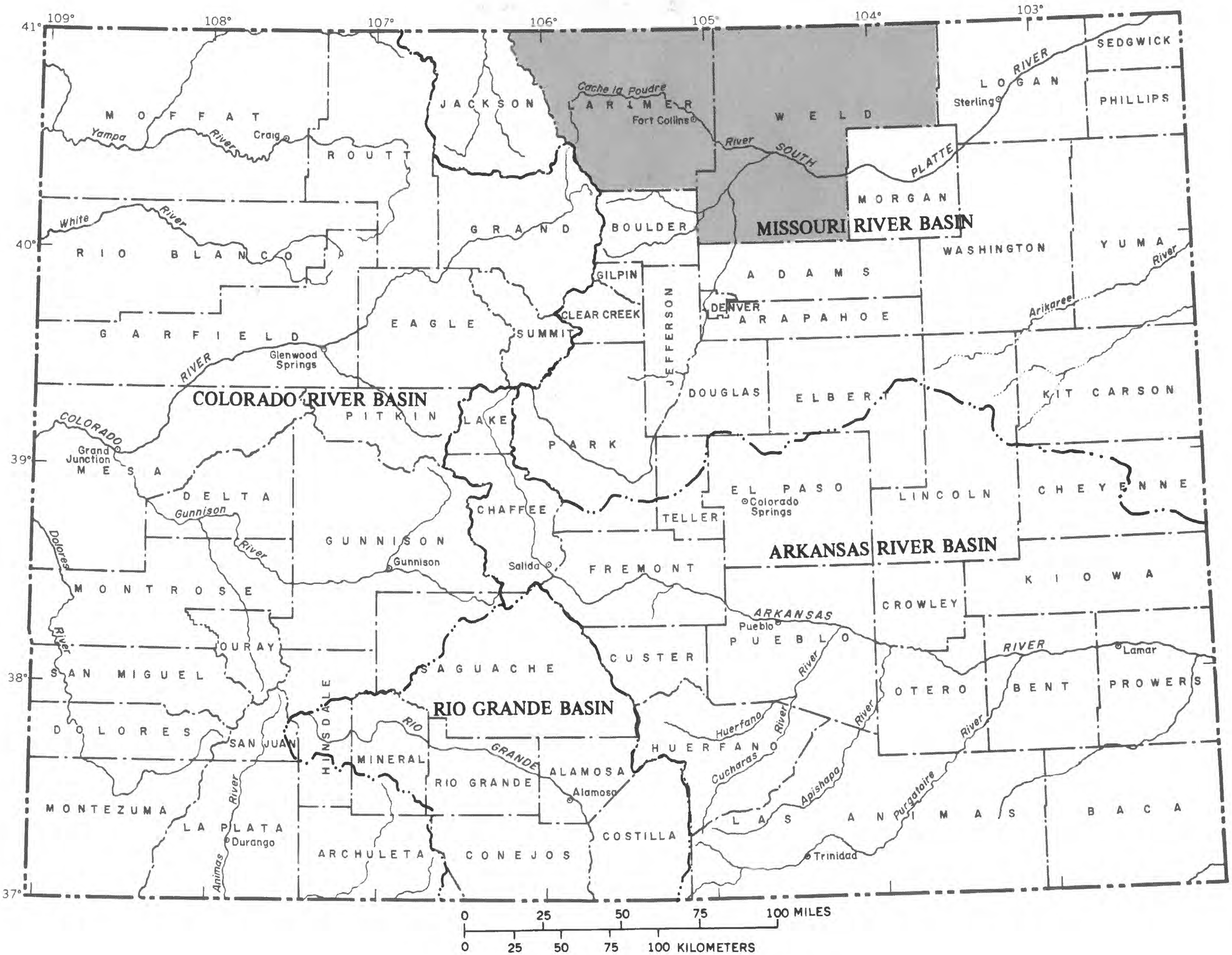

Figure 21.-- Location of Larimer and Weld Counties.

PROJECT TITLE: Regional Streamflow and Water-Quality Monitoring in Larimer and Weld Counties (fig. 21)

COOPERATING AGENCY: Larimer-Weld Regional Council of Governments

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

PERIOD OF PROJECT: June 1979 to September 1982

Problem.--A streamflow quantity and water-quality data base is needed to define existing conditions, particularly with regard to the impact of urban runoff, nonpoint agricultural pollution, and sewage-return flow. An accurate and comprehensive data base also will be necessary in order to achieve other phases of the planning process, including assessing water quality of streams and lakes, determining the low-flow stream characteristics, modeling of the ground-water system, and demonstrating adherence to Federal and State water-quality regulations.

Objectives.--Define the quality and quantity of streamflow, the water quality in lakes and reservoirs, and the interaction between surface water and ground water.

Approach.--Establish and operate streamflow stations, collect and analyze water-quality samples of river and lake water, and conduct gain-loss investigations.

Progress.--Six streamflow stations have been operated and maintained. Water samples have been collected monthly at nine stream sites and analyzed for quality. Samplings of dissolved oxygen over a 24-hour period have been conducted quarterly at three sites.

Plans.--Continue to operate and maintain the six streamflow stations. Collect quality of water samples monthly at 12 stream sites and 1 lake.

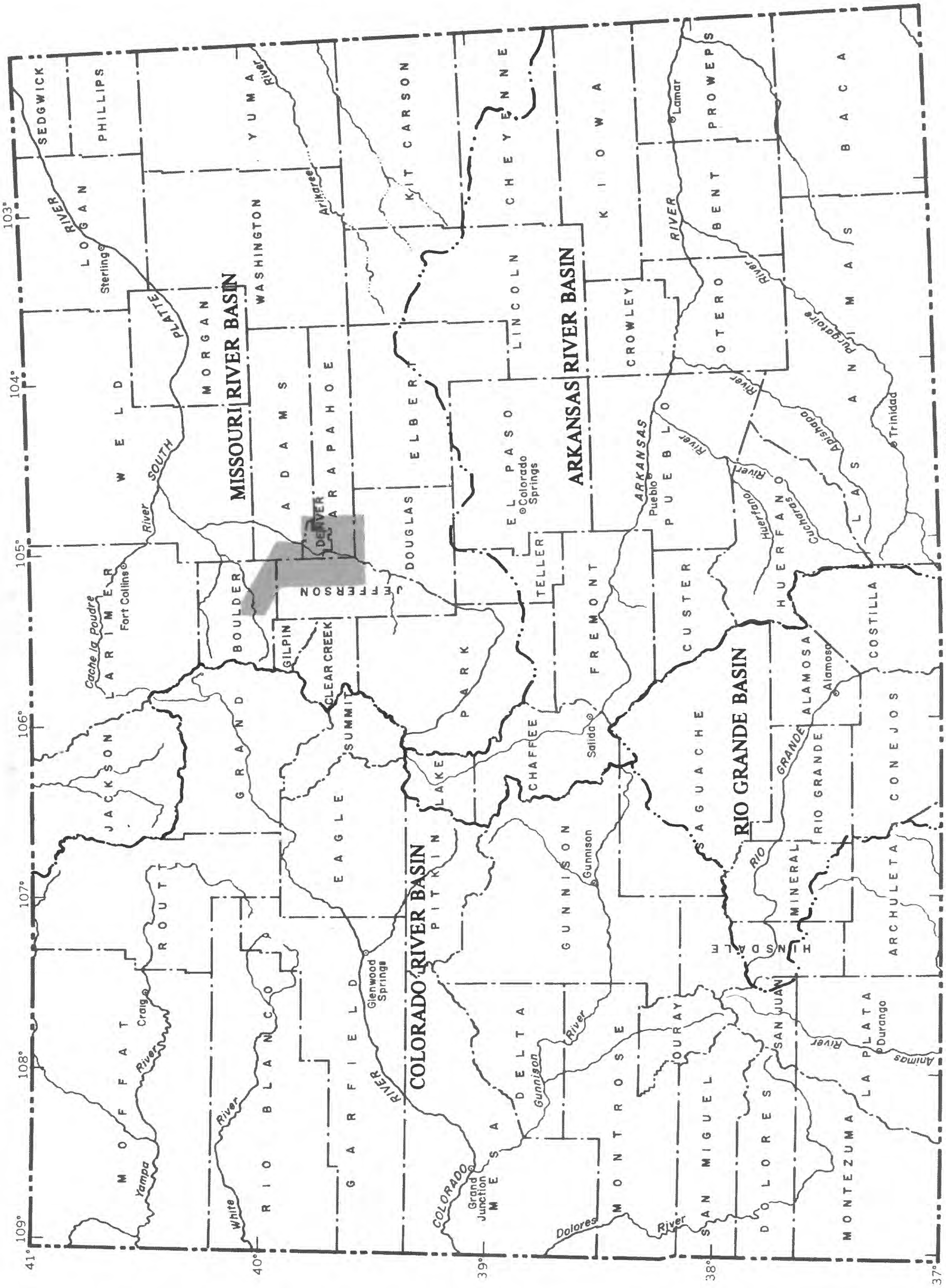

Figure 22.--Location of the Denver-Boulder urban area.

PROJECT TITLE: Flood Frequency in Urban Areas (fig. 22)

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 consideration 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 in urban areas.

Objectives.--Collect data to define the relations between rainfall intensity, duration, and runoff in small watersheds 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 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 rainfall-runoff data from 30 watersheds in the six-county area. Rainfall data are to include continuous records supplemented by data from standard rain gages. Runoff data are to include continuous records from each watershed. Select watersheds having the following ranges of characteristics: (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 has been continuing at 12 watersheds. Additional watershed characteristics have been determined. Verification of discharge ratings has been completed. Computer models have been developed and calibrated for selected watersheds where sufficient data are available. Four new crest-stage indicator sites were installed, surveyed, and rated; several rating-check measurements were made.

Plans.--Discontinue three rainfall-runoff sites. Install three new rain gages and one runoff gage. Analyze data for an interpretive report and prepare the report.

PROJECT TITLE: Rainfall-Runoff Management Model for the Denver Federal Center (fig. 22)

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 in 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 non-urbanized 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. Data collection is continuing; numerous discharge measurements have been made to verify the station ratings. An orthophotographic base map has been prepared. 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 rainfall-runoff computer model has been developed and sufficient data now exist to test the model. Data analysis has begun. Analysis of the data and preliminary modeling indicate that runoff from the Federal Center contributes to McIntyre Gulch runoff after upstream peak flows have passed through the Federal Center.

Plans.--Continue data collection. Begin work on a basic-data report for 1977-80.

PROJECT TITLE: Monitoring of Storm Runoff Quality, Denver Metropolitan Area (fig. 22)

COOPERATING AGENCY: Denver Regional Council of Governments

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

PERIOD OF PROJECT: January 1975 to September 1982

Problem.--Two flood-control and recreational reservoirs, each located on the mainstem of a major Denver area river, are rapidly approaching advanced stages of cultural eutrophication. No major point-source discharges of storm runoff and little irrigated agricultural land exist upstream from these two water bodies. Yet, high loads of nutrients enter these lakes each year, accelerating the productivity of algae. The increase in runoff volumes resulting from urban development have resulted in a nutrient load that more than offsets the higher nutrient concentrations in the runoff from idle agricultural lands.

Objectives.--Determine the relation between land use and the runoff-pollution loadings. Identify the sources of pollutants. Determine the rate of accumulation of pollutants characteristic of different types of land use for input to nonpoint-source hydrologic models. Investigate the transferability of the results of the study to other urban areas in the semiarid West.

Approach.--Take samples of runoff from areas of different types of land use, such as single-family detached housing, multi-family detached housing, commercial development, and unused land. Determine the relations between total and soluble chemical constituents in the runoff. Sample the bodies of water receiving runoff. Monitor the fallout of dry-weather dust and dirt. Determine the relationship of various constituents to particle size in sediments. Map the spatial and temporal distribution of precipitation and determine its chemical quality. Test the effectiveness of the measures used to control pollution.

Progress.--Urban runoff data have been collected at nine sites in the Denver metropolitan area. Five rainfall simulations have been made to obtain the washoff and buildup rates of selected constituents. Preliminary results indicate that the concentration of lead and zinc in the runoff from all of the sites is significantly less than the concentrations measured in previous studies in the Denver area.

Plans.--Continue the collection and interpretation of urban-runoff data from the nine sites. Test the effectiveness of detention ponds in removing certain chemical constituents. Collect and analyze selected priority pollutants for the Environmental Protection Agency. Prepare a hydrologic-data report.

PROJECT TITLE: Quantity and Quality of Urban Runoff (fig. 22)

COOPERATING AGENCY: None

PROJECT CHIEF: Steven R. Blakely, District Office, Lakewood

PERIOD OF PROJECT: April 1979 to September 1981

Problem.--Section 208 of the Federal Water Pollution Control Act, Amendment of 1972, Public Law 92-500 requires the development and implementation of a plan for a coordinated waste-treatment management system. Major sources of water pollution have been examined but less obvious sources such as storm runoff have not been examined. Data must be developed to permit determination of the magnitude and type of pollution caused by storm-water runoff.

Objectives.--Provide data to improve knowledge of the types, concentrations, sources, build-up rates, and movement of materials in storm water runoff in the Denver Metropolitan Area. An attempt will be made to quantify the effect of urban storm runoff on the quality of the South Platte River. This phase of the study will concentrate on selection of the site to be monitored in the National Urban Runoff Study.

Approach.--Use maps, field surveys, aerial photographs, and interviews with local officials to select nine urban-runoff sites that are representative of the following land uses: multi-family, single family, open space, shopping center, mixed multi-family, and light commercial. Collect samples and analyze for nitrogen and phosphorus compounds, organic and pesticide compounds, and heavy metals; collect discharge data.

Progress.--Selection of study sites has been completed. Instrumentation has been installed at five sites. Water quality and flow data were collected during one large storm on August 14, 1980. The data are to be used to obtain loadings on the South Platte River resulting from rainfall runoff. Streamflow data have been collected at two sites on the South Platte River and Cherry Creek.

Plans.--Delineate basin boundaries and obtain land-use data on five tributaries in the greater Denver metropolitan area. Collect water-quality and flow data on five storms. Continue collecting streamflow data on the South Platte River and Cherry Creek.

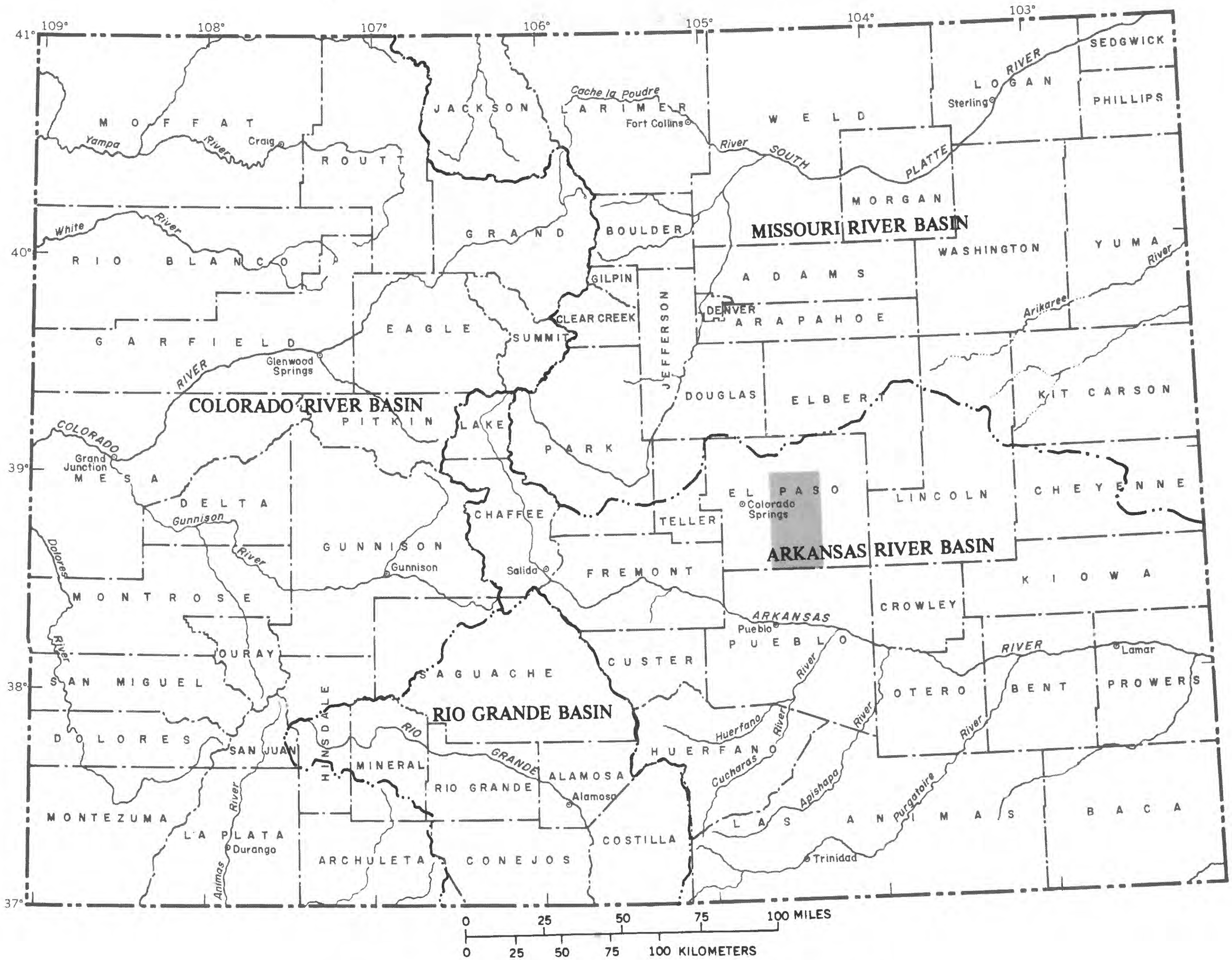

Figure 23.--Location of Upper Black Squirrel Creek basin.

PROJECT TITLE: Upper Black Squirrel Creek Basin Digital Model (fig. 23)

COOPERATING AGENCIES: Cherokee Water District and the El Paso County Board of Commissioners

PROJECT CHIEF: Jerry L. Hughes, Subdistrict Office, Pueblo

PERIOD OF PROJECT: October 1980 to September 1984

Problem.--The Upper Black Squirrel Creek drainage basin has been designated by the State as a major future source of ground water. Existing and anticipated demands upon the water supply of the basin make it imperative that ground-water changes be monitored and data collected for a digital model that can be used in making long-term management decisions.

Objectives.--Establish a ground-water level monitoring network and develop a digital computer model.

Approach.--Inventory wells in the basin study area. Select wells that best represent dynamic ground-water conditions. Measure water levels monthly and install water-level recorders on selected wells. Collect and evaluate aquifer and other hydrogeologic data and develop a digital model.

Progress.--The evaluation of historic data has been completed. The Cherokee Water District has been providing water-level data for about 60 wells. Continuous water-level recorders have been operating on four wells.

Plans.--Install and maintain automatic water-level recorders and process data from them. Record and process bimonthly ground-water data provided by cooperator.

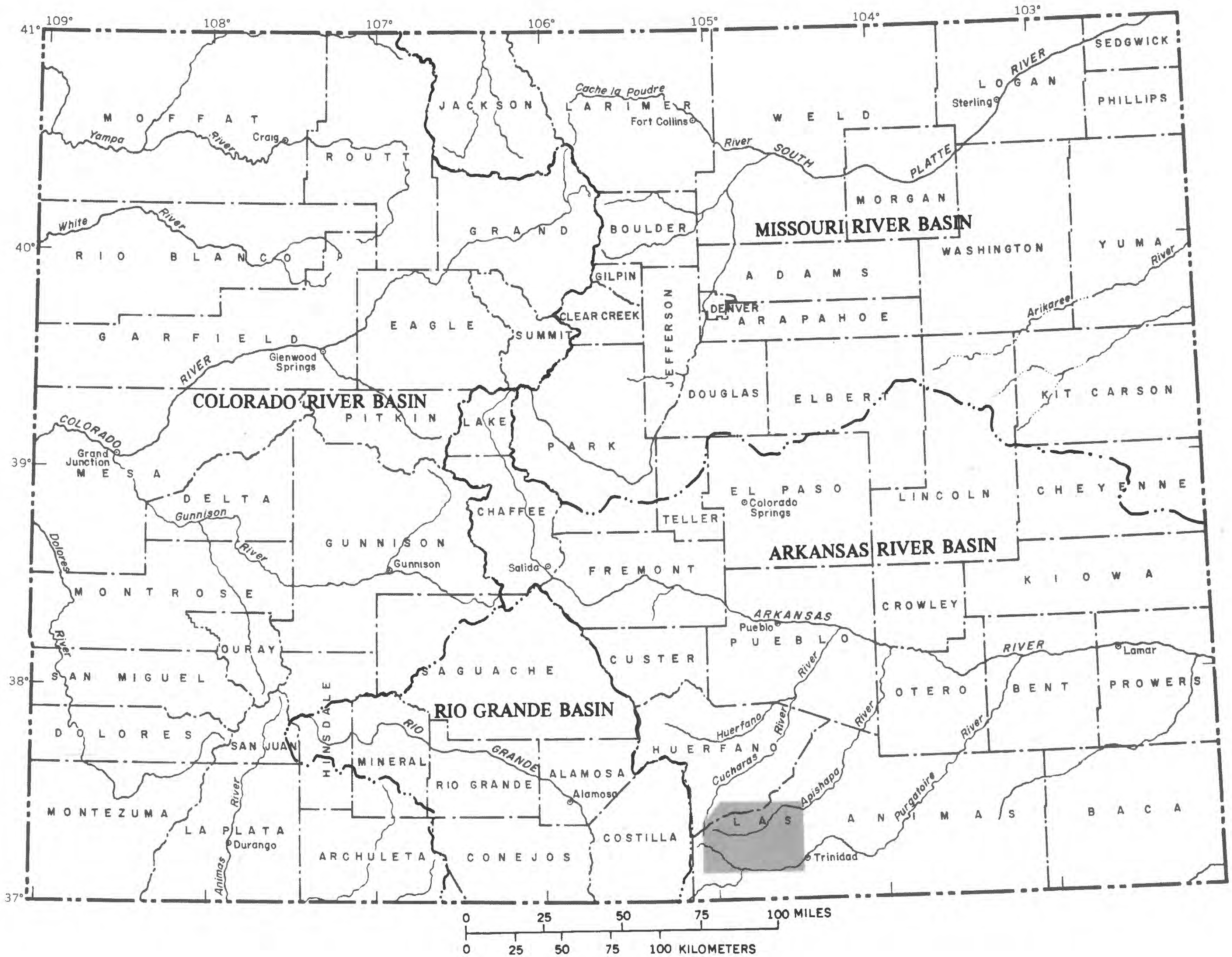

Figure 24.--Location of Raton Mesa.

PROJECT TITLE: Monitoring of the Hydrologic System of Raton Mesa (fig. 24)

COOPERATING AGENCY: None

PROJECT CHIEF: Payton O. Abbott, Subdistrict Office, Pueblo

PERIOD OF PROJECT: October 1978 to September 1982

Problem.--Proposed expansion of coal mining in the Raton Mesa coal fields may have adverse effects on the hydrologic system of the area. A knowledge of the existing hydrologic system is needed prior to the expansion of coal mining so that the effects of mining can be determined.

Objective.--Determine the hydrologic system of the area; determine the relations between climatic conditions, surface water, and ground water.

Approach.--Install five surface-water stations; collect streamflow and water-quality data at the stations. Obtain ground-water data from personnel working on the project "Ground-Water Studies in Coal-Mining Areas" (p. 17).

Progress.--Surface-water stations have been installed, and sediment, streamflow, and water-quality data are being collected at five sites. Both direct and automatic sediment-sampling techniques are being used. The flows at each station have been rated. Two high flows provided valuable data on sediment yield and water quality. All data have been evaluated and stored in the computer. A preliminary report has been completed.

Plans.--Continue data collection.

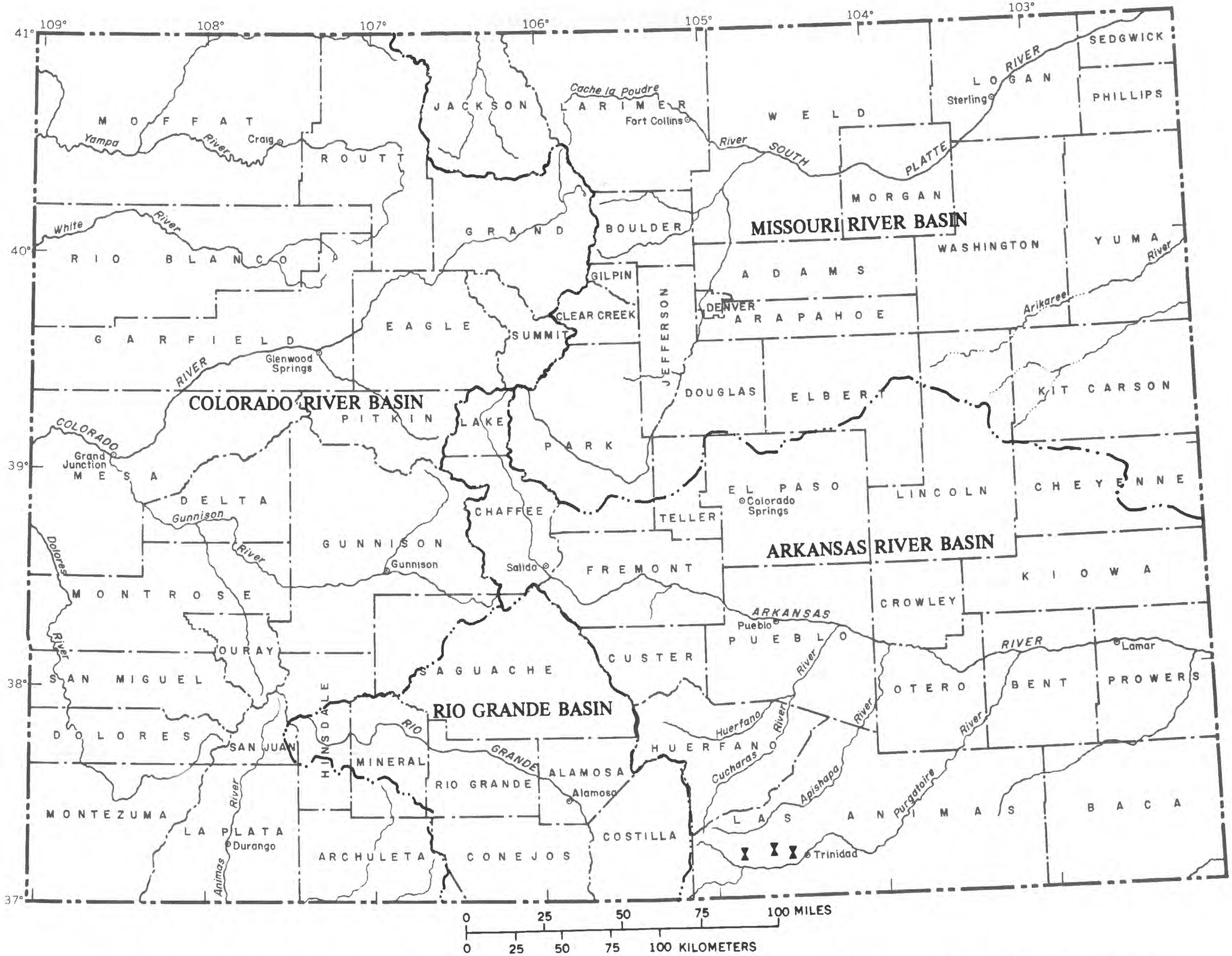

Figure 25.--Location of stations monitoring the hydrologic system in three small basins, Raton Mesa coal fields.

PROJECT TITLE: Intensive Hydrologic Monitoring of Small Basins in the Raton Mesa Coal Fields (fig. 25)

COOPERATING AGENCY: U.S. Bureau of Land Management

PROJECT CHIEF: Payton O. Abbott, Subdistrict Office, Pueblo

PERIOD OF PROJECT: October 1978 to September 1982

Problem.--Because it will not be possible to directly determine the hydrologic system of every area where coal mining will occur and to monitor the effects of coal mining during and after mining, a method of evaluation needs to be developed that can be easily adapted to areas for which detailed studies are not planned.

Objectives.--Determine the hydrologic system in three small unmined basins. Use the data to develop computer models that can be used to predict the effects of mining on the hydrologic system in areas for which detailed studies are not planned.

Approach.--Select three small basins where coal mining may occur within 3 to 5 years and that are representative of other areas where mining may occur. Install climatological stations in two of the basins. Install two surface-water gaging stations equipped with automatic sediment samplers in each basin. Periodically collect samples of streamflow for chemical analysis. Obtain ground-water data from personnel working on the project "Ground-Water Studies in Coal-Mining Areas" (p. 17). Use the data to develop the computer model.

Progress.--All stations have been installed, and data are being collected on climate, soil moisture, stream discharge, sediment, and water quality. All data collected have been entered into the U.S. Geological Survey's computer storage and retrieval system.

Plans.--Continue intensive collection of data. Install three additional stations in different geographic and geologic settings; the stations are essential for adequate predictive modeling. Construct low-flow, flood-flow, and rainfall-runoff models. Begin an interim report describing the available data.

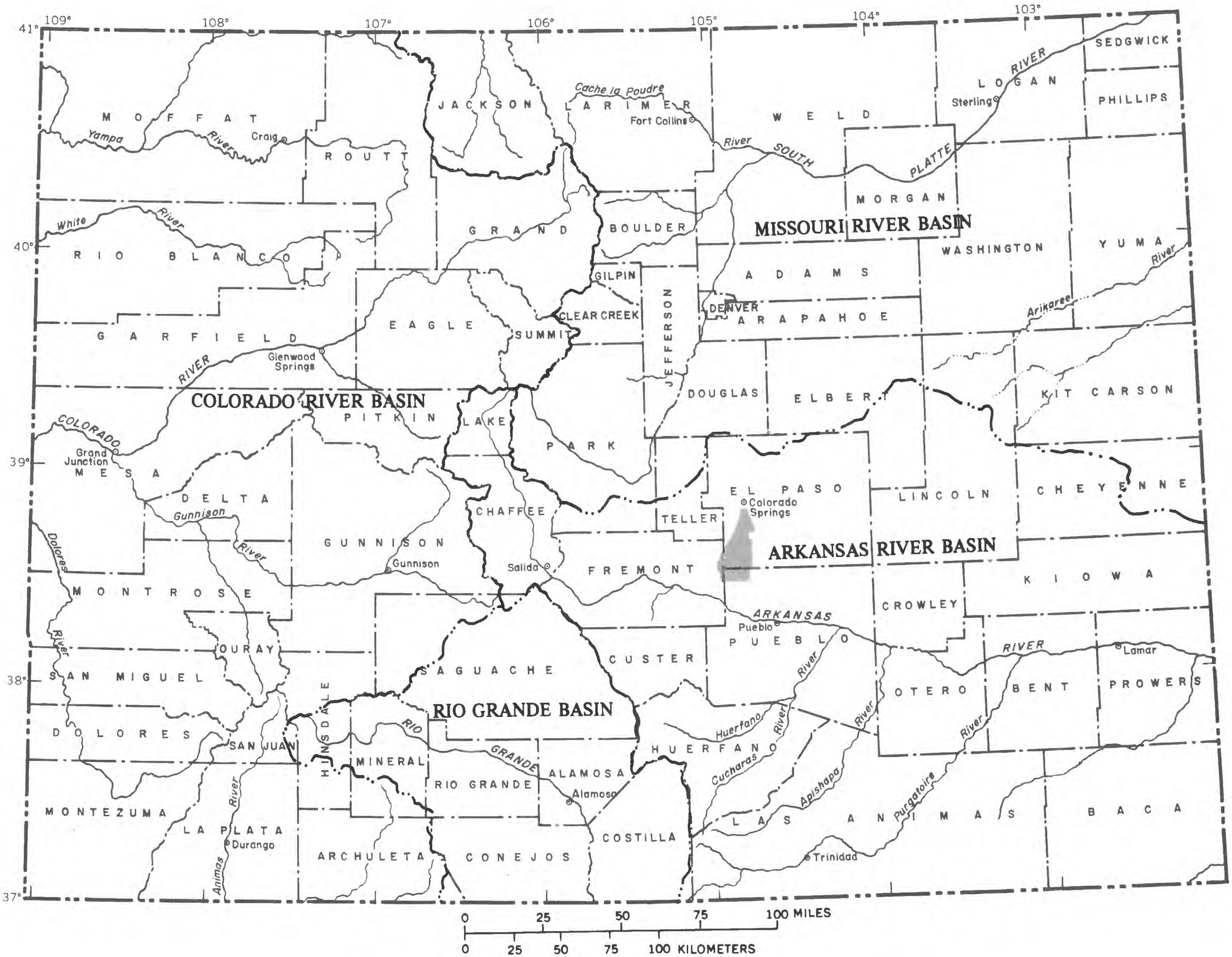

Figure 26.--Location of the Fort Carson Military Reservation.

PROJECT TITLE: Water-Resources Appraisal of the Fort Carson Military Reservation (fig. 26)

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

PROJECT CHIEF: Jerry L. Hughes, Subdistrict Office, Pueblo

PERIOD OF PROJECT: October 1977 to September 1983

Problem.--The water resources of the reservation cannot be properly developed and managed because knowledge of the resources is inadequate.

Objective.--Assess the present surface- and ground-water resources of the reservation.

Approach.--Use water-rights records to determine the existing water rights of the reservation and their effect on water use in the reservation. Collect surface-water data to determine annual streamflow into and out from the reservation, seasonal variations in the quantity and water quality of streamflow, and seasonal variations in storage and water quality of existing reservoirs. Collect ground-water data from existing wells to determine the extent of alluvial and bedrock aquifers, areas of recharge to and discharge from the aquifers, yield characteristics, and seasonal variations in water quality. Use the data to determine areas of potential development of the water resources.

Progress.--Water rights have been tabulated. Twenty streamflow-gaging stations have been installed and are operating. Sediment data have been collected by automatic samples at two reservoir-inflow sites. Samples for water-quality analysis are routinely being collected at nine stations. About 105 wells have been inventoried; water levels are being measured in 40 wells. Continuous water-level recorders have been installed and are operating on three wells. Samples for water-quality analysis have been collected from the wells. All data have been evaluated and entered into computer storage.

Plans.--Continue data collection. Auger and case 25 test holes near the Fort Carson golf course to detect any ground-water degradation from the use of waste effluent for golf-course watering. Make additional water-level measurements and do extensive water sampling. Assist in the preparation of environmental-impact statements on the Fort Carson expansion. Prepare reports on the hydrology of Fort Carson and on the golf course study.

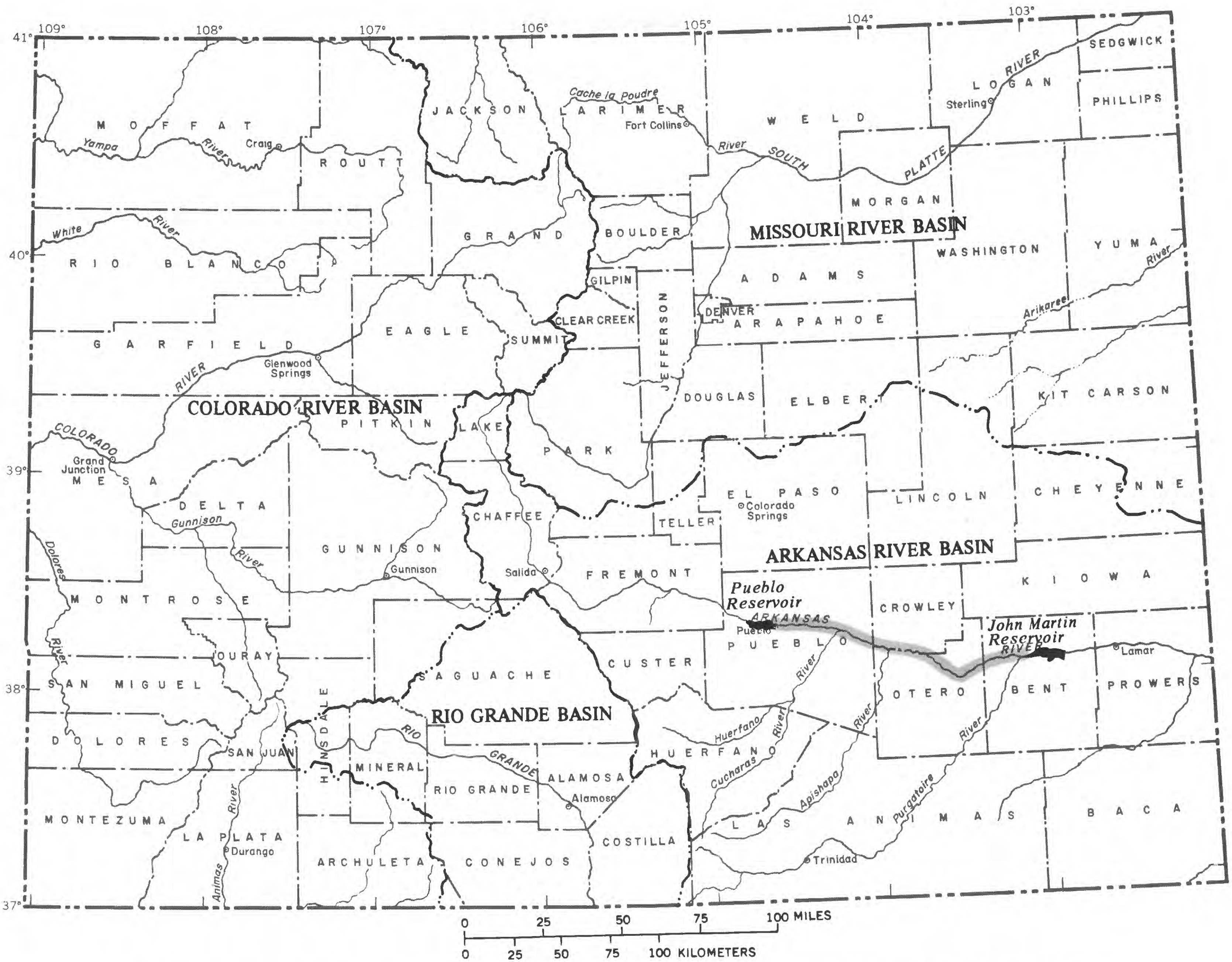

Figure 27.-- Location of the reach of the Arkansas River between Pueblo and John Martin Reservoirs.

PROJECT TITLE: Travel Time and Transit Losses, Arkansas River, Colorado (fig. 27)

COOPERATING AGENCIES: Southeastern Colorado Water Conservancy District; Arkansas River Compact Administration

PROJECT CHIEF: Payton O. Abbott, Subdistrict Office, Pueblo

PERIOD OF PROJECT: October 1980 to September 1984

Problem.--According to Colorado water law, the transit loss of surface flows delivered to a point of diversion is 0.07 percent per mile. Transit losses in reality depend upon antecedent conditions along the river and the volume and duration of the release. The rate of loss is therefore not a constant. An accurate method of predicting transit losses for a given flow, however, is essential for proper management of the Arkansas River.

Objectives.--Develop a method of calculating the traveltime and transit losses of a given release to a point of diversion downstream. The method must be one that can be easily used by managers to minimize transit losses by scheduling releases according to antecedent conditions.

Approach.--Collect and evaluate data on historic releases to determine actual losses. Investigate the effects of bank storage, channel storage, evaporation, and other factors that determine antecedent conditions, and use the data from controlled releases to calibrate a digital model. Repeat the controlled releases at different times of the year for a period of years to verify the model and to determine the effect of pumping on the antecedent conditions. Develop an algorithm for calculating transit losses on a computer and instruct the Division Engineer in its use.

Progress.--The traveltime and transit losses computation has been adapted for use on a computer. A 6-day verification of the transit-loss model has been performed by using a 600-acre-foot release from the Pueblo Reservoir. The results of the test release have been evaluated.

Plans.--Continue verification tests on the transit-loss model and instruct the Division Engineer in its use. Prepare a proposal to extend the transit-loss studies downstream from the John Martin Reservoir.

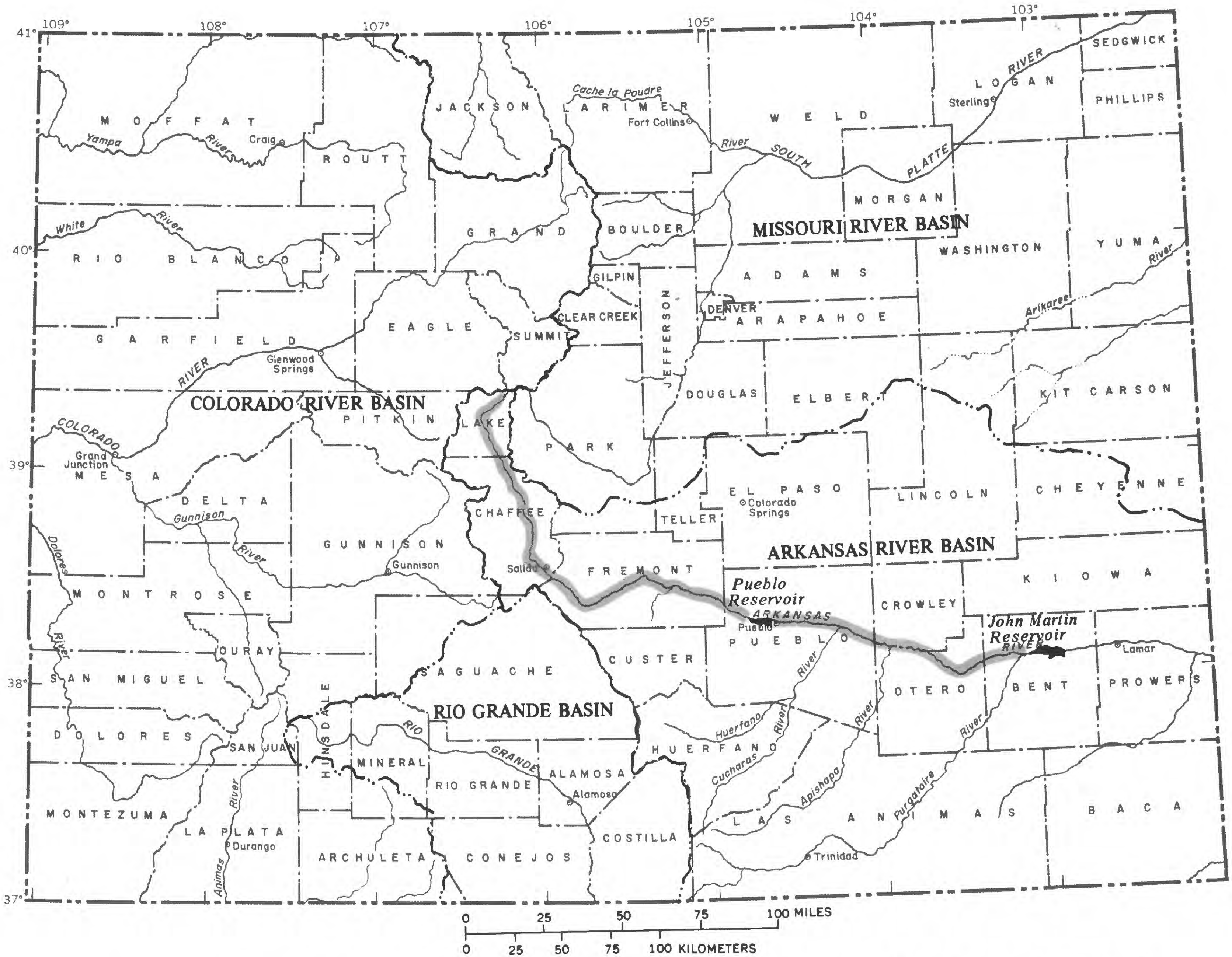

Figure 28.--Location of the reach of the Arkansas River between its headwaters and the John Martin Reservoir.

PROJECT TITLE: Hydrology of the Arkansas River Valley in Colorado (fig. 28)

COOPERATING AGENCY: Southeastern Colorado Water Conservancy District

PROJECT CHIEF: Jerry L. Hughes and Doug L. Cain, Subdistrict Office, Pueblo

PERIOD OF PROJECT: October 1980 to September 1984

Problem.--The Arkansas River valley from its headwaters in Lake County to the John Martin Reservoir in Bent County is an area of intensive water use. Although most of the streamflow originates in the basin above Canon City, most of the water is used for irrigation downstream from Pueblo. The stream is overappropriated. The distribution of water in time and space must be known to evaluate alternate water-management plans for the conjunctive use of ground and surface water.

Objectives.--To collect, analyze, and compile hydrologic data needed for planning and administering water use in the Arkansas River basin in Colorado. Provide technical assistance to the cooperator whenever needed. Supply information that will guide legislators enacting improved water codes, enable water administrators to perfect regulations and compacts governing the distribution of water, and help water users schedule irrigation releases.

Approach.--Provide a continuing inventory of both surface- and ground-water use. Collect data on the natural variations of water availability.

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. Approximately 1,000 water levels have been measured in 700 wells along the Arkansas River. Automatic water-level recorders have been operating on nine wells. Surface-water stations have been modified for the installation in fiscal year 1981 of COMSAT General's satellite-communications system. Streamflow data from numerous sites have been collected and analyzed.

Plans.--Continue collecting basic data on ground water, surface water, and quality of water. Evaluate the ground-water network. Install two new streamflow stations to record ground-water levels. Review all existing interpretive reports and relate them to present studies. Determine the feasibility of developing a computer model of the hydrologic system of the Arkansas River valley that incorporates management options and optimization routines and that can simulate solute transport.

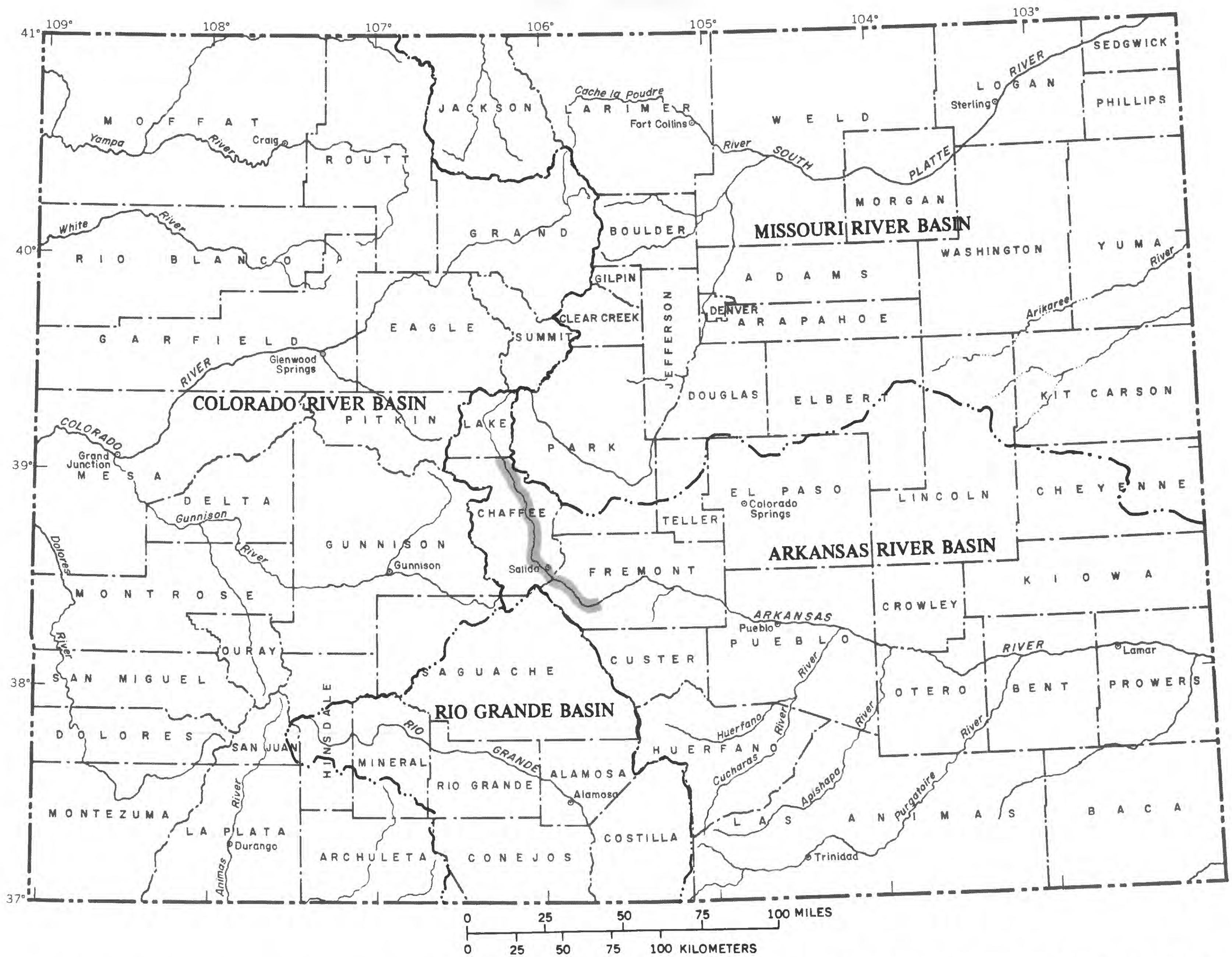

Figure 29.--Location of the reach of the Arkansas River between the Lake County-Chaffee County line and Cotopaxi, Colo.

PROJECT TITLE: Hydrology of the Arkansas River Valley in Colorado (fig. 29)

COOPERATING AGENCY: Upper Arkansas River Water Conservancy District

PROJECT CHIEFS: Jerry L. Hughes and Doug L. Cain, Subdistrict Office, Pueblo

PERIOD OF PROJECT: October 1980 to September 1984

Problem.--Water use in the upper Arkansas River valley is increasing, resulting in many water-related problems. The sources of some of these problems are seepage from septic tanks, contamination by fertilizers, effluents from coal and uranium processing, irrigation by stream diversions and from pumping wells, and the use of water for municipal and domestic purposes.

Objectives.--To learn more about the geology and hydrology of the basin and apply this knowledge to better management of the water resources.

Approach.--Continue the inventory of ground- and surface-water use, determine variations in water quality, collect data on water availability and relate them to the geology and hydrology, and develop conceptual and digital computer models that will add to our understanding by simulating the hydrologic system.

Progress.--Measurements were being continued in 38 wells that complement the network of 75 wells measured by the Southeastern Colorado Conservancy District and the Colorado State Engineer. A 1974 report on the availability and quality of ground water in the upper Arkansas River valley has been updated.

Plans.--Measure water levels in the 38 observation wells. Publish the 1974 report on ground water in the upper Arkansas River valley.

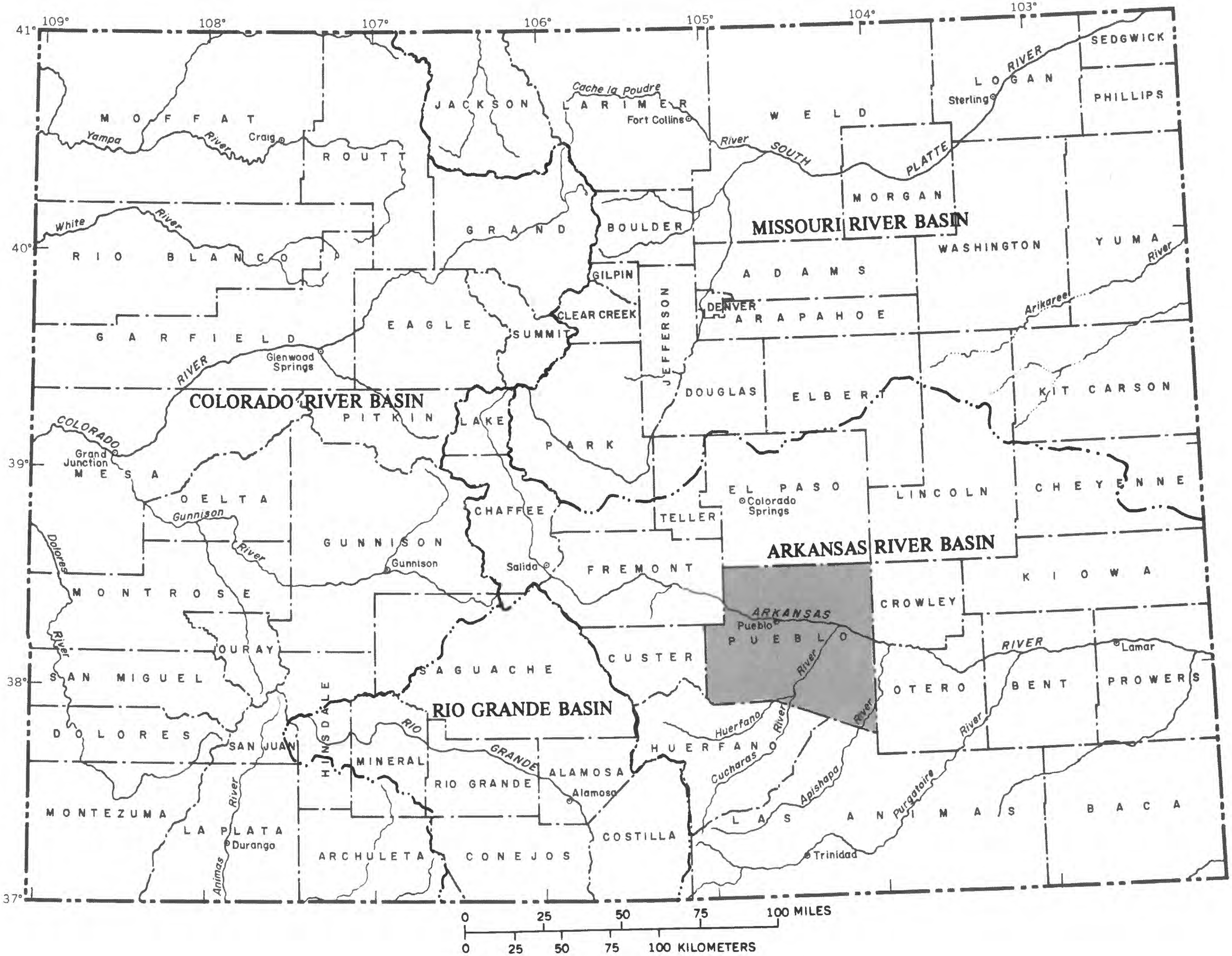

Figure 30.-- Location of Pueblo County.

PROJECT TITLE: Waste-assimilation capacity of the Arkansas River in Pueblo County (fig. 30)

COOPERATING AGENCY: Pueblo Area Council of Governments

PROJECT CHIEF: Doug L. Cain, Subdistrict Office, Pueblo

PERIOD OF PROJECT: August 1976 to December 1980

Problem.--In order to comply with Section 208 of Public Law 92-500, the Pueblo Area Council of Governments needs to develop and implement water-pollution controls to meet the goal of making streams suitable for body-contact recreation and fish propagation by 1983. The Pueblo Area Council of Governments needs a predictive tool to evaluate the effects of proposed management alternatives on water quality of the Arkansas River in Pueblo County.

Objectives.--Calibrate and verify a steady-state water-quality model for a 42-mile reach of the Arkansas River between Pueblo Dam and the streamflow-gaging station at Nepesta. The model will be used by the Pueblo Area Council of Governments to predict the effects of proposed management alternatives. Determine the area and extent of waste mixing downstream from point sources of waste discharges.

Approach.--Calibrate and verify an existing U.S. Geological Survey model to conditions in the Arkansas River so that the model can predict concentrations of dissolved oxygen, biochemical oxygen demand, nitrogen and phosphorus species, and coliform bacteria. Calibrate and verify the model using data collected during high- and low-flow periods. Establish a water-quality-monitoring network.

Progress.--Reports on the waste-assimilation capacity of the Arkansas River in Pueblo County have been completed.

Plans.--Project completed.

Reports published or released during fiscal year 1980.--See reference 4 under Water-Resources Data reports and references 7, 8, and 15 under Water-Resources Interpretive Reports at back of report.

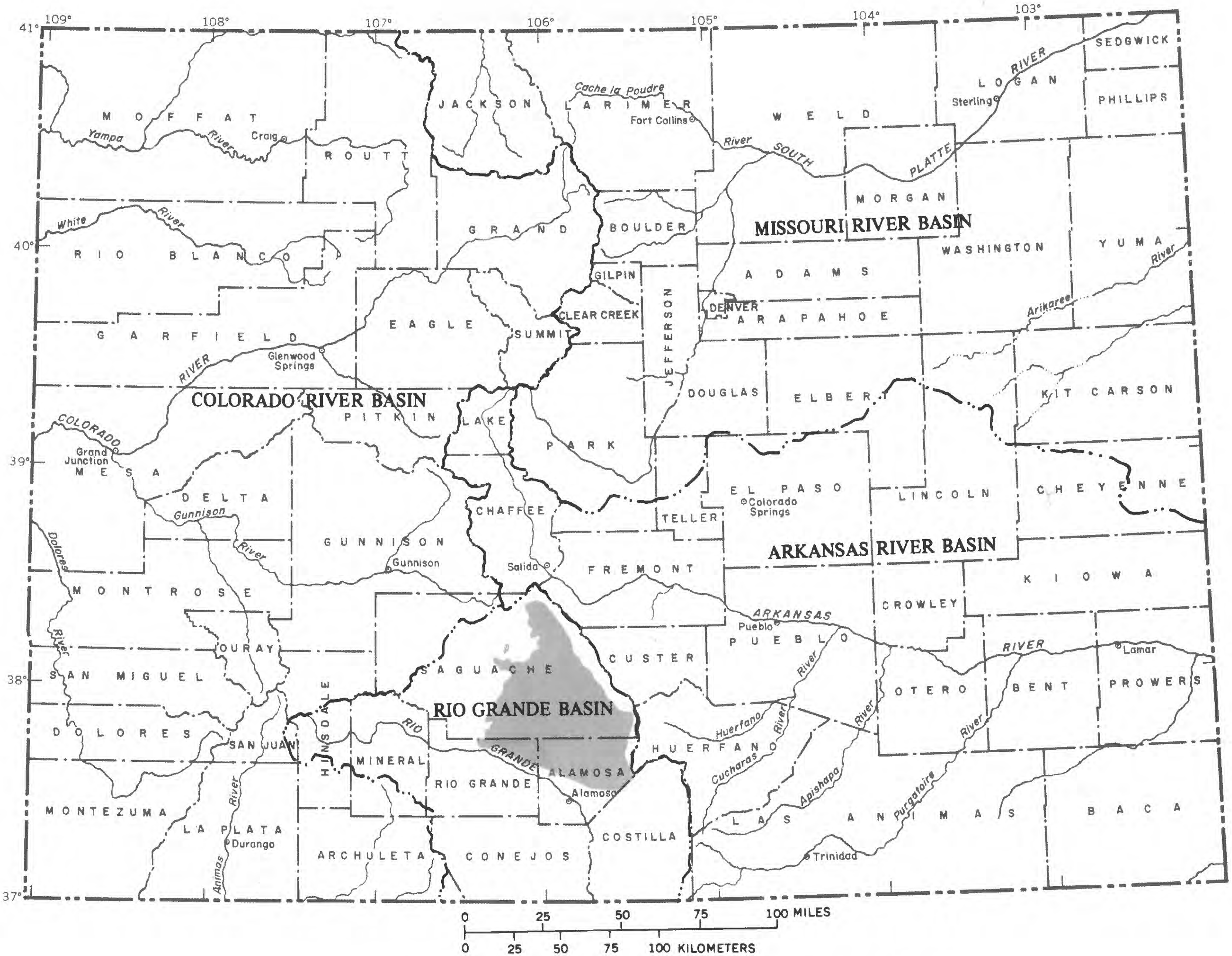

Figure 31.--Location of the closed-basin part of the San Luis Valley.

RIO GRANDE BASIN

PROJECT TITLE: Hydrology of the Closed-Basin Part of the San Luis Valley in Colorado (fig. 31)

COOPERATING AGENCY: U.S. Water and Power Resources Service

PROJECT CHIEF: Guy J. Leonard, Subdistrict Office, Pueblo

PERIOD OF PROJECT: October 1980 to September 1984

Problem.--Significant quantities of ground water in the closed-basin part of the San Luis Valley are lost to evapotranspiration. This water could be salvaged and used to irrigate crops or to fulfill Colorado's obligations to the interstate Rio Grande Compact.

Objectives.--Thoroughly describe and quantitatively evaluate the hydrology of the closed basin. Construct and utilize a digital model of the ground-water system to evaluate water availability from the aquifer and pumpage impacts on the potentiometric-surface distribution in the basin.

Approach.--Compile and evaluate existing data on wells, pumpage, regulation, and ground-water and surface-water inflow to quantify the hydrologic budget. Drill test holes to better define the hydraulic gradients, geology, hydrogeology, and quality of water. Build and interrogate a two-dimensional difference model to determine the effects of pumping on both the confined and unconfined aquifers. Use temperature profiles to help define leakance. Build a three-dimensional solute-transport model to predict long-term changes in the quality of water.

Progress.--Automatic water-level recorders have been installed on 15 wells, water samples have been collected for chemical analysis from 20 wells, and aquifer tests have been performed on 7 wells. A two-dimensional difference model of areas 1 and 2 in the closed basin has been completed and the model has been interrogated to determine the optimum well locations and pumping pattern needed to minimize the drawdown.

Plans.--Install digital recorders on 10 additional test holes drilled by the Water and Power Resources Service. Interpret data from aquifer tests. Construct temperature profiles. Update the digital model of the aquifer system. Complete a hydrologic budget and interrogate the two-dimensional aquifer model to determine what well spacings and pumping pattern will minimize drawdown in the unconfined aquifer. Begin preparation of a report.

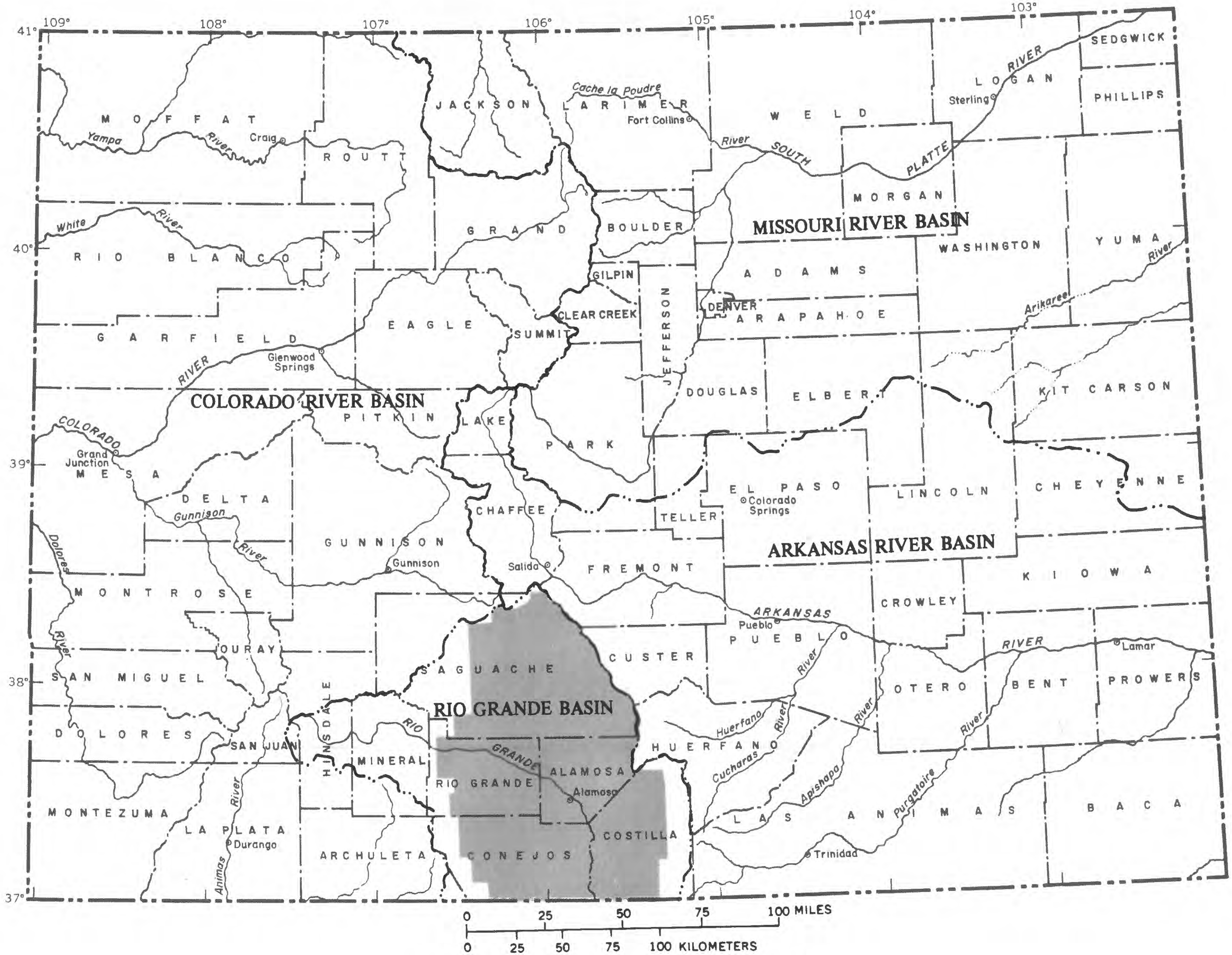

Figure 32.--Location of the San Luis Valley.

PROJECT TITLE: Water Resources of the San Luis Valley in Colorado (fig. 32)

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

PROJECT CHIEF: Jerry L. Hughes, Subdistrict Office, Pueblo

PERIOD OF PROJECT: October 1980 to September 1984

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 and monitor changes in the hydrologic system.

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.

Progress.--Sufficient data have been collected to define most of the hydrologic system. Data collection is continuing to complete the definition of the hydrologic system and to provide data for use in the computer models of the valley. Eighteen additional wells on and near the ground-water divide between the Rio Grande drainage and the closed-basin part of the San Luis Valley have been located and added to the water-level monitoring network. Automatic water-level recorders have been installed on five wells in the Trinchera Water District.

Plans.--Expand the network of wells in which water-level measurements are being made to include an additional 18 wells on the ground-water divide between the Rio Grande and the closed basin. This expansion will bring the total number of monthly measurements to 68. Install and operate water-level recorders on 5 additional wells in the Trinchera Water District, bringing the total to 10. Run thermal and geologic logs on 17 wells drilled by the State of Colorado for geothermal research. Prepare hydrographs and evaluate data.

PROJECT TITLE: Feasibility of Artificial Ground-Water Recharge, San Luis Valley, Colorado (fig. 32)

COOPERATING AGENCY: Rio Grande Water Conservation District

PROJECT CHIEF: Guy J. Leonard, Subdistrict Office, Pueblo

PERIOD OF PROJECT: October 1980 to September 1984

Problem.--Underground storage of excess runoff is needed in the San Luis Valley because surface-storage facilities are very small. Storage of the water underground will reduce the loss by evapotranspiration and will avoid unnecessary water contributions to the interstate Rio Grande Compact.

Objectives.--Investigate the potential for artificially recharging the ground-water system, which is being heavily pumped for irrigation.

Approach.--Dig pits and closely monitor the infiltrating water. Use geophysical equipment to describe the recharge-impulse wave from the pits to the zone of saturation. Evaluate the results of the study for transferability to other parts of the valley.

Progress.--Participated in meetings of the ad hoc San Luis Valley Water Resources Advisory Committee that is directing the study. The committee includes representatives from the Colorado School of Mines, Colorado State University, Rio Grande Water Conservation District, U.S. Geological Survey, and U.S. Forest Service.

Plans.--Interpret data from the tests and locate additional sites for testing in other parts of the San Luis Valley. The new sites will have different recharge potentials. The results of the previous tests will be used to modify the approaches in the new tests.

PROJECT TITLE: Hydrologic and Water-Quality Monitoring of the San Luis Valley, Colorado (fig. 32)

COOPERATING AGENCY: Rio Grande Water Conservation District

PROJECT CHIEF: Guy J. Leonard, Subdistrict Office, Pueblo

PERIOD OF PROJECT: October 1980 to September 1984

Problem.--The intense development of water supplies in the San Luis Valley has resulted in many hydrologic problems, some of which are legal in nature. Water is pumped from the unconfined aquifer for agricultural use, which recently has included many center-pivot sprinklers. This pumping has resulted in a decline in the water levels of wells penetrating the confined aquifer and a reduction in the flow of the Rio Grande and the Conejos River. The quality of water in the unconfined aquifer has deteriorated and deliveries to the downstream States of the Rio Grande Compact have been deficient.

Objectives.--Use a digital model of the aquifers to determine the effects of (1) evapotranspiration salvage in the closed basin part of the San Luis Valley on the basin hydrology and Compact deliveries, (2) the export of water from Costilla County for coal slurry, (3) the exchange of poor quality water in the closed basin for good quality water in Costilla County, (4) the impacts of pumping in Costilla County on the interstate ground-water movement, and (5) the degradation of the quality of ground water caused by intense irrigation.

Approach.--Verify the conversion of the existing analog model to digital format, and incorporate new data. Interrogate model for the solution of selected hydrologic problems. Collect data on the depletion of the Rio Grande and the Conejos River. Collect and evaluate water-quality data in the Del Norte and Monte Vista areas and use the model to predict the effects of irrigation on the quality of water.

Progress.--Conversion of the San Luis Valley model from analog to digital form has been completed.

Plans.--Verify the conversion of the analog model to digital format. Interrogate the model for solutions to various hydrologic problems.

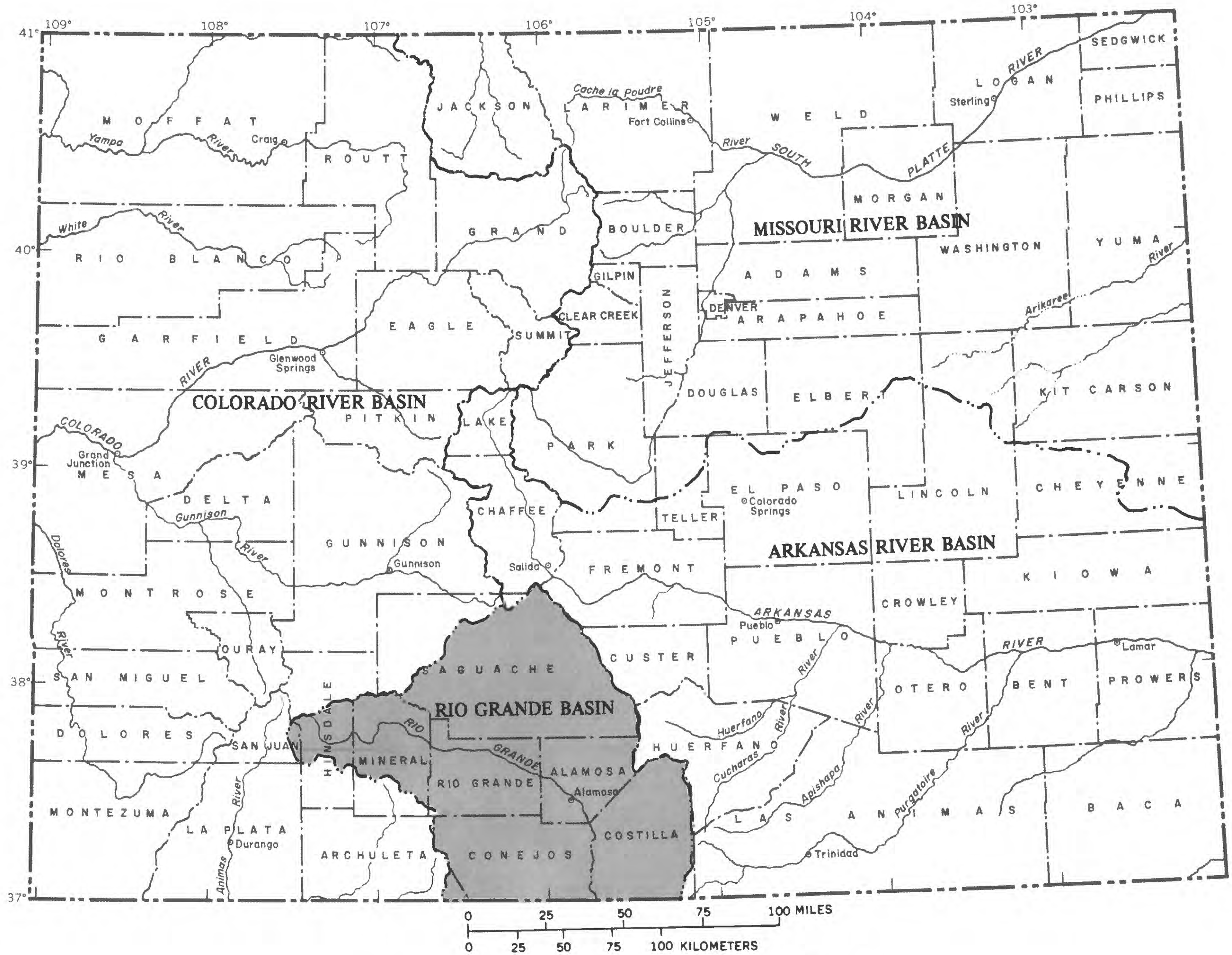

Figure 33.--Location of the Upper Rio Grande basin.

PROJECT TITLE: Hydrology of the Southwest Alluvial Valleys Regional Aquifer System--Upper Rio Grande Basin (fig. 33)

COOPERATING AGENCY: None

PROJECT CHIEF: Thomas M. Crouch, Subdistrict Office, Pueblo

PERIOD OF PROJECT: October 1978 to September 1982

Problem.--Rapid population increases and consequent greater use of water resources is occurring in the "Sunbelt" States of the southwest. To augment surface-water supplies, ground water from alluvial fill in desert basins is being developed. This development has resulted in continued water-level declines, land subsidence, depletion of streamflow, and water-quality changes.

Objectives.--Define the hydrology of the alluvial-aquifer systems in the Upper Rio Grande basin as part of the analysis of the regional aquifer system. Determine the extent, hydraulic properties, water quality, and recharge to and discharge from the aquifers. Determine the relations between the ground water and surface water. Describe the flow system in the area and the response of the system to ground-water development.

Approach.--Develop a predictive digital model of the entire Upper Rio Grande basin using existing models for the San Luis Valley as a base. The expanded model will include the Sunshine Valley in New Mexico.

Progress.--Nineteen miles of seismic surveys have been completed in southern San Luis Valley and northern Sunshine Valley. Collation of existing data and conversion of existing models has begun. Data from approximately 500 wells in the San Luis and Sunshine Valleys have been evaluated and placed in the Ground Water Site Inventory (GWSI) computer file. Data on water levels, streamflow, depletion of the Rio Grande, and geology have been assimilated. Some of these data were used in previously constructed computer models. Expansion of the digital modeling into Sunshine Valley has begun.

Plans.--Collect and evaluate pumpage data. Complete entry of well data into GWSI. Finish expanding the digital model into Sunshine Valley. Enter into model data resulting from recent studies on NO_3 degradation, depletion of the Conejos River, and aquifer testing in Costilla County and the closed basin. Begin model calibration and writing of the report. Continue coordinating work on the Rio Grande model with the New Mexico District.

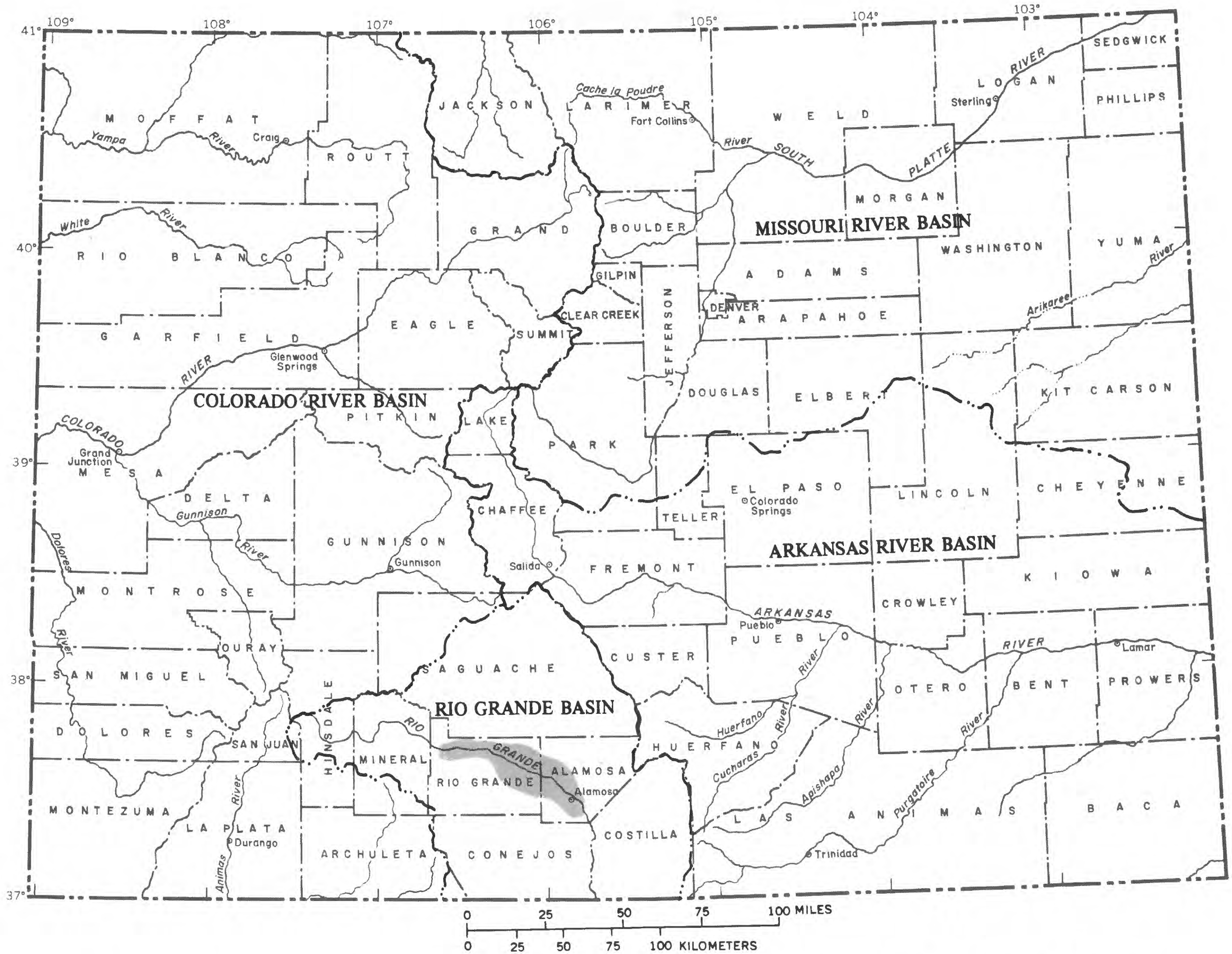

Figure 34.--Location of the Rio Grande drainage south of the closed basin, Rio Grande and Alamosa Counties.

PROJECT TITLE: Investigation of the Concentration and Distribution of Nitrogen and Dissolved Ions in the Ground- and Surface-Water Resources of Parts of Rio Grande and Alamosa Counties (fig. 34)

COOPERATING AGENCY: Rio Grande Water Conservation District

PROJECT CHIEF: Patrick Edelmann, Subdistrict Office, Pueblo

PERIOD OF PROJECT: October 1980 to October 1982

Problem.--Ground water south of the ground-water divide separating the closed basin part of the San Luis Valley from the rest of the Rio Grande drainage is impaired by high concentrations of dissolved solids and nitrogen and could discharge into the Rio Grande. The high concentrations would be especially noticeable during low flows. High rates of evapotranspiration tend to increase the concentration of dissolved solids in the ground water. Continued use of fertilizers and increased irrigation will probably lead to a greater concentration and distribution of nitrogen in the ground water and irrigation-return flow.

Objectives.--Investigate the quality of the ground and surface waters in the agricultural area south of the ground-water divide and determine the areal and vertical distribution of nitrate-nitrogen and dissolved ions.

Approach.--Collect water-quality samples from approximately 45 wells in the confined aquifer. Sample seven surface-water sites. Sampling will be semiannual, before and after the irrigation season. Analyze all samples for dissolved nitrogen species and major anions and cations. Measure water levels in the wells during both sampling periods to determine the direction of ground-water movement.

Progress.--None--new project.

Plans.--Locate monitor wells. Measure water levels in the wells and sample them twice a year. Collect records of streamflow on the Rio Grande and on all diversions and canals carrying return flow to the river system. Interrogate the San Luis Valley digital model (another project) to determine directions of ground-water flow under different historic pumping conditions. Collate the data and other information from previous reports on the area.

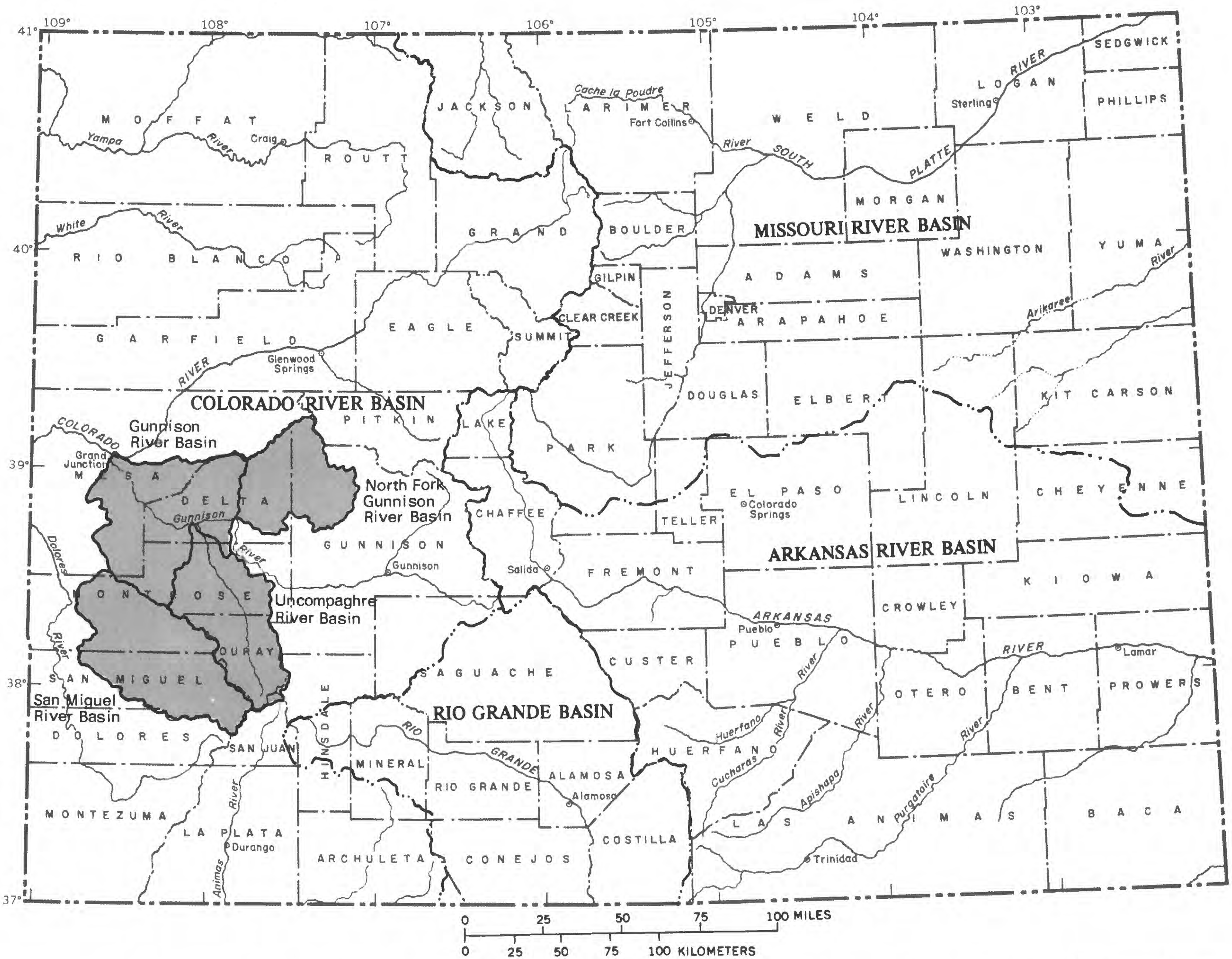

Figure 35.--Location of the Gunnison River, North Fork Gunnison River, San Miguel River, and the Uncompaghre River basins.

COLORADO RIVER BASIN

PROJECT TITLE: Evaluation of Aquifers, Western Colorado (fig. 35)

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

PROJECT CHIEF: Daniel J. Ackerman, 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.--The ground-water data bases for the North Fork Gunnison River and San Miguel River basins have been revised and updated. Three reports on the ground-water hydrology of these basins have been begun. The collection of ground-water data has begun in the Gunnison River and Uncompaghre River basins.

Plans.--Publish the three reports now in preparation. Continue data collection in the Gunnison River and Uncompahgre River basins.

Reports published or released during fiscal year 1980.--See reference 14 under Water-Resources Interpretive Reports at back of report.

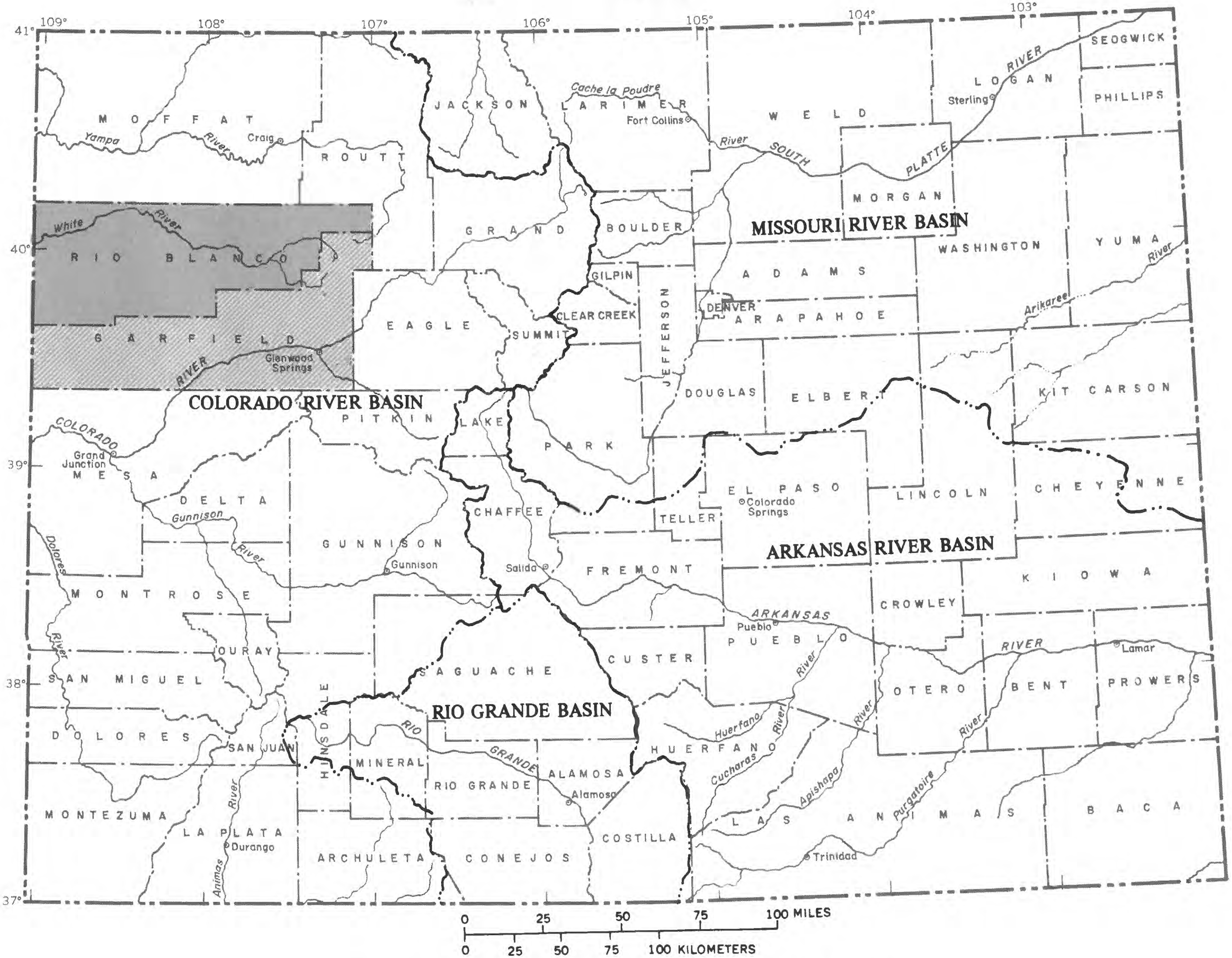

Figure 36.--Location of Rio Blanco and Garfield Counties.

PROJECT TITLE: Evaluation of Deep-Well Drilling Sites, Rio Blanco and Garfield Counties, (fig. 36)

COOPERATING AGENCY: None

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

PERIOD OF PROJECT: November 1980 to October 1981

Problem.--Increased coal and shale-oil production and related population and commercial growth in northwestern Colorado will increase water demands in the near future. Before irreversible management decisions are made to undertake the costly development of surface supplies, it is imperative that the ground-water resources be considered.

Objectives.--Study all available geologic and hydrologic data in order to select a site for exploratory drilling to deep potential aquifers below the Green River Formation. These aquifers may yield sufficient ground water to meet anticipated needs. Provide information on the suspected ground-water potential of not only the study area, but of all northwestern Colorado.

Approach.--Interpret existing oil-well logs. Obtain geologic and hydrologic information from field studies of outcrop areas. Construct maps of formation depth, thickness, permeability, and storativity. Map the potentiometric surface, yields of wells, and quality of water. Plot the geologic structure. Search the literature for related studies, such as those in the Piceance Creek structural basin.

Progress.--None--new project.

Plans.--Study all available geologic and hydrologic data to select a site for exploratory drilling to deep potential aquifers below the Green River Formation.

PROJECT TITLE: Ground-Water Resources of Rio Blanco County (fig. 36)

COOPERATING AGENCY: White River Soil Conservation District

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

PERIOD OF PROJECT: October 1977 to September 1983

Problem.--Development of energy resources in Rio Blanco County will require large quantities of ground water. Little is now known about the ground-water resources of the county. State and local officials need to know the extent of the ground-water resources so they can effectively manage them.

Objective.--Determine the ground-water resources of the county.

Approach.--Collect and evaluate historic ground-water data. Collect new ground-water data to determine the number and areal extent of aquifers in the county and to determine the volume and quality of water in the aquifers.

Progress.--Evaluation of historic data has been completed. Data collection continues. About 200 wells and springs have been inventoried. Geologic and hydrologic data have been obtained from four new core holes northeast of Rangely. Five wells in the alluvium near Rangely have been inventoried, and an aquifer test has been attempted on one.

Plans.--Continue well inventory.

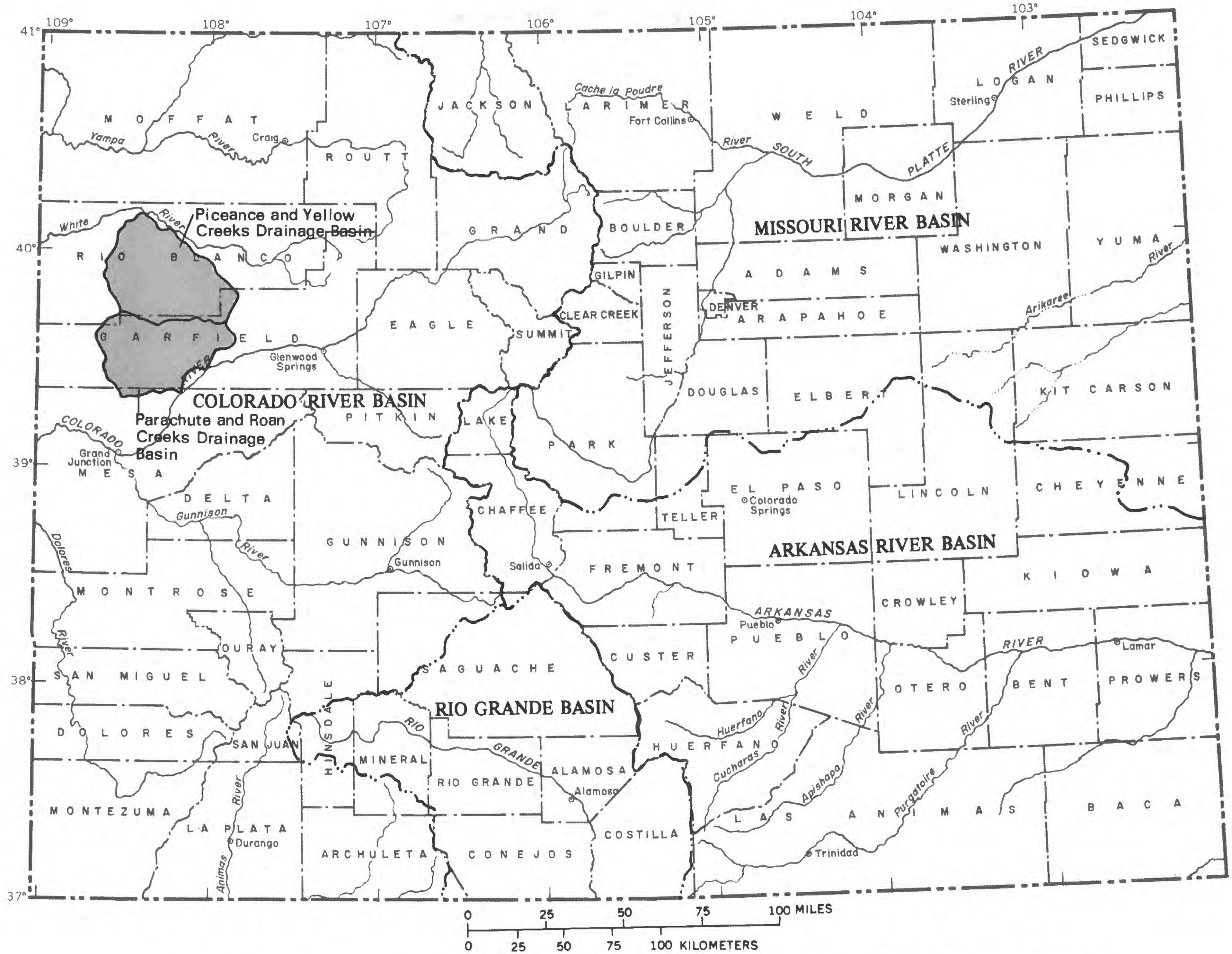

Figure 37.--Location of Piceance and Yellow Creeks and Parachute and Roan Creeks drainage basins.

PROJECT TITLE: Hydraulic Research of Springs, Piceance Creek and Yellow Creek Drainage Basins (fig. 37)

COOPERATING AGENCY: None

PROJECT CHIEF: Robert L. Tobin, Subdistrict Office, Meeker

PERIOD OF PROJECT: Continuous since July 1974

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 photographs and thermal images 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 about 100 springs. The discharge and water temperature of 29 springs have been measured monthly. Weekly measurements of specific conductance, discharge, and temperature have been made at 20 of these sites near the C-a and C-b tracts. A report describing the hydraulics of the springs has been prepared by the contractor. A report describing geologic sources of springs is being prepared by the U.S. Geological Survey.

Plans.--A progress report on the hydrology of the springs will be written by the contractor. Water-quality samples will be taken at selected sites for use in a comprehensive analysis of the quality of ground water in the Piceance basin.

PROJECT TITLE: Observation-Well Drilling and Potentiometric-Surface Mapping, Piceance Creek and Yellow Creek Drainage Basins (fig. 37)

COOPERATING AGENCY: None

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

PERIOD OF PROJECT: July 1974 to September 1982

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 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 are being measured in 70 wells twice a year. Continuous water-level recorders have been installed in two wells on Lease Tract C-b. Water levels have been measured monthly in seven wells on and near Lease Tract C-a; two of these wells are equipped with automatic water-level recorders. A network of observation wells has been established on and near Lease Tract C-b; water levels have been measured monthly by lessee personnel.

Plans.--Twice yearly, monthly, and continuous monitoring of water levels in wells will continue throughout the basin. The frequency of water sampling will probably be increased in wells on and near Lease Tract C-b. Additional wells will be included in the monitoring network if a new test-drilling program is approved.

PROJECT TITLE: Aquifer Testing, Piceance Creek and Yellow Creek Drainage Basins (fig. 37)

COOPERATING AGENCY: None

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

PERIOD OF PROJECT: July 1974 to September 1982

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 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. Use the data to improve the calibration of the computer model.

Progress.--Based upon the results of three aquifer tests made by the U.S. Geological Survey and aquifer tests made by lessees of the oil-shale tracts, it was determined that leaky aquifer tests cannot provide conclusive results within a reasonable testing time and cost. Therefore, no additional leaky aquifer tests were completed. Contracts were awarded to private firms to rehabilitate existing wells to prevent flow between aquifers in the well bores; the contracts have been completed. Three wells in the southern part of the area have been reconditioned to provide access to both the upper and lower aquifers. Eleven single-well aquifer tests have been conducted. Gassy water was encountered in some of the wells during the tests. Considerable time and effort were spent in trying different methods of conducting tests on the gassy wells, but the results were only partially successful. Several planning workshops and meetings were held with other Divisions, agencies, firms, and consultants in an effort to evaluate and coordinate well drilling and testing in the basin.

Plans.--Single-well aquifer testing will continue in the fall. If funds are available, groups of wells will be drilled and aquifer tests conducted in them. Test holes will also be drilled in the Piceance Creek valley to better define the bedrock-alluvium interface and the characteristics of the flow through it.

PROJECT TITLE: Geochemical Investigation, Piceance Creek and Yellow Creek Drainage Basins (fig. 37)

COOPERATING AGENCY: None

PROJECT CHIEF: Robert L. Tobin, Subdistrict Office, Meeker

PERIOD OF PROJECT: July 1974 to September 1983

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 can be used 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 essentially has been completed. In conjunction with the activities of the aquifer-testing project, 15 water samples have been collected and analyzed to better define the chemistry of ground water.

Plans.--Collect water-quality samples during future aquifer tests. Review and update data on the quality of water from wells and springs in the basins.

Reports published or released during fiscal year 1980.--See reference 21 under Water Resources Interpretive Reports at back of report.

PROJECT TITLE: Sediment Yield of Streams, Piceance Creek and Yellow Creek Drainage Basins (fig. 37)

COOPERATING AGENCY: None

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

PERIOD OF PROJECT: July 1974 to September 1982

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 load alter channel geometry and morphology and reduce the conveyance capacity of streams. The existing sediment load of streams needs to be known so that the effects of mining on the sediment load can be determined.

Objectives.--Determine the present sediment load 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.--The monitoring of suspended and total sediment load continued at 20 gaging stations. Fifty-two channel cross sections and thirty-five hillslope-erosion transects have been surveyed periodically. Monitoring of sediment movement on hillslopes, into reservoirs and stream channels, and suspended in streamflow was continued. The sampling frequency was increased at all stream-gage sites and has resulted in a much more detailed picture of suspended-sediment movement in the basins. Construction and mining have increased in the basins and have changed the characteristics of the flow and sediment at several sites. Reinjection of mine-dewatering effluent has decreased the surface-water flow from the C-a tract. Additional water encountered in shaft sinking has resulted in an increase in surface-water flow from the C-b tract. This increase in flow has caused erosion in a normally dry channel.

Plans.--Monitoring will continue. Artificial streamflow controls will be built at two sites and controls modified at two other sites. An interpretive report will be completed.

PROJECT TITLE: Occurrence of Benthic Invertebrates, Piceance Creek Drainage Basin (fig. 37)

COOPERATING AGENCY: None

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

PERIOD OF PROJECT: October 1976 to September 1982

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 in the creek can be used to determine the effects of mining on the water quality. 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 two to five artificial substrates at each site. Identify the species.

Progress.--Artificial substrates have been installed at all sites and the benthic invertebrates on them have been collected and identified. A reference collection has been started that contains representatives of all organisms collected. Benthic-invertebrate data have been tabulated for the 1977-79 water years. The data include number of organisms, percentage composition, and number of organisms per square meter. Diversity indexes have been determined for all of the samples and range from 0 to 3.62. Bar graphs showing the composition of the samples and the trophic relations are being prepared. The quality-of-water data are being analyzed.

Plans.--Collect benthic invertebrates on a quarterly basis. Relate quality-of-water data to biological data. Begin preparation of report.

PROJECT TITLE: Ground-Water Model of the Piceance Structural Basin (fig. 37)

COOPERATING AGENCY: Colorado River Water Conservation District

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

PERIOD OF PROJECT: August 1977 to September 1983

Problem.--Development of shale oil by industry will cause widespread changes in the ground-water regimen of the area. Extensive dewatering of the aquifers during mining of the oil shale may reduce the flow of springs and streams.

Objective.--Develop a ground-water model that can be used to predict the change in ground-water regimen resulting from the mining of the oil shale.

Approach.--Extend and refine a model developed for the Piceance basin to include the areas of Roan and Parachute Creeks.

Progress.--The existing computer model has been redesigned to improve its predictive capability. The present model is a five-layer, three-dimensional model that incorporates the effect of intensive fracturing on the anisotropy of the hydraulic conductivity.

Plans.--Adapt the model to more accurately portray stream depletion. Use the model to determine if benefits may result from injecting surplus water into bedrock aquifers for temporary storage or streamflow augmentation. Complete progress report on the model.

PROJECT TITLE: Plan for Study of the Water-Resource Systems of Oil-Shale Areas in Colorado (fig. 37)

COOPERATING AGENCY: None

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

PERIOD OF PROJECT: February 1980 to September 1981

Problem.--Available hydrologic data are inadequate to allow an accurate appraisal to be made of the effects of shale-oil development on the water resources of the oil-shale areas (Piceance Creek structural basin) in Colorado.

Objectives.--Analyze all existing hydrologic data to determine data needs, acquisition standards, and design of an efficient master plan.

Approach.--Ask specialists in different hydrologic disciplines to appraise existing information and determine future needs. Design a master plan and publish it as an open-file report.

Progress.--Plans for a study of the hydrology of oil shales have been prepared by hydrology specialists in the Conservation Division, Geologic Division, and Water Resources Division.

Plans.--The plans will be incorporated into a single report for publication.

PROJECT TITLE: Public-Oriented Report on the Piceance Creek Structural Basin (fig. 37)

COOPERATING AGENCY: None

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

PERIOD OF PROJECT: June 1980 to September 1981

Problem.--A clear, concise description of the occurrence of the oil-shale deposits in the Piceance Creek structural basin, the development technologies, and the effects of this development is not available. Therefore, legislators, planners, officials of industry, and environmentalists are not fully aware of the numerous choices and challenges that oil-shale production will create.

Objectives.--Prepare a clear and graphic description of (1) the mineral resources of the Piceance basin and their significance to the region and nation, (2) alternatives to the resource development and constraints upon it, and (3) tradeoffs in resource use, development, and environmental impact.

Approach.--Organize data and material from existing reports into major categories, including (1) geology of oil-shale deposits, (2) grade of oil-shale deposits and related minerals, (3) hydrologic systems, including water quality, (4) oil-shale development alternatives and related problems, (5) regional water supply and management, (6) environmental concerns, (7) conclusions, and (8) an extensive bibliography. Information on the categories listed will be collected by specialists in the Conservation, Geologic, and Water-Resources Divisions of the U.S. Geological Survey.

Progress.--A preliminary outline has been prepared and reviewed by government officials, representatives from industry, and private individuals. A final outline has been prepared from these reviews and a general report format has been designed.

Plans.--Complete manuscript and illustrations and publish report.

PROJECT TITLE: Streamflow Analysis, Piceance Creek and Yellow Creek Drainage Basins (fig. 37)

COOPERATING AGENCY: None

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

PERIOD OF PROJECT: January 1981 to September 1983

Problem.--Oil-shale mining and processing will place many demands on the surface waters of the Piceance Creek and Yellow Creek basins. An analysis of all available streamflow data is urgently needed to determine if the existing network provides an adequate description of the surface-water system prior to mining. Information must also be compiled and analyzed from other networks (such as precipitation and other climatic data) in the area to determine what data are currently available and what data will be needed in the future.

Objectives.--Define the natural and the existing streamflow regimes of the study area. Determine the relations between ground water and surface water. Develop methods of transferring hydrologic data from gaged watersheds to ungaged watersheds. Identify data deficiencies and design a comprehensive hydrologic-data network to meet current and long-term needs.

Approach.--Divide the study into three phases. In the first phase, collate and compile all hydrologic data in the area. These data will be put into hydrologic models and will be analyzed statistically. Conduct an investigation of stream gains and losses to improve our understanding of the relation between the surface water and ground water in the alluvium. In the second phase, use modeling and statistical techniques to analyze the current data networks, to determine our current level of understanding of the hydrologic system, and to identify data-deficient areas within the system. Use the U.S. Geological Survey daily flow snowmelt model and the peak-flow model to define average and peak-flow conditions in streams for which flow records are short. Possibly use the index station method to define low-flow characteristics. Develop regional-regression models that can be used to transfer hydrologic information from one drainage to another. Measure low flows to determine the relations between ground water and surface water. Collect additional data where needed. In the third phase, fine-tune the hydrologic models and regional statistical analyses developed earlier. Use the results to design a data network that will meet future needs.

Progress.--None--new project.

Plans.--Conduct a study of stream gains and losses.

PROJECT TITLE: Springflow Monitoring, Parachute Creek and Roan Creek Drainage Basins (fig. 37)

COOPERATING AGENCY: None

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

PERIOD OF PROJECT: January 1981 to September 1984

Problem.--There is much interest in developing the shale-oil reserves of the Parachute Creek and Roan Creek drainage basins. Aquifer dewatering resulting from oil-shale mining could reduce the discharge of springs in the basins and adversely affect the quality of the spring water. These springs are important sources of water for agriculture and wildlife. Information on the flow of springs is also needed for further development of the Piceance basin ground-water model. It is therefore necessary to determine the sources and characteristics of the springs in order to infer the possible effects of mining on them and to better understand the hydrologic system.

Objectives.--Define the relation of the springs to ground-water recharge in the basin, the aquifers of the Green River Formation, and the quality of water in these aquifers. Obtain information on recharge to the Wasatch Formation and discharge from the formation.

Approach.--Monitor the discharge and water quality of selected springs on a monthly basis. Conduct an intensive inventory of springs in the Green River Formation to determine if there is significant discharge from the aquifers of the formation to the alluvium along the Parachute Creek and Roan Creek valleys. Study particularly recharge to, and discharge from, the underlying Wasatch Formation.

Progress.--None--new project.

Plans.--Evaluate the information from 286 springs previously inventoried in the area. Select approximately 50 of these springs for monitoring of discharge, temperature, and specific conductance. Give a high priority to a continuing reconnaissance of springs discharging from the Lower Green River and Wasatch Formations. Include these springs in the monitoring program. Select 10 to 15 springs in the Wasatch, Lower Green River, Upper Green River, and Uinta Formations for quarterly sampling of the quality of water. Make seepage runs in the lower stream reaches to determine the relation between streamflow and the ground water in the underlying alluvium.

PROJECT TITLE: Hydrologic Reconnaissance of the U.S. Naval Oil Shale Reserve No. 1, Parachute Creek Drainage Basin (fig. 37)

COOPERATING AGENCY: U.S. Department of Energy

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

PERIOD OF PROJECT: October 1976 to September 1982

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. Coordinate project activities with the activities of the project that is to determine the hydrologic conditions in the Parachute Creek and Roan Creek basins and with the project that is to develop a computer model of the ground-water system in the Parachute and Roan Creek drainage basins.

Progress.--A data-collection network consisting of five streamflow stations, two automatic sediment samplers, two precipitation gages, and one weather station has been established. Seven test wells have been completed. Aquifer tests have been conducted on three of the wells.

Plans.--Continue data collection. Prepare supplement to a basic-data report.

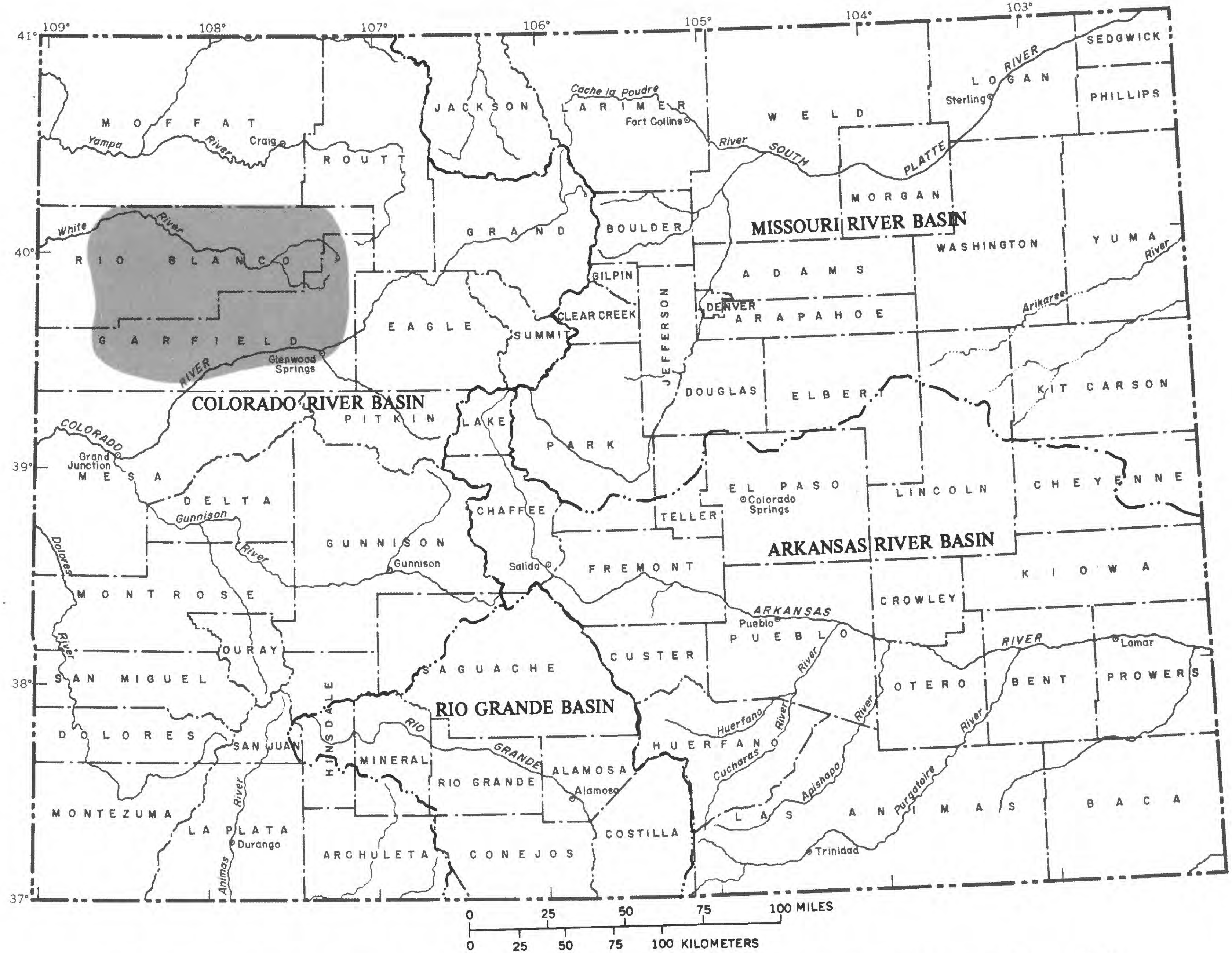

Figure 38.—Location of area in which effects of energy-production emissions on lakes are being studied.

PROJECT TITLE: Effects of Energy-Production Emissions on Lakes (fig. 38)

COOPERATING AGENCY: None

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

PERIOD OF PROJECT: November 1979 to September 1982

Problem.--Current and proposed production of energy in Colorado and surrounding States will release acidic gases and other constituents that can affect the chemistry of precipitation and of poorly buffered water in lakes and streams. The lakes and streams in the Flat Tops Wilderness Area in western Colorado are located downwind from areas of oil-shale development and coal-burning power plants. The chemically unreactive geologic formations of the area, combined with the orogenic effect on precipitation, may cause the area to be particularly susceptible to the adverse effects of acid rain. Data on precipitation and lake quality do not exist to define predevelopment conditions.

Objectives.--By the use of aerial reconnaissance and other methods, delineate areas in Colorado most susceptible to the effects of acid rain. In each area, identify those lakes in which the water has little buffering capacity and small nutrient concentrations. Select lakes representative of other lakes within the susceptible areas for more detailed study. Determine predevelopment chemical quality of precipitation.

Approach.--Select areas most susceptible to acid rain based on: Downwind location from acid-gas sources, chemically unreactive geologic formations, and large snowpack accumulation. Determine the relative buffering capacity of lakes by developing alkalinity titration curves. Determine nutrient loading by measuring hypolimnetic-nutrient concentrations, snowpack amount and nutrient concentrations, and stream discharge and nutrient concentrations. Install precipitation and weather stations. Collect samples of precipitation and lake water for chemical analysis. Collect data on wind direction and speed.

Progress.--Lakes to be studied have been selected. Scheduled sampling has been completed. Precipitation and weather stations are ready for installation.

Plans.--Make another aerial reconnaissance to help determine which lakes are most susceptible to acid rain. Establish a network of precipitation and weather stations.

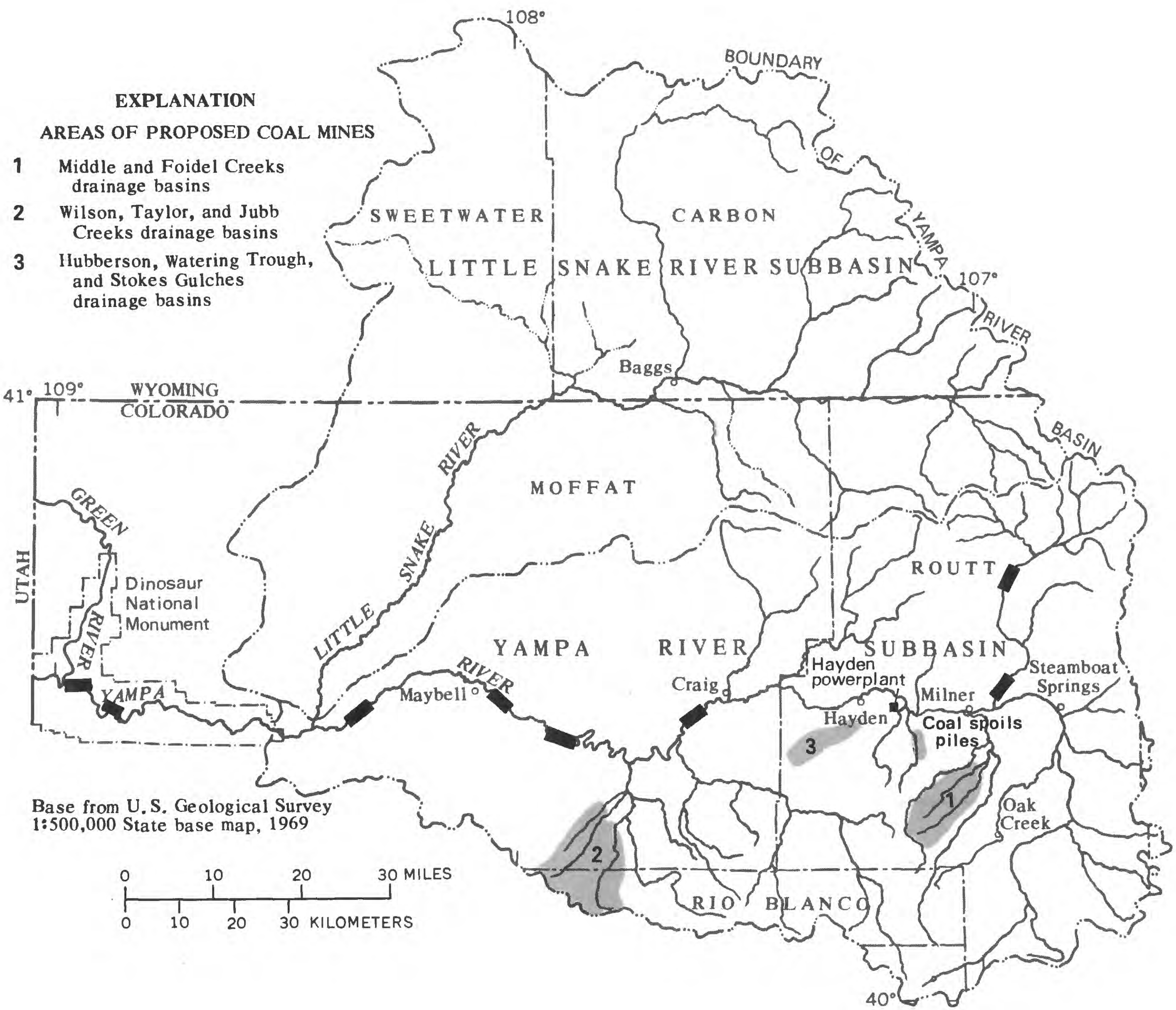

Figure 39.--Location of study reaches on the Yampa and Elk Rivers in the Yampa River basin, areas of proposed coal mines and coal-spoils piles, and the Hayden powerplant.

PROJECT TITLE: Hydrologic Characteristics for Instream Flow Requirements (fig. 39)

COOPERATING AGENCY: U.S. Environmental Protection Agency

PROJECT CHIEF: Daniel P. Bauer, District Office, Lakewood

PERIOD OF PROJECT: August 1978 to September 1981

Problem.--Throughout Colorado, as well as in many other parts of the country, intense competition exists for the available water supplies. This competition is especially intense in the arid and semiarid western States. One important water use commonly overlooked is the maintenance of a balanced aquatic environment to support fishery and other recreational activities. There is, therefore, a need to determine the optimum streamflow, including velocity and depth characteristics, for fishery and recreational uses. The velocity and depth characteristics required also can vary seasonally depending on the fish activity; for example, different flows are required for migration than for reproduction. Several methods are available for determining velocity-depth characteristics at given locations in a stream reach and for different discharge conditions. Little is known of the accuracy of these methods and their applicability to different types of stream reaches and flow conditions.

Objectives.--Evaluate three methods for determining depth-velocity characteristics of selected sites in a stream to provide operational techniques for additional studies throughout Colorado and the United States.

Approach.--Determine individual cross-section velocity-depth characteristics and mean reach velocities and depths. The cross-section velocity-depth data will be analyzed by two methods: (1) Step-backwater analysis and (2) the use of stage-discharge and stage-velocity relations. The mean reach velocity-depth data will be analyzed using a two-parameter dispersion and mean-velocity computer model. Velocity-depth prediction accuracies will then be tested by using additional velocity-depth measurements.

Progress.--Analysis of most of the data on the velocity-depth relation, traveltime, and reaeration has been completed. One additional field trip was made to collect data on the Yampa River in Dinosaur National Monument. Reports dealing with the following three aspects of the study are in preparation: (1) Effects of different types of reservoir development on the volume of streamflow, (2) reaeration, traveltime, and longitudinal dispersion in selected stream reaches, and (3) velocity-depth prediction methods.

Plans.--Complete the three reports on the project.

PROJECT TITLE: Hydrology of Proposed Coal-Mining Areas, Moffat, Rio Blanco, and Routt Counties (fig. 39)

COOPERATING AGENCY: U.S. Bureau of Land Management

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

PERIOD OF PROJECT: July 1974 to September 1982

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. 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 a computer model that can be used to predict the effects of coal mining on the hydrology of areas in which intensive studies are not planned.

Approach.--Select areas for intensive study. Install streamflow-gaging stations and two-parameter water-quality monitors in each basin. Equip one station in each area with an automatic pumping sampler to obtain data on sediment yield; take grab samples in the other six basins. 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.

Progress.--Three areas have been selected; area 1--drainage basins of Middle Creek and Foidel Creek (two basins), area 2--drainage basins of Wilson, Taylor, and Jubb Creeks, and area 3--drainage basins of Hubberson, Watering Trough, and Stokes Gulches. All monitoring instruments have been installed and data collection is continuing in these basins. Monitoring instruments were recently installed in a 10th basin. Data from six watersheds were used to calibrate the U.S. Geological Survey daily flow model. Initial results from operation of the model suggest that shallow ground water, including water from the bedrock beneath the alluvium, is an important component of the surface-water flow measured by the gages.

Plans.--Data collection will continue in the 10 watersheds. In order to monitor the shallow ground-water system, water wells and holes for soil-moisture access tubes will be drilled across certain sections in selected watersheds. Calibration of the daily flow model will continue.

Reports published or released during fiscal year 1980.--See reference 26 under Water-Resources Interpretive Reports at back of report.

PROJECT TITLE: Hydrology and Reclamation Potential of Coal-Spoils Piles (fig. 39)

COOPERATING AGENCY: U.S. Bureau of Land Management

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

PERIOD OF PROJECT: July 1975 to September 1982

Problem.--Coal mining will create large areas of spoils piles. The hydrology and reclamation potential of the piles needs 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 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 in which intensive studies are not planned.

Approach.--Install nine lysimeters, five in a spoils area and four in an unmined area. Use rainfall simulators to produce runoff into four lysimeters in the spoils area and two lysimeters 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 all the wells and collect water samples for chemical analysis from them. 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 a computer model.

Progress.--All lysimeters have been installed and all wells have been drilled including four wells in the alluvium at the mine site. Soil-water measurements have been continued at all established sites. Three soil-water access tubes have been installed to the bottom of the spoils pile. A well has been drilled to the bottom of the spoils pile near each access tube. Water levels and water quantity and quality are being monitored at each site. A progress report is being prepared.

Plans.--Samples of water will be obtained from the lysimeters for chemical analysis. The quality of water in six to eight wells will be monitored on a quarterly basis. Soil-water quantity will continue to be measured at all soil-waste access tubes, but the frequency of measurement will be variable. Water levels will be measured in all wells on a monthly or quarterly basis, depending on the location of the well.

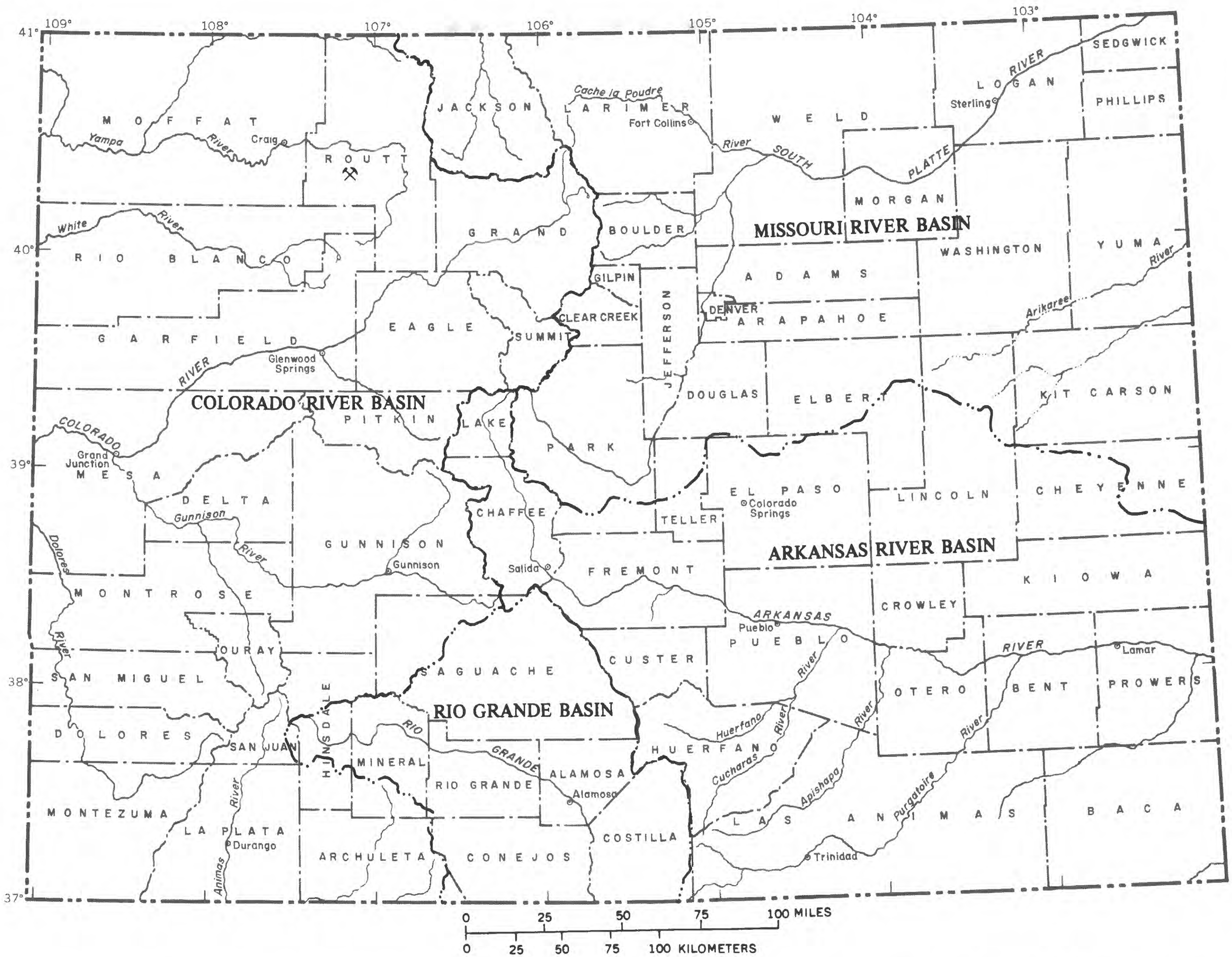

Figure 40.--Location of a proposed strip mine area in Routt County for which a baseline reconnaissance is to be made.

PROJECT TITLE: Baseline Reconnaissance of an Area to be Strip Mined (fig. 40)

COOPERATING AGENCY: U.S. Bureau of Land Management

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

PERIOD OF PROJECT: June 1980 to September 1983

Problem.--Recent studies of coal-mining hydrology have generally been started after strip mining has begun. It is then difficult to separate man-induced effects from the natural conditions.

Objectives.--Define and interpret the undisturbed natural hydrologic regime of an area which is to be strip mined. Define the hydraulic and hydrologic characteristics of the shallow or alluvial aquifers, overburden aquifers, coal aquifers, and underburden aquifers. Determine the interaction of these aquifers with each other and with the surface water.

Approach.--Begin studies at a site where surface mining will start in approximately 3 years. Evaluate the hydrology of the natural system by monitoring the ground water, surface water, and climate. Following this, monitor and evaluate the disturbance from surface mining.

Progress.--From 20 to 30 ground-water wells have been drilled at the proposed strip-mining site in Routt County. Geological and geophysical logs have been run on each well. Water levels have been measured in the wells and continuous recorders installed on two of them. A site has been selected for a stream-gaging station. Two sites have been selected for rain gages and one site for climatologic instruments.

Plans.--Install a stream-gaging station and climatologic instruments. Select snow-course sites; run the courses once a month in season. Collect water samples monthly at the gaging station and quarterly from selected wells. Run aquifer tests. Install soil-water access tubes throughout the area and monitor the soil water.

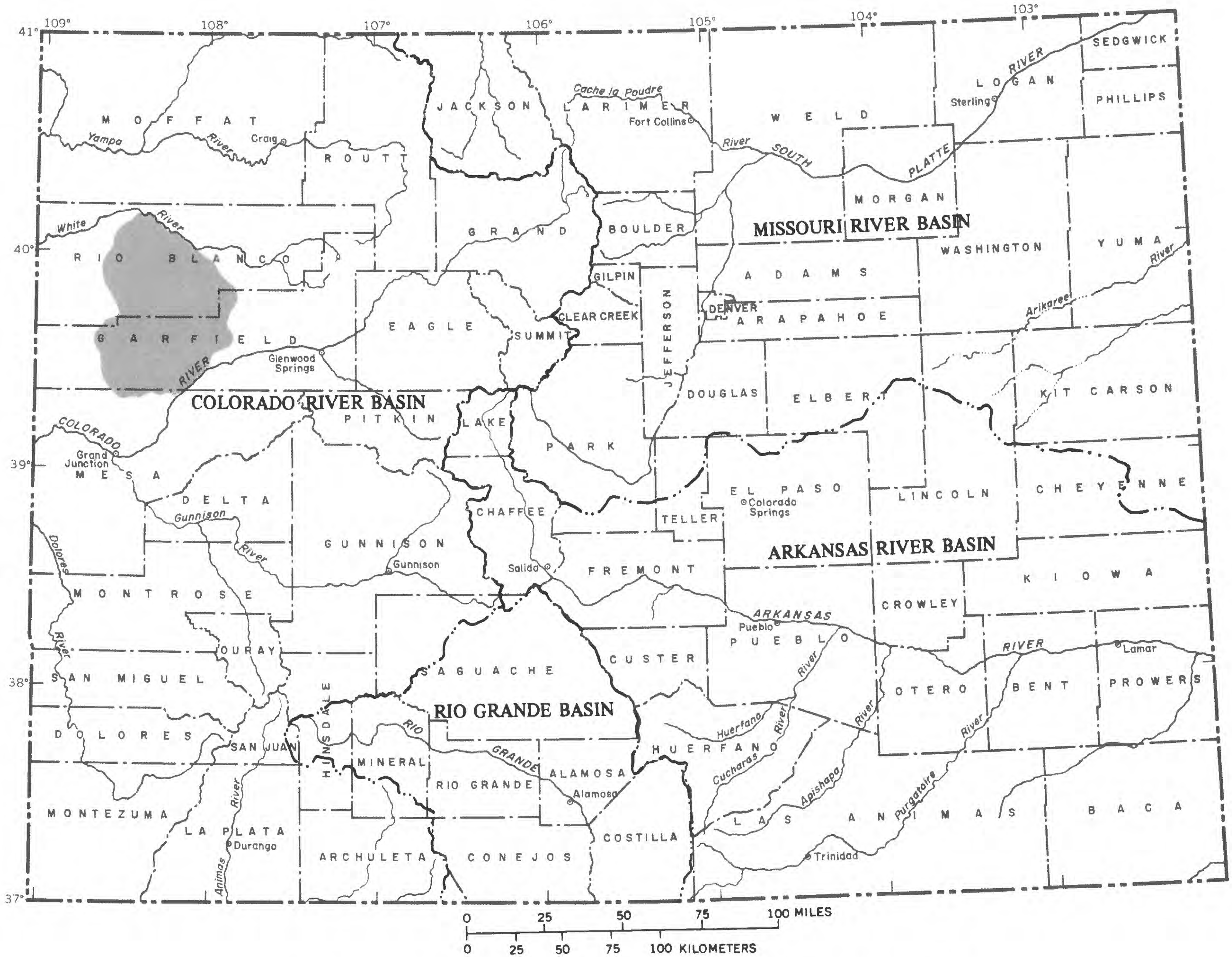

Figure 41.--Location of area in which oil-shale spoils are being studied.

PROJECT TITLE: Geochemistry and Hydrology of Oil-Shale Spoils (fig. 41)

COOPERATING AGENCY: None

PROJECT CHIEF: Daniel J. Ackerman, Subdistrict Office, Grand Junction

PERIOD OF PROJECT: October 1980 to September 1984

Problem.--The development of shale-oil resources by either surface or modified in-situ retorting will result in large amounts of spoils. Concern for possible degradation of water resources by seepage from the spoils has resulted in study of the interaction of spoils and water; however, this work has been limited to freshly retorted shale. The high temperature of retorting results in very unstable products, such as calcined dolomite, that dominate the reactions of spent shale with water for a short time after disposal. No work has been done on the interactions that begin a few years after disposal and remain important for long periods of time. Similarly, no work has been done to determine how the hydraulic properties of the spent shale change as mineralogy changes and recrystalization proceeds. Realistic long-term models must incorporate such changes if they are to be used to accurately predict recharge rates and the transport rates of ground water.

Objectives.--Describe the mineralogy and geochemistry of the weathered spoils piles. Determine the hydraulic charactersitics of the piles. Describe the quality of water that has percolated through the piles. Use methods of analysis to characterize water quality that are not routinely available and determine which of these methods are the most effective in delineating the effects of retorting on the oil shale. Develop a work plan to characterize the ambient water quality prior to retorting.

Approach.--Use records of the Conservation Division and the Colorado Heritage Center in Denver to locate old spoils piles. Drill and case observation and sampling wells that penetrate the spoils piles and the strata beneath them. Collect samples of water and analyze them for major and trace constituents. Perform slug or other types of aquifer tests on the completed wells to define the hydraulic properties of the mined materials. Make X-ray diffraction, X-ray fluorescence, and wet chemical analyses of the spoils materials. If the spent shale has recrystallized, obtain thin sections for examination using optical microscopy. Determine the controlling mineral equilibria. Select constituents for analysis that uniquely indicate the presence or absence of the elevated temperatures used in retorting.

Progress.--None--new project.

Plans.--Search the literature for previous work related to the geochemistry and hydrology of oil-shale spoils. Locate and date old spoils piles; obtain access to them. Develop specifications for the coring of test holes and the drilling and casing of observation wells. Perform slug tests on the completed wells.

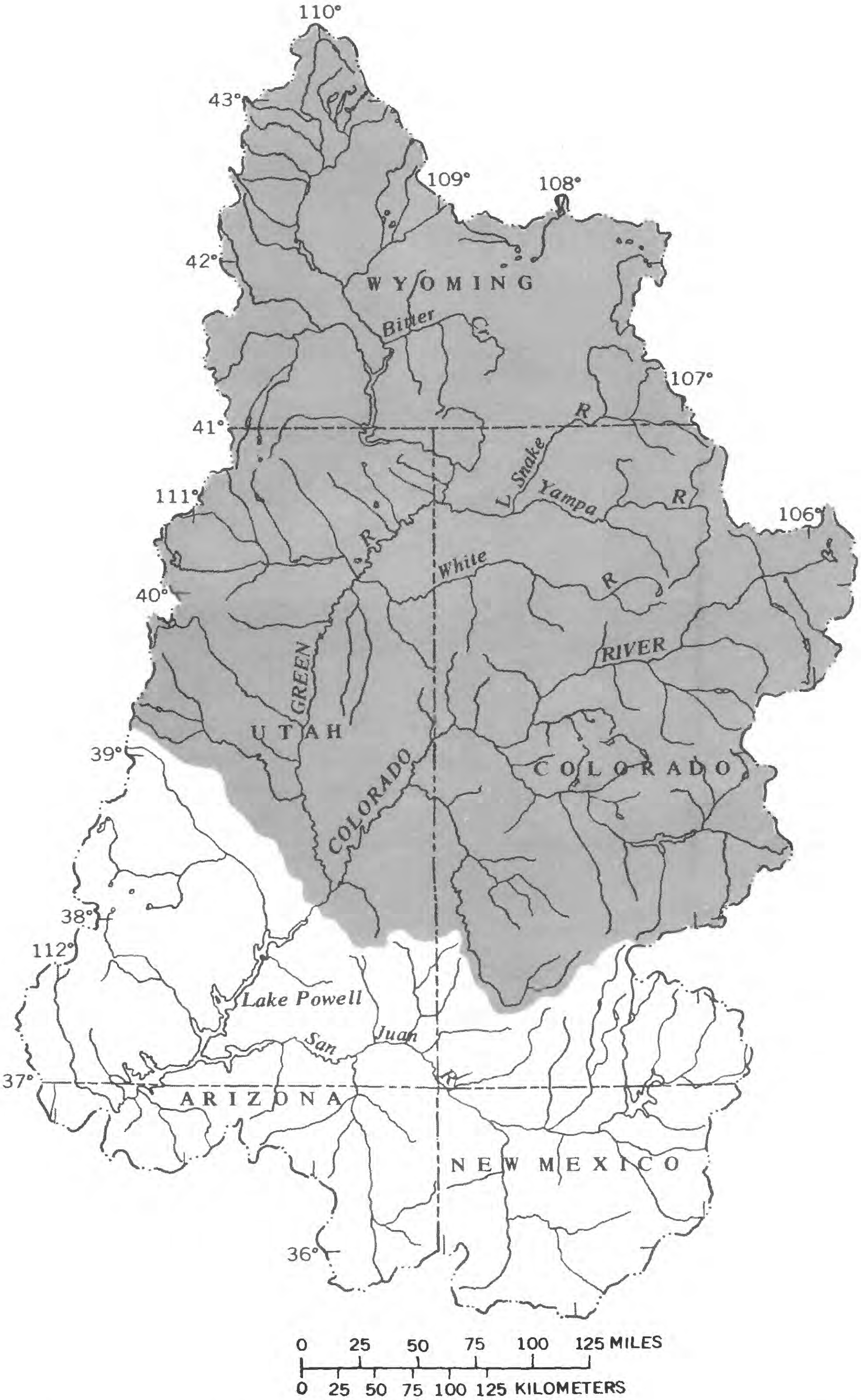

Figure 42.—Location of the Upper Colorado River Basin upstream from Lake Powell.

PROJECT TITLE: Ground-Water Contribution to Salinity of Streams in the Upper Colorado River Basin Upstream from Lake Powell (fig. 42)

COOPERATING AGENCY: U.S. Bureau of Land Management

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

PERIOD OF PROJECT: October 1977 to October 1982

Problem.--Salinity of the Colorado River and its tributaries results in substantial economic losses each year. The U.S. Bureau of Land Management, which is responsible for controlling salinity in streams on federally owned lands, needs to know where saline ground water enters streams and the magnitude of the contamination resulting from the ground-water inflow.

Objective.--Determine the ground-water contribution to the salinity of streams in the area.

Approach.--Use historic water-quality data to identify streams affected by saline ground-water inflow. Collect ground-water, surface-water, and water-quality data to determine the rate and quality of saline ground water entering the streams. Establish a monitoring network on those streams where salinity is a significant problem.

Progress.--Reconnaissance evaluation of area and data interpretation have been completed. Two streams, Salt Creek in Colorado and Onion Creek in Utah, have been selected for additional study to determine the causes of the salinity and to determine the feasibility of controlling the salinity. A monitoring network of nine stations has been established on streams in western Colorado and eastern Utah. A report describing a detailed study of the salinity problems in Salt Creek and Onion Creek basins was prepared.

Plans.--Continue stream-gaging and water-quality sampling. Install five recording precipitation gages and begin collecting records from them.

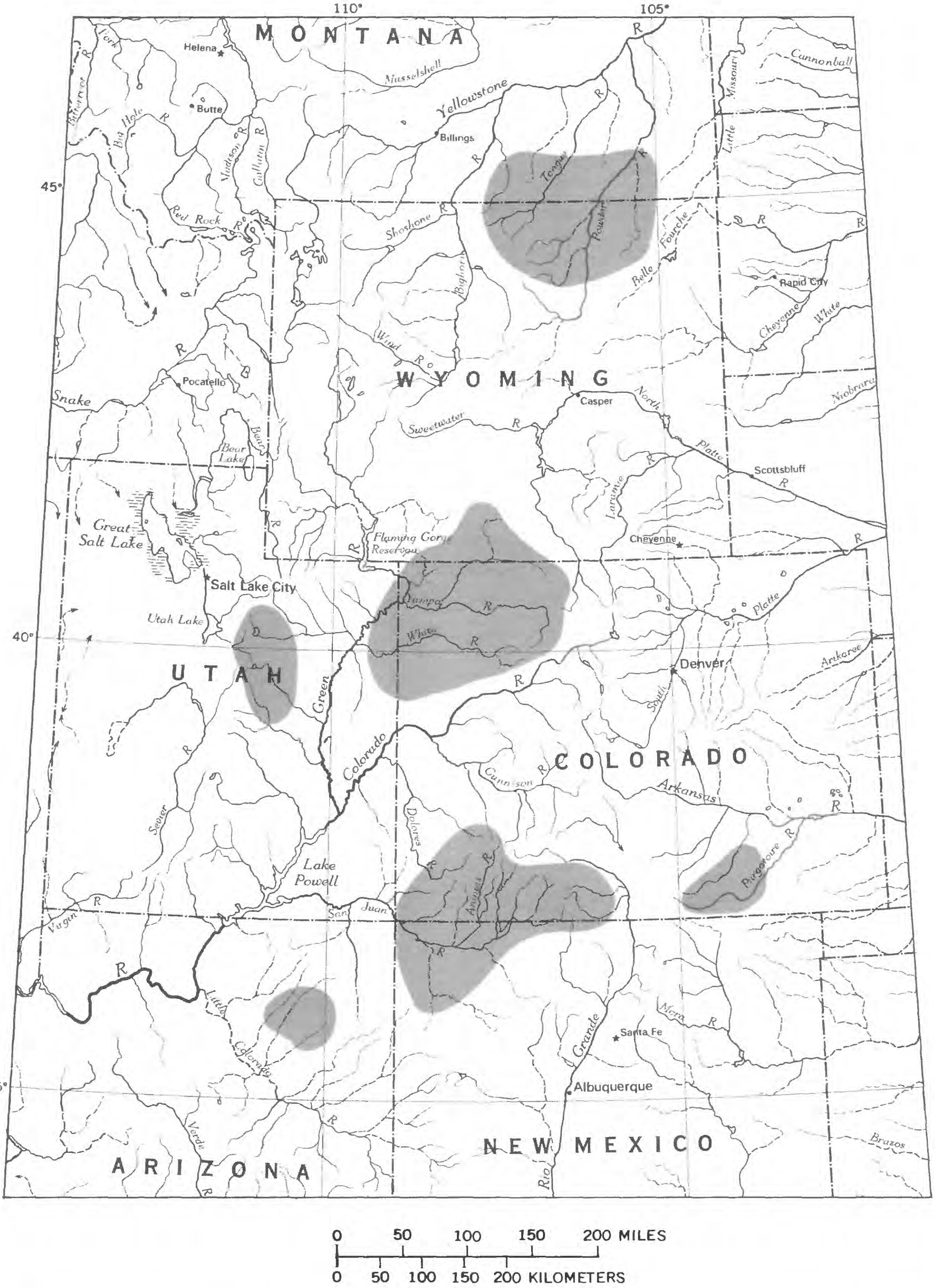

Figure 43.-- Locations of study areas for which hydraulic and geomorphic characteristics of stream channels are being determined, including the Green River Coal Region.

PROJECT TITLE: Hydraulic and Geomorphic Characteristics of Stable Alluvial Stream Channels in The Rocky Mountain Region (fig. 43)

COOPERATING AGENCY: None

PROJECT CHIEF: Edmund D. Andrews, District Office, Lakewood

PERIOD OF PROJECT: February 1979 to February 1982

Problem.--Development of coal and oil-shale resources in the Rocky Mountain Region by surface-mining techniques during the 1980's will disturb large areas of land. As a result, the hydrologic balance of many streams will be altered, and, in some instances, completely destroyed during mining. In order to protect or restore the hydrologic balance of these streams, it is necessary to acquire detailed knowledge of the hydraulic and geomorphic factors that control the stability of alluvial streams in the region.

Objectives.--Develop consistent hydraulic and geomorphic relations that are indicative of stream-channel stability. These relations will link the sediment and water discharge of a stream with the values of velocity, depth, width, roughness, slope, and sinuosity required to maintain stability. Direct data collection and analysis towards determining the hydraulic and geomorphic factors that affect alluvial-channel stability and the amount of time required for a stream to adjust to a change in quantity of water and sediment supplied to it from the watershed.

Approach.--Collate historic data such as streamflow gaging-station records, stream-channel surveys, sediment-concentration and load records, and reports describing stream-channel adjustments to long-term changes in discharge. Collect additional data as needed.

Progress.--Methods for determining total bed-material discharge of streams having various size distributions of bed material have been evaluated. A study was made to determine the hydraulic characteristics of stable gravel stream channels in Colorado. Sites at more than 45 gaging stations were selected for possible study. Stream reaches at 23 of these sites were studied in detail. The hydraulic characteristics of each study reach were determined immediately after field work and before proceeding to the next site. The draft of a report describing this investigation and its results is being prepared.

Plans.--Complete analysis of the data collected on sand-bed streams and prepare an annotated outline for a report on this portion of the project. Begin the analysis of hydraulic and sediment-transport data collected in the Piceance Creek basin during the spring of 1980.

Reports published or released during fiscal year 1980.--See reference 2 under Water-Resources Interpretive Reports at back of report.

PROJECT TITLE: Simulation of the Streamflow Characteristics of Small Basins in the Green River Coal Region (fig. 43)

COOPERATING AGENCY: None

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

PERIOD OF PROJECT: February 1980 to September 1981

Problem.--Streamflow variability is large in the Green River Coal Region, which lies within the Green River basin of Colorado, Wyoming, and Utah. Many small basins in the region are drained by ephemeral streams that flow only during the spring snowmelt season or following convective thunderstorms. Little streamflow data exist for these basins because they are not regarded as reliable sources of water. Environmental and water-supply problems caused by the rapid increase in coal production in the region, however, have created a critical need for streamflow data in these semiarid basins.

Objectives.--Use a hydrologic-simulation model having a mean daily discharge output and snow-accumulation and melt routines to provide the flow characteristics of small semiarid basins in the Green River-Uinta coal region.

Approach.--Measure soil-moisture storage values in the field. Calibrate the U.S. Geological Survey daily flow model by using these data to determine the optimal values of soil moisture for individual vegetation types. Determine the range of soil-moisture storage values characteristic of each vegetation type by calibrating the model with a large number of gaged basins having different proportions of these vegetation types. Use this method to extend the daily flow record on calibrated sites or to predict daily flows at ungaged sites if the range of soil-moisture values is small.

Progress.--Use of the daily flow model on several basins with snowmelt runoff is continuing. Important parameters of the soil-moisture component could be estimated well enough to calibrate the model. A cursory analysis of peak flows for the period of record showed that all of these peaks resulted from snowmelt or rain-on-snow events. Peaks from rainfall events certainly exist but have not been recorded at the gaging stations.

Plans.--Calibration of the model will be continued on additional watersheds. Several watersheds having long-term records will be calibrated with the model to compare observed and predicted flow-duration curves.

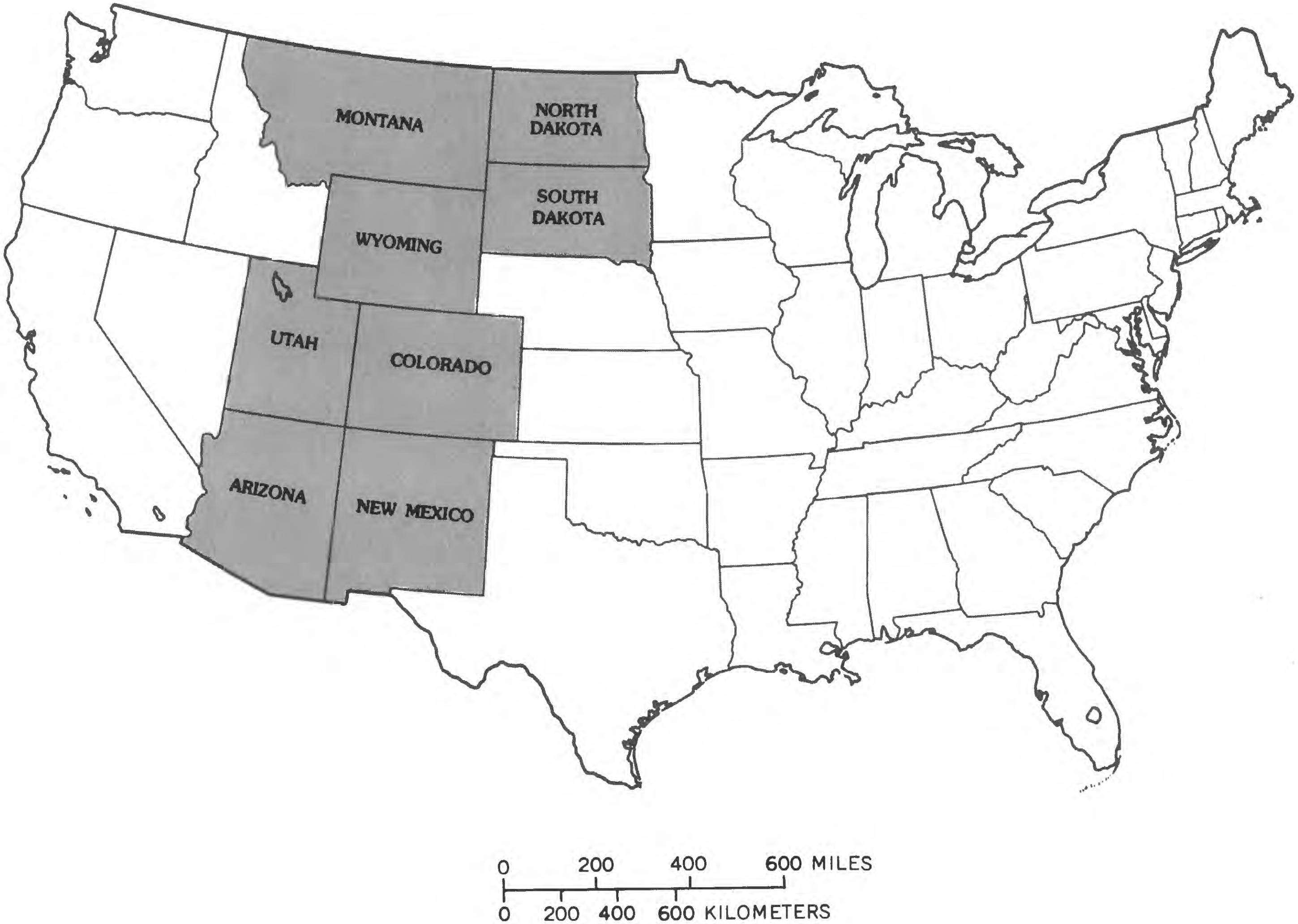

Figure 44.--Location of the western coal-mining States.

PROJECT TITLE: Technical Manual for Hydrologic Monitoring in the Western United States (fig. 44)

COOPERATING AGENCY: U.S. Office of Surface Mining

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

PERIOD OF PROJECT: April 1980 to April 1981

Problem.--The Permanent Regulatory Program (PRP) of the Office of Surface Mining (OSM) specifies that permit applications for coal mining must contain baseline information on surface- and ground-water conditions and information on conditions during and after mining. The regulations do not contain detailed information on the techniques and equipment needed to meet the monitoring requirements. A technical manual on hydrologic monitoring is needed to provide uniform and cost-effective guidelines.

Objectives.--Prepare a technical manual containing guidelines for the hydrologic monitoring of coal mining in the arid and semiarid States of North Dakota, South Dakota, Montana, Wyoming, Colorado, Utah, New Mexico, and Arizona. The guidelines will complement the PRP in providing guidance to the coal-mining industry, the OSM staff, and other governmental agencies.

Approach.--Review existing publications dealing with the techniques and equipment for hydrologic monitoring and prepare a summary containing a listing of references. Describe hydrologic principles by the use of examples. Develop monitoring schemes for from four to six proposed mine sites. The sites will vary greatly in geology, climate, and topography. The examples will show how the Water-Resources Division (WRD) would apply hydrologic principles in designing and operating a monitoring network for a mine site. Describe techniques in a "how to" manual and give references to the "Techniques of Water-Resources Investigations" series of the WRD and other manuals.

Progress.--Background material has been assembled on sample mine plans and on legal constraints.

Plans.--Prepare the manual.

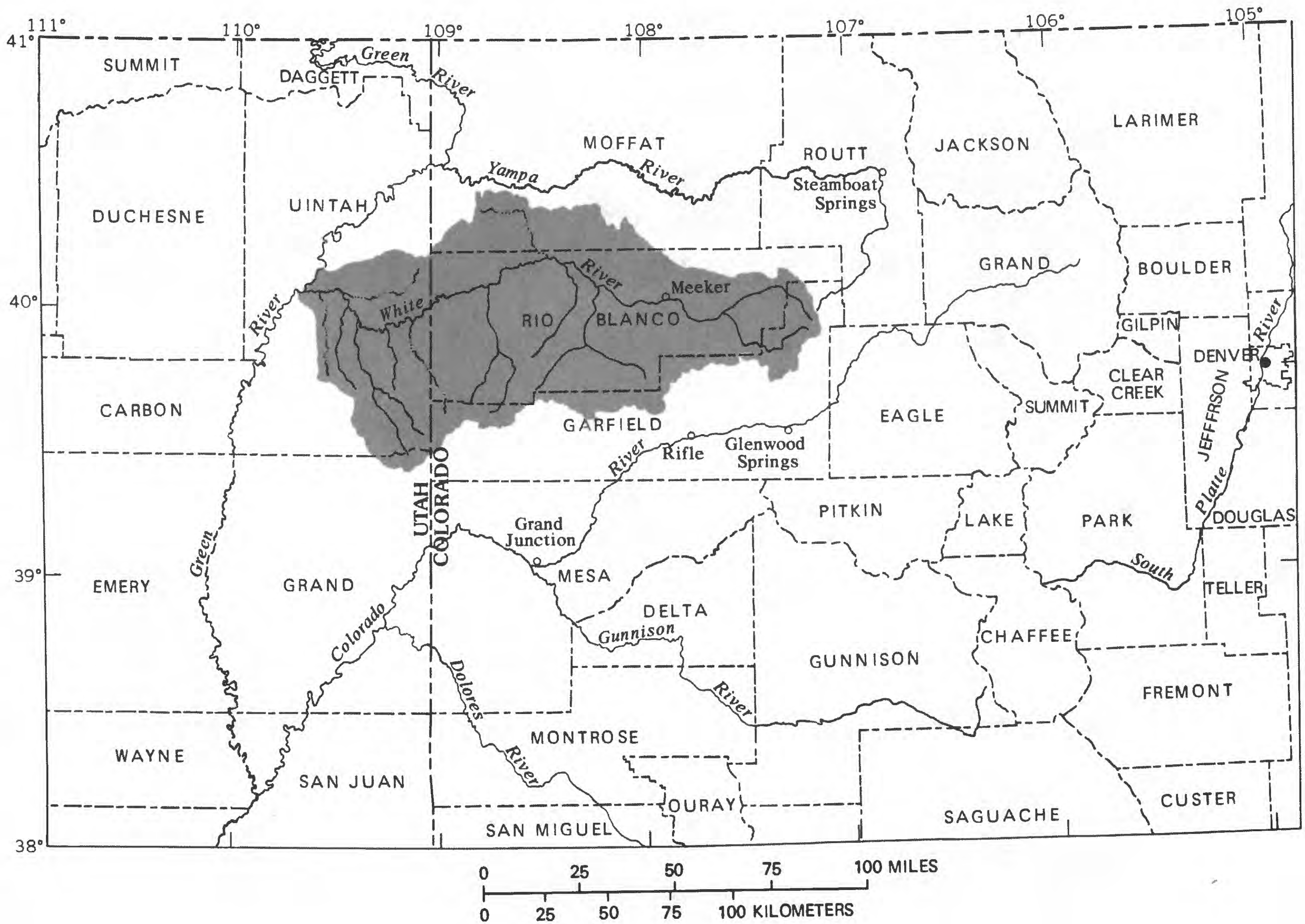

Figure 45.--Location of the White River basin.

PROJECT TITLE: Effects of Energy Development on the Stream-Water Resources of the White River Basin, Colorado and Utah (fig. 45)

COOPERATING AGENCY: U.S. Environmental Protection Agency

PROJECT CHIEF: Daniel P. Bauer

PERIOD OF PROJECT: January 1981 to September 1984

Problem.--The White River basin in Colorado and Utah is underlain by rich reserves of shale oil, coal, and natural gas. The anticipated large development of these energy resources will make it necessary to study the quantity and quality of streamflow to help solve problems that will result from mining and the projected increase in population in the basin.

Objectives.--Describe the hydrology of the basin prior to the anticipated large development of energy resources. Evaluate the effects of this development on the quantity and quality of the stream water.

Approach.--Collect available information on the quantity and quality of both ground and surface waters in the basin. Conduct a water-quality reconnaissance by sampling streams at approximately 50 sites. Collect samples quarterly at 25 of these sites. Measure water levels in approximately 100 wells drilled in the alluvium along the White River and Piceance Creek and take quality of water samples from the wells. Sample benthic invertebrates in the Yellow Creek drainage basin and along the main stem of the White River. Relate benthic invertebrate and periphyton data to bed-material size, the availability of nutrients, and stream-reaeration rates. Conduct reaeration, traveltime, and mean-velocity studies on selected stream reaches. Augment the present sediment-sampling program by adding five sediment sites to the present network. Investigate the gains and losses in streams to determine the amount and nature of the interchange of water between the alluvial aquifers and the streams. Determine the composition and geometry of the alluvial aquifers in the basin and conduct aquifer tests on them. Evaluate the waste-load assimilative capacities of selected stream reaches. Using both monthly and daily time intervals, complete a streamflow, precipitation, and evaporation data matrix for gaged streams in the basin. Consider the effects of several different reservoir-development schemes in the basin. Simulate the streamflow conditions for different multireservoir configurations.

Progress.--None--new project.

Plans.--Conduct a water-quality reconnaissance of the basin by sampling streams at approximately 50 sites during the 1981 low-flow season. Drill 50 wells in the alluvium of the Piceance Creek drainage.

REPORTS PUBLISHED OR RELEASED DURING FISCAL YEAR 1980

Reports published or released during fiscal year 1980 may be purchased or inspected as follows:

U.S. GEOLOGICAL SURVEY: PROFESSIONAL AND WATER-SUPPLY PAPERS--May be purchased over the counter or by mail from:

U.S. Geological Survey, Public Inquiries Office
Room 169, Federal Building
1961 Stout Street
Denver, CO 80294

U.S. Geological Survey, Branch of Distribution
1200 South Eads Street
Arlington, VA 22202

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

U.S. Geological Survey, Colorado District Office
Room H-2107, Building 53
Denver Federal Center
Lakewood, CO 80225

U.S. Geological Survey, Library
1526 Cole Boulevard at West Colfax Avenue
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(Mail address: Box 25046, Mail Stop 914
Denver Federal Center
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U.S. Geological Survey, Public Inquiries Office
Room 169, Federal Building
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Denver, CO 80294

Selected WATER-RESOURCES INVESTIGATIONS and WATER-RESOURCES DATA REPORTS may be purchased from:

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The National Technical Information Service order number, and prices for paper copies or microfiche are indicated in the report reference.

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Denver Federal Center
Denver, CO 80225
(telephone: 303-234-5888)

Prices for black and white paper copies or microfiche are indicated in the report reference.

Water-Resources Data Reports

1. Blakely, S. R., compiler, 1980, Water-resources investigations of the U.S. Geological Survey in Colorado--Fiscal Year 1980: U.S. Geological Survey Open-File Report 80-442, 111 p.; available only from Open-File Services Section, Denver, CO 80225. Paper copy $16.75; microfiche $4.
2. Borman, R. G., 1980, Water-level records for the northern High Plains of Colorado, 1975-79: U.S. Geological Survey Open-File Report 80-5, 28 p.; available only from Open-File Services Section, Denver, CO 80225. Paper copy $4; microfiche $3.50.
3. ____1980, Water-level records for the northern High Plains of Colorado, 1976-80: U.S. Geological Survey Open-File Report 80-438, 29 p.; available only from Open-File Services Section, Denver, CO 80225. Paper copy $4; microfiche $3.50.
4. Cain, Doug, and Edelmann, Patrick, 1980, Selected hydrologic data, Arkansas River basin, Pueblo and southeastern Fremont Counties, Colorado, 1975-80: U.S. Geological Survey Open-File Report 80-1185, 233 p.; available only from Open-File Services Section, Denver, CO 80225 (in press).
5. Hall, D. C., and Duncan, A. C., 1980, Hydrologic data from Upper Grange Hall Creek basin, Northglenn, Adams County, Colorado: U.S. Geological Survey Open-File Report 80-578, 132 p.; available only from Open-File Services Section, Denver, CO 80225. Paper copy $17.75; microfiche $3.50.
6. Petsch, H. E., Jr., 1980, Streamflow statistical summaries for Colorado streams through September 30, 1975, Volume 2, Colorado River above Gunnison River: U.S. Geological Survey Open-File Report 79-1060, 350 p.; available only from Open-File Services Section, Denver, CO 80225. Paper copy $46; microfiche $3.50.
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PROJECTS COMPLETED DURING FISCAL YEAR 1980 EXCEPT FOR REPORT(S)

1. Reconnaissance of ground-water contamination by landfill leachate.

2. Hydrologic impact of in-situ mining of uranium ores.

3. Effects of effluents from coal-fired electric-generating plants on ground-water quantity and quality near Hayden, Colo.

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