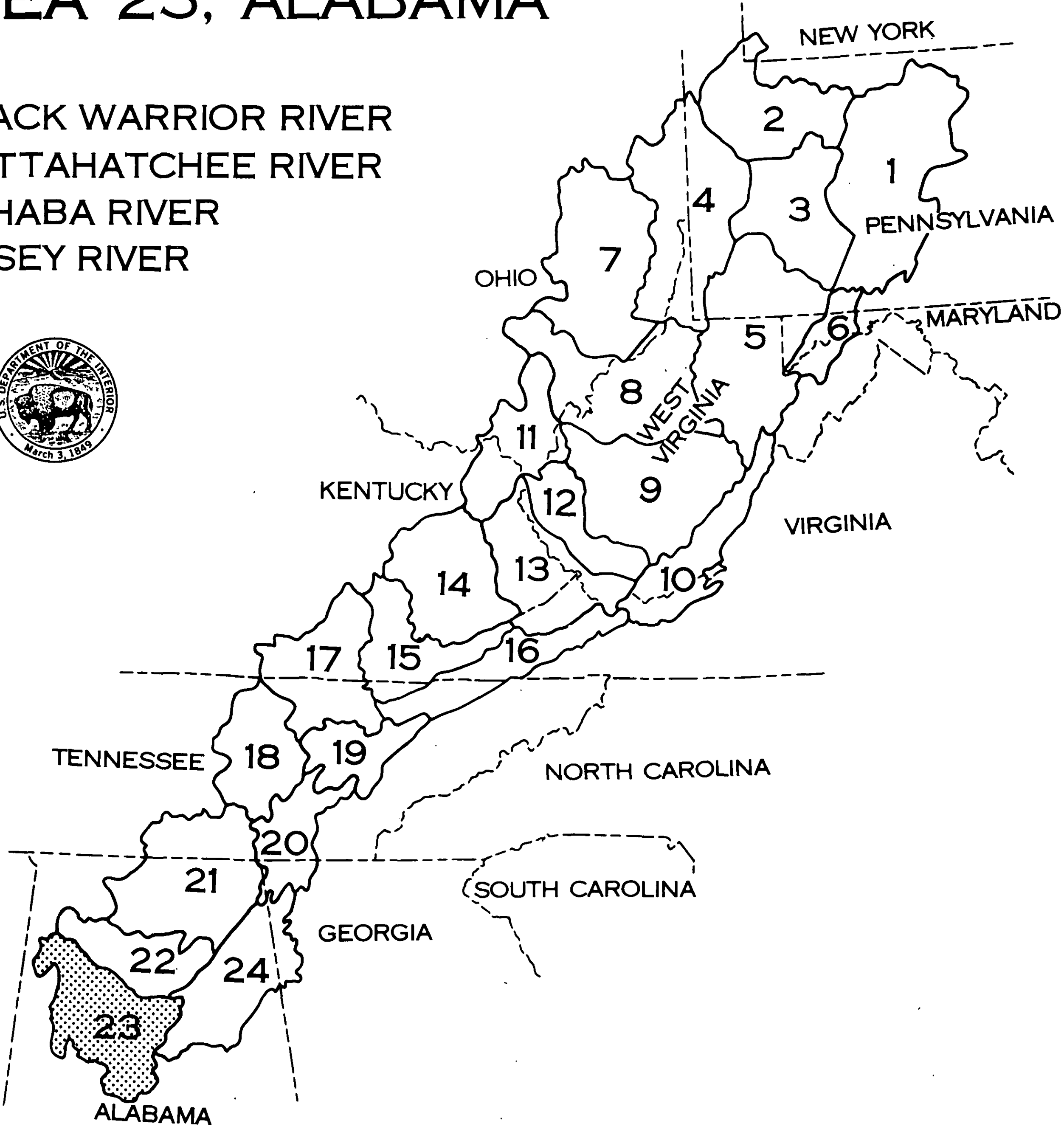
HYDROLOGIC ASSESSMENT, EASTERN COAL PROVINCE AREA 23, ALABAMA

- BLACK WARRIOR RIVER
- BUTTAHATCHEE RIVER
- CAHABA RIVER
- SIPSEY RIVER



UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

WATER-RESOURCES INVESTIGATIONS
OPEN-FILE REPORT 80-683

HYDROLOGIC ASSESSMENT, EASTERN COAL PROVINCE AREA 23, ALABAMA

BY
JOE R. HARKINS AND OTHERS

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WATER-RESOURCES INVESTIGATIONS 80-683

TUSCALOOSA, ALABAMA
JUNE 1980

UNITED STATES DEPARTMENT OF THE INTERIOR

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CONTENTS

FACTORS FOR CONVERTING INCH-POUND UNITS TO INTERNATIONAL SYSTEM OF UNITS (SI)

For the convenience of readers who may want to use Internation System of Units (SI), the data may be converted by using the following factors:

Mulitply inch-pound units	By	To obtain SI units
inches (in)	25.4	millimeters (mm)
inches per hour (in/h)	25.4	millimeters per hour (mm/h)
	2.54	centimeters per hour (cm/h)
feet (ft)	0.3048	meters (m)
feet per mile (ft/mi)	0.1894	meters per kilometer (m/km)
miles (mi)	1.609	kilometers (km)
square miles (mi^2)	2.590	square kilometers (km^2)
gallons per minute (gal/min)	0.06309	liters per secons (L/s)
million gallons per day (mgal/d)	0.04381	cubic meters per second (m^3/s)
	3785.	cubic meters per day (m^3/d)
cubic feet per second (ft^3/s)	0.02832	cubic meters per second (m^3/s)
cubic feet per second per square mile [$(ft^3/s)/mi^2$]	0.01093	cubic meters per second per square kilometer [$(m^3/s)/km^2$]
tons per square mile per year [$(tons/mi^2)/yr$]	0.03753	metric ton per square kilometer per year [$(metric\ ton/km^2)/yr$]

HYDROLOGIC ASSESSMENT, EASTERN COAL PROVINCE AREA 23, ALABAMA

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ABSTRACT

The Eastern Coal Province is divided into 24 separate hydrogic reporting areas. The division is based on hydrologic factors, location, size, and mining activity. Hydrologic units (drainage basins) or parts of units are combined to form each area. Area 23 is located at the southern end of the Eastern Coal Province, in the Mobile River basin, includes the Warrior, Cahaba, and edges of the Plateau coal fields in Alabama, and covers an area of 4,716 square miles.

Each report is designed to be useful to mine owners and operators and consulting engineers by presenting information about existing hydrologic conditions and identification of sources of hydrologic information. General hydrologic information is presented in a brief text and illustrations on a single water-resources related topic.

Area 23, this report, is underlain by the Coker and Pottsville Formations and the pre-Pennsylvanian rocks. The Pottsville Formation contains coal beds and is overlain by the Coker Formation in the western and southern parts of the area. The pre-Pennsylvanian rocks crop out in two northeast-southwest trending belts or ridges along and near the eastern boundary where folding and faulting is common. The outcrop of rocks along the western ridge forms the divide between the Warrior and the Cahaba coal fields.

The area lies in four river basins, the Black Warrior, Cahaba, Sipsey, and Buttahatchee. The Black Warrior River drains most of the Pottsville Formation with some outliers of the Coker Formation in the southern edge. The Sipsey and Buttahatchee Rivers are incised into the Pottsville Formation but drain, for the most part, the overlying Coker Formation. The Cahaba River flows over the Pottsville Formation in a valley between two ridges of pre-Pennsylvanian rocks.

Area 23 has a moist temperate climate with an annual average rainfall of 54 inches and the majority of the area is covered by forest. The soils have a high erosion potential when the vegetative cover is removed.

Use of water is primarily from surface-water sources as ground-water supplies generally are not sufficient for public supplies. The principal uses of water are for cooling water for thermoelectric power generation and for industrial and municipal supplies for the city of Birmingham.

The U.S. Geological Survey operates a network of hydrologic data collection stations to monitor the streamflow and ground-water conditions. This network includes data for 180 surface-water stations and 49 ground-water observation wells. These data include rate of flow, water levels, and water-quality parameters. These data are available from computer storage through the National Water Data Exchange (NAWDEX).

Hydrologic problems relating to surface mining are (1) erosion and sedimentation, (2) decline in ground-water levels, and (3) degradation of water quality. Average annual sediment yields can increase by four magnitudes in surface mined areas from 20 (tons/mi^2)/yr from areas not affected by mining to 300,000 (tons/mi^2)/yr from mined areas. Sediment yields increase drastically when vegetation is removed from the highly erosive soils and from unregulated surface mining operations. Decline in ground-water levels can occur in and near surface-mining areas when excavation extends below the static water level in the aquifer. This can cause nearby wells and springs to go dry. Acid mine drainage is a problem only adjacent to the mined area. The acid water is neutralized quickly by the buffering action of calcareous minerals and (or) alkaline water, but does increase trace-element concentrations including aluminum, copper, lead, iron, manganese, and zinc. Dissolved-iron concentrations which are high in and near surface mining areas rapidly decrease due to aeration and dilution as the water moves downstream and in short distances downstream are comparable with water from unmined areas. Sulfate is usually the major dissolved constituent in water from mined areas and tends to stay dissolved and its concentrations are reduced by dilution. Sulfate concentrations, like most water-quality parameters, are higher at times of low flow of streams.

1.0 INTRODUCTION
1.1 OBJECTIVE

Area 23 Report Submitted in Response to Public Law 95-87

Existing hydrologic conditions and identification of sources of hydrologic information are presented.

This report provides general hydrologic information, using a brief text on a single water-resources related topic (for example, low flow) with an accompanying map, chart, graph, or other illustrations. The summation of each topical discussion provides a description of the hydrology of the area. The information contained herein should be useful to surface mine owners and operators and consulting engineers. The location of Area 23 within the State of Alabama is shown on figure 1.1-1.

A need for hydrologic information and analysis on a scale never before required nationally was initiated when the "Surface Mining Control and Reclamation Act of 1977" was signed into law as Public Law 95-87 on August 3, 1977.

The Act created a Federal agency, U.S. Department of the Interior, Office of Surface Mining Reclamation and Enforcement (OSM), whose function is to set guidelines for controlling the adverse effects of coal mining on the environment. The act provided for establishment of State-level regulatory authority to administer and enforce a State law meeting the Federal guidelines. Further provided in the Act is the backup provision that if no satisfactory State program is developed the Federal regulations will be enforced by OSM.

In recognizing the potentially adverse impact that coal mining may have on water resources, Public Law 95-87 requires (1) that each mining-permit applicant make an analysis of the potential effects of the proposed mine on the hydrology of the mine site and adjacent area, (2) that "an appropriate Federal or State agency" provide to each mining-permit applicant "hydrologic information on the general area prior to mining," and (3) that measures be taken by mining permittees to control adverse effects of mining on the "hydrologic balance" and reclamation of the land.

Figure 1.1-1 Location map

Hydrology and Water Resources Assessed for Area 23 in Alabama

This report assesses the hydrology and water resources of Area 23 in the southern end of the Eastern Coal province in Alabama.

The Eastern Coal province is divided into 24 hydrologic reporting areas. The division is based on hydrologic factors, location, size, and mining activity. Hydrologic units (drainage basins) or parts of units are combined to form each area (fig. 1.2-1) (see front cover for areas in the Eastern Coal province).

Area 23 is at the southern end of the Eastern Coal province in Alabama. The area, which includes parts of Jefferson, Shelby, Bibb, Tuscaloosa, Walker, Marion, Lamar, Fayette, Winston, St. Clair, Chilton, Blount, and Pickens Counties, lies within the Mobile River basin, and covers the entire Cahaba Coal Field, the entire Warrior Coal Field, and small areas along the edges of the Plateau Coal Field (fig. 1.2-2).

Most of the area is in the southern part of the Cumberland Plateau, however, the eastern part is in the Valley and Ridge province, and the western part is in the Coastal Plain province (fig. 1.2-3).

The area encompasses the upper part of the Cahaba River basin from its source to Centreville, the upper part of the Black Warrior River basin from the confluence of Mulberry and Locust Forks to Tuscaloosa, the upper part of the Sipsey River basin from its source to Elrod, the upper part of the Buttahatchee River basin from its source to Sulligent, the southwestern part of the Mulberry Fork basin, and the southern half of the Locust Fork basin from Trafford to its confluence with Mulberry Fork which forms the Black Warrior River.

The surface area of Area 23 is 4,716 square miles. Surface drainage from 2,194 square miles of Area 22 flows through Area 23 by way of the Black Warrior River.

Location of Area 23 report in Alabama

EXPLANATION

Coal Fields

Cahaba Field

Warrior Field

Plateau Field

SCALE 1:1,000,000

0 10 20 30 MILES

0 10 20 30 KILOMETERS

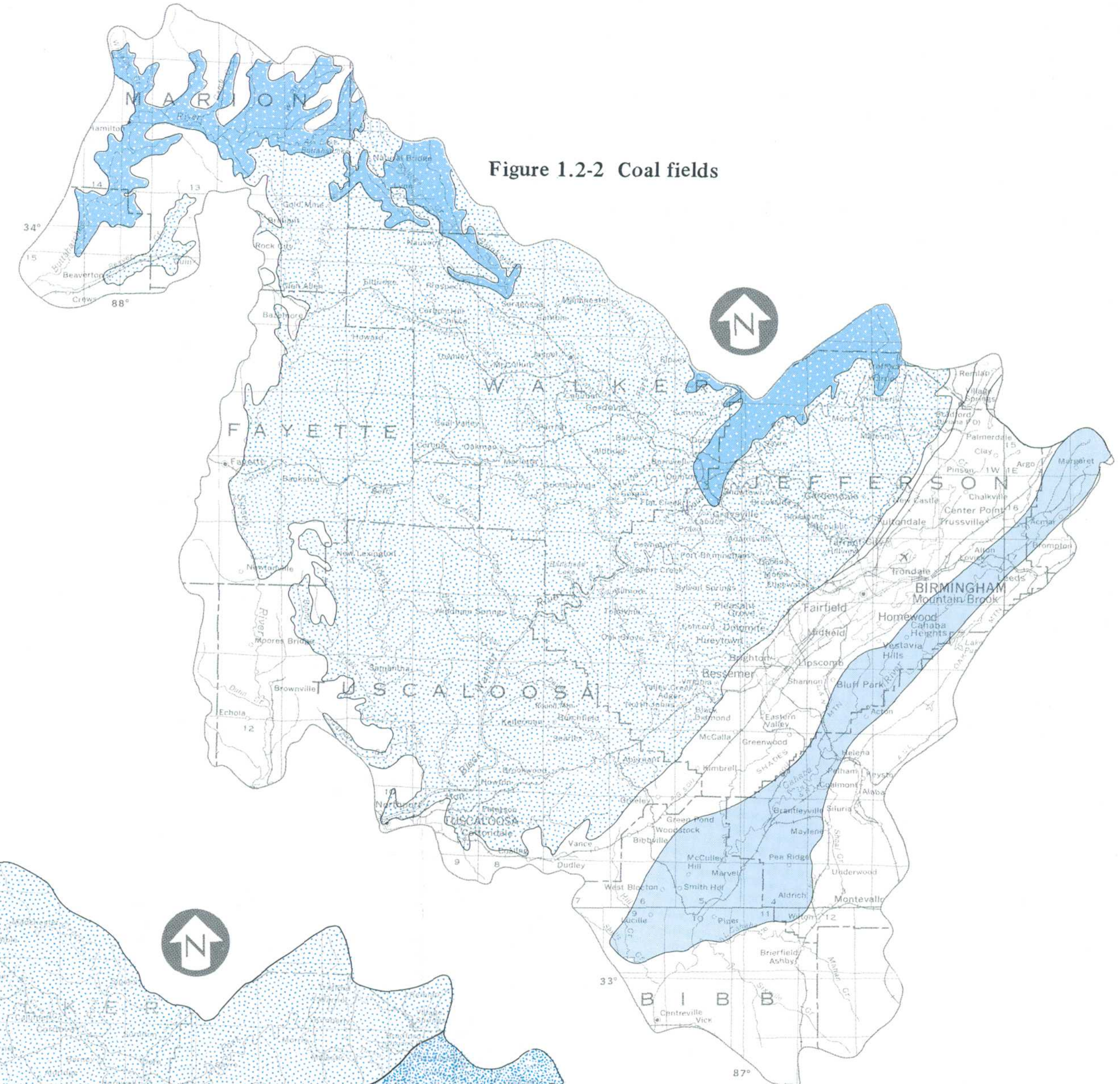


Figure 1.2-2 Coal fields

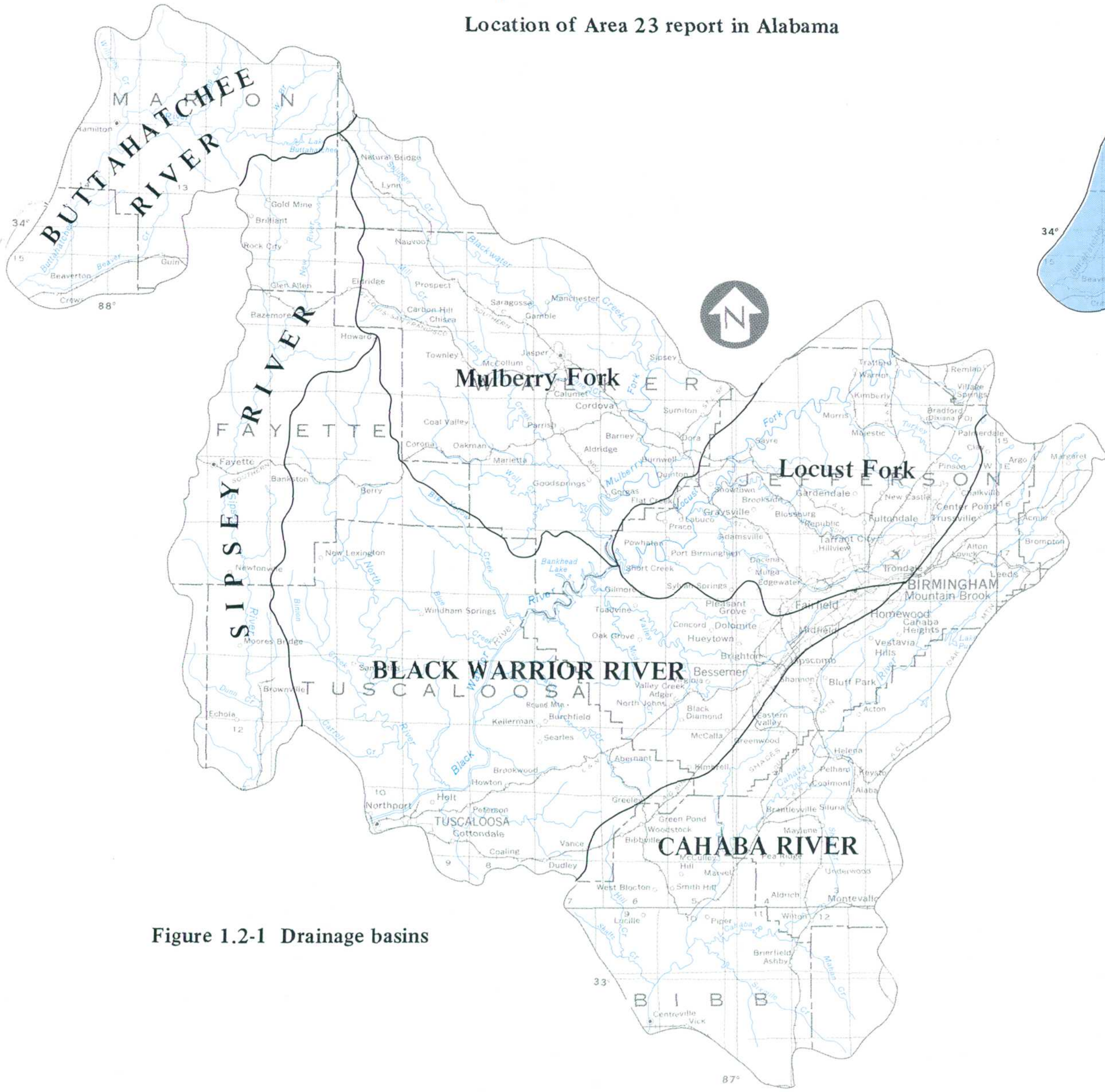


Figure 1.2-1 Drainage basins

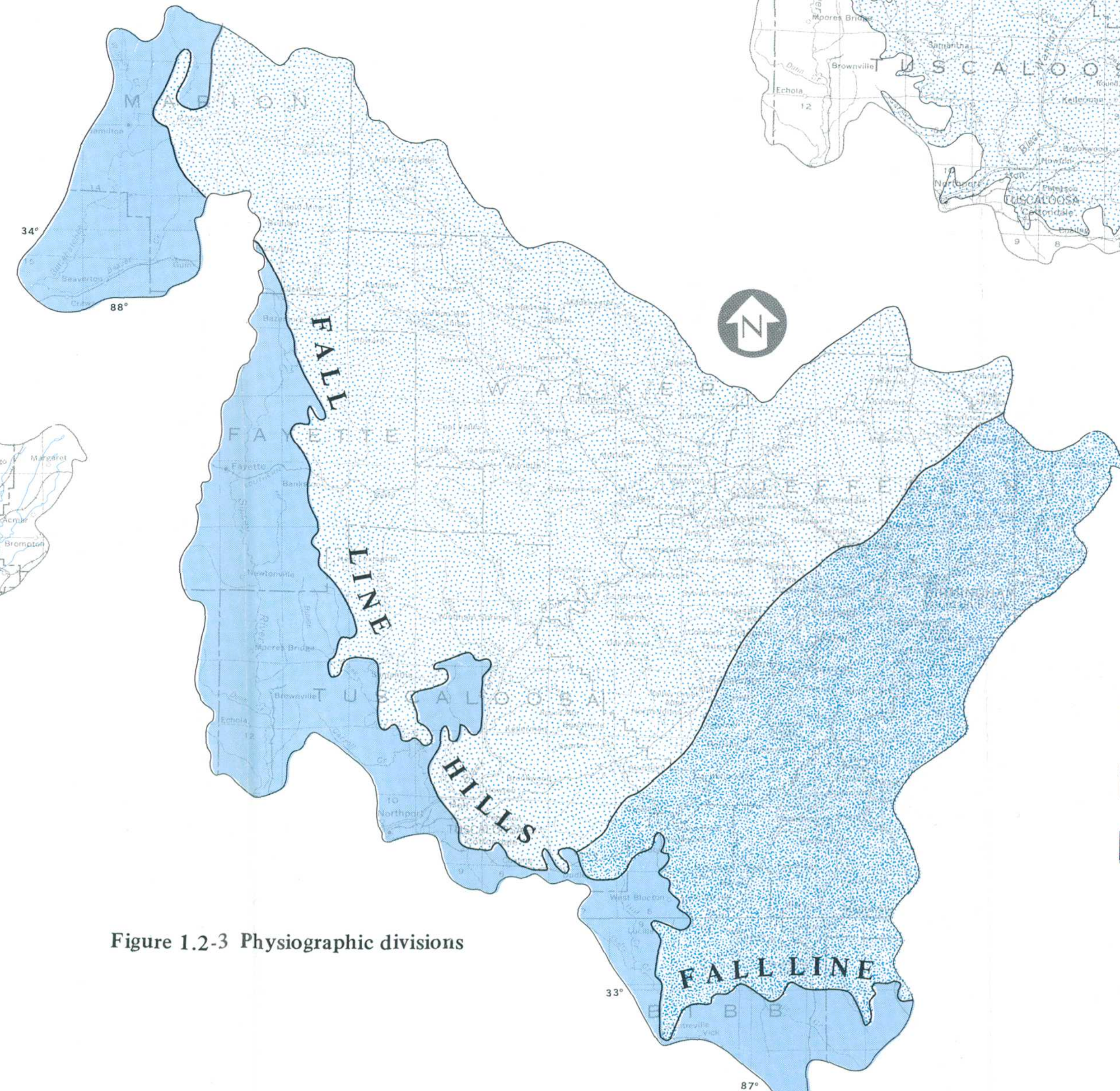


Figure 1.2-3 Physiographic divisions

EXPLANATION

Physiographic Divisions

Cumberland Plateau section

Coastal Plain province

Valley and Ridge province

Physiography from
Sapp and Emplaincourt (1975)

BASE FROM U. S. GEOLOGICAL SURVEY
STATE BASE MAP, 1966

Hydrologic Environment can be Adversely Altered by Surface Coal Mining

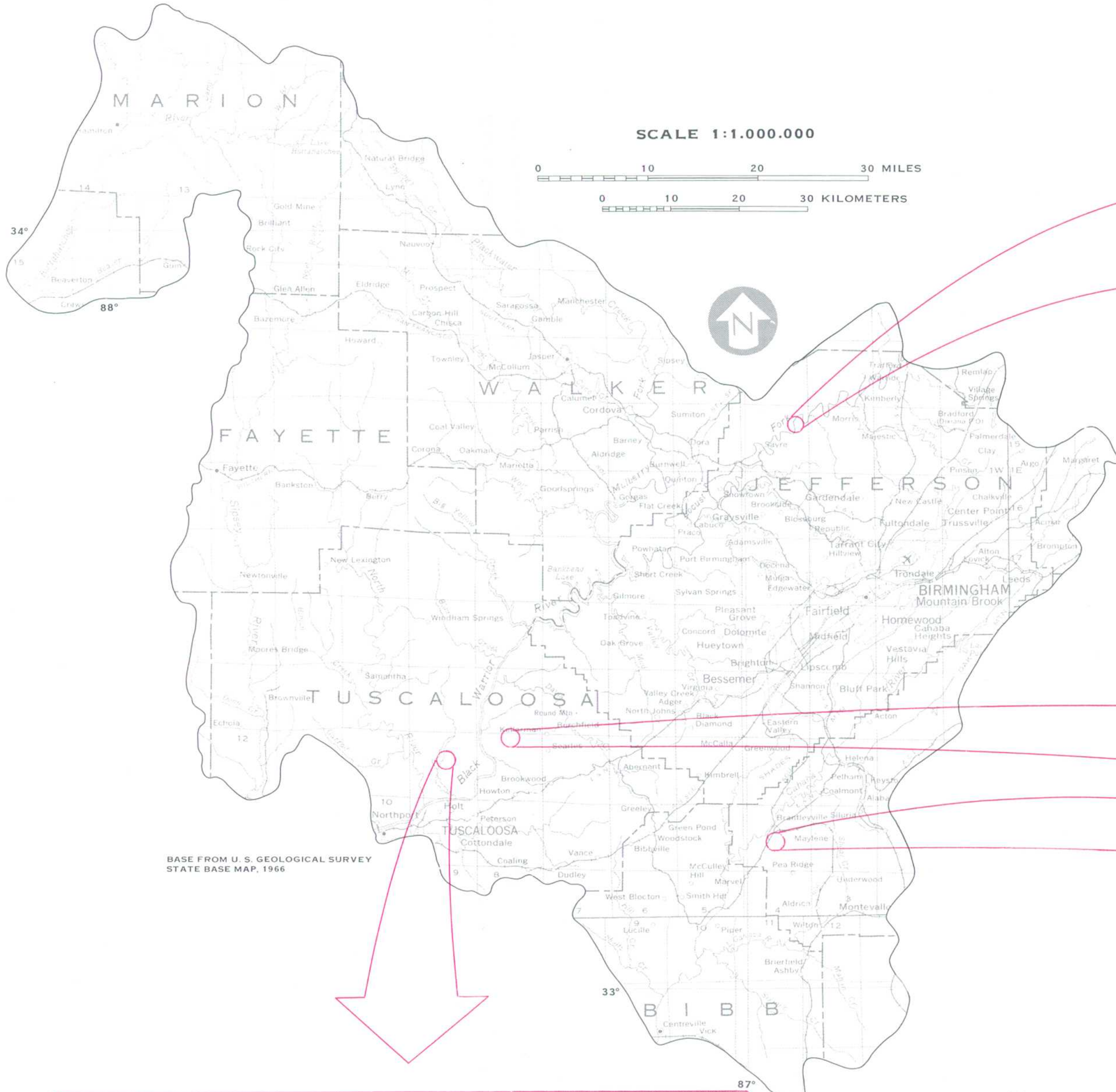
Erosion, sedimentation, decline in water levels, and degradation of water quality are typical problems associated with surface coal mining.

Surface mining drastically alters, at least temporarily, the environment of previously undisturbed lands and if the areas are unreclaimed there can be long-term detrimental environmental consequences. Mining activities such as the removal of vegetation, excavation, and creation of large volumes of unconsolidated spoil materials provide a major opportunity for erosion and increased sediment yield (see fig. 1.3). Average annual sediment yields for streams draining relatively undisturbed basins in Area 23 generally range from 20 to 800 (tons/mi^2)/yr (tons per square mile per year). In contrast, annual sediment yields for streams draining heavily mined but unreclaimed areas can be as high as 300,000 (tons/mi^2)/yr (Hubbard, 1976).

Adverse effects generally associated with increased erosion and sediment yields include excessive sediment deposition in streams and reservoirs which increases the cost of maintaining navigation channels and treating industrial and domestic water. Photographs showing examples of extreme erosion and sediment are shown in figure 1.3. Sediment deposition in Daniel Creek near Tuscaloosa and Locust Fork of the Black Warrior River near Sayre has resulted in severe reduction of aquatic habitat, increased flooding due to filling of the stream channel by sediment, and reduction of aesthetic value in recreation areas. Sediment deposition at Lake Harris, a municipal water-supply source for the city of Tuscaloosa, has reduced reservoir storage capacity.

Decline of ground-water levels can occur in and near surface-mining areas when excavation extends below the base water level of the basin. This can cause wells and springs to go dry. For example, four wells that produced water for domestic supplies at Boothton in Shelby County failed during or immediately after the excavation of a surface mine (Knight and Newton,1977). The decline of water levels in the area is shown in figure 1.3-1.

One of the most common and troublesome water-quality problems is acid-mine drainage. During mining, accelerated weathering of iron bearing minerals (pyrite and marcasite) exposed in spoil materials and coal beds produces sulfuric acid and large quanities of soluble mineral salts. Water draining such a mined area generally has low pH values (2.5-5.0), high sulfate, and high dissolved-solids concentrations. The acidic water reacts with other minerals and commonly increases trace-element concentrations including alumium, copper, lead, iron, manganese, and zinc. Adverse effects associated with acidic and highly mineralized mine drainage include: (1) reduction of stream aquatic life, (2) increased corrosiveness, (3) limited use of water for most domestic and industrial purposes, and (4) reduction of aesthetic value and recreational use.



Spoil banks along Locust Fork of Black Warrior River near Sayre, Jefferson County

Sediment deposits in upper reach of Daniel Creek, Tuscaloosa County

Sediment deposited in Lake Harris, Tuscaloosa County

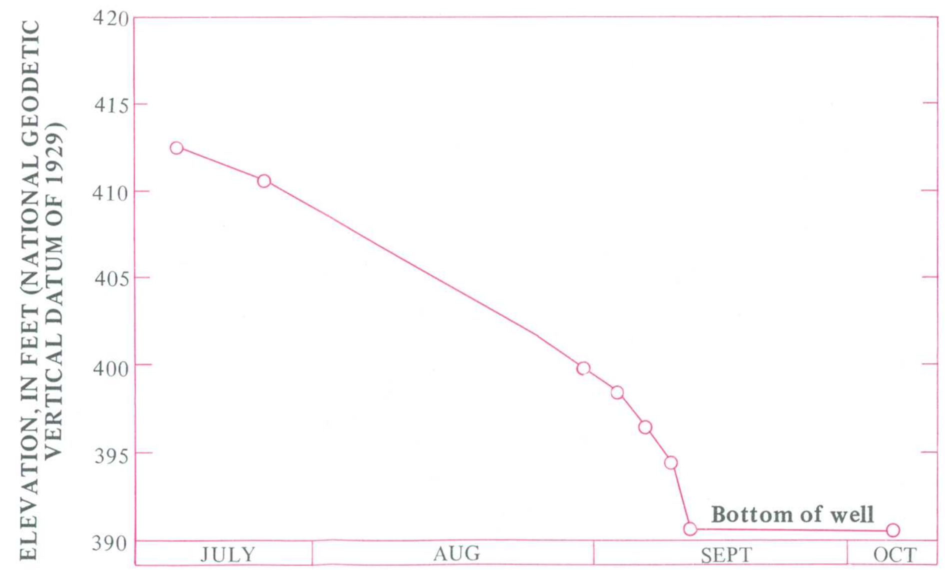


Figure 1.3-1 Decline of water level at Boothton, Shelby County, 1973.

Three Major Rock Units Underlie the Area

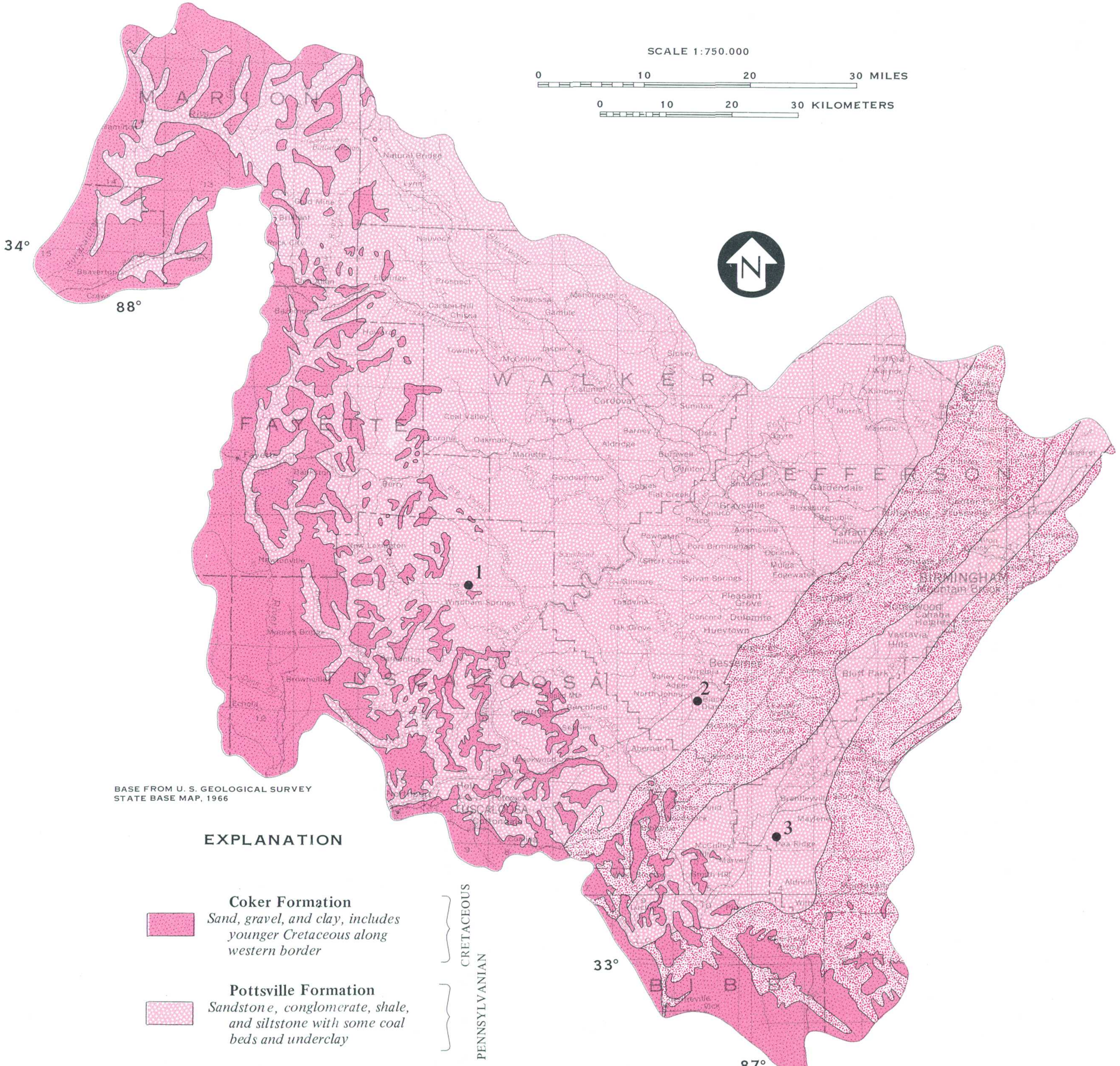
The rock formations underlying Area 23 can be subdivided into three principal units: the Pottsville Formation, which contains the coal beds; the Coker Formation, which overlies the Pottsville; and the undifferentiated pre-Pennsylvanian rocks, which underlie the Pottsville.

The Pottsville Formation crops out in a western area and an eastern area. The two areas are separated by undifferentiated pre-Pennsylvanian rocks (see fig. 2.1-1). The Warrior Coal Field is in the western area and the Cahaba Coal Field is in the eastern area. A part of Marion County in the west is in the Plateau Coal Field and a very small area along the eastern boundary of Area 23 is in the Coosa Coal Field. The only significant difference between the eastern and western areas is the attitude of strata that underlies them. In the west, strata generally trend northwestward and dip southwestward 30 to 200 ft/mi (feet per mile). This regional dip and strike is modified locally by faults, folds, and synclines. The belt of outcrop in the eastern area is underlain by a narrow synclinal trough. Strata along the northwest limb of the syncline dip about 20° SE and those along the southeast limb are truncated by a large thrust fault.

The Pottsville Formation consists chiefly of alternating beds of gray sandstone, conglomerate, siltstone, and shale with beds of coal and underclay. The maximum thickness of the formation in the western part of the area is about 4,500 feet, and in the eastern part it is about 9,000 feet (Culbertson 1964). Except for conglomeratic sandstone at the base of the formation, few lithologic horizons can be correlated regionally. The basal sandstone and other correlatable sandstone members in the Warrior and Cahaba Coal Fields are shown on figure 2.1-1. Also shown are named and unnamed coal beds and groups in the two fields. Regionally, these beds are discontinuous. As many as 60 coal beds have been reported in the Cahaba Coal Field where the formation is thickest.

The Coker Formation unconformably overlies the undifferentiated pre-Pennsylvanian rocks and the Pottsville Formation in western and southern parts of the area (fig. 2.1-1). The Coker consists chiefly of unconsolidated sand, gravel, and clay with the more prominent sand and gravel beds occurring at or near the base of the formation. Strata in the formation trend northwestward and generally dip southwestward 30 to 40 ft/mi. The maximum thickness of the Coker in the area is about 475 feet. This thickness, penetrated near Echola in the southwesternmost part of the area, includes some younger Cretaceous strata not differentiated on the geologic map. Most surface coal mining that requires the removal of the Coker Formation has occurred and likely will continue to occur where the thickness of the Coker is considerably less than 100 feet.

The undifferentiated pre-Pennsylvanian rocks are about 4,900 feet thick and consist primarily of limestone, dolomite, chert, sandstone, shale, and some beds of hematite. These strata crop out in two northeast-southwest trending belts along and near the east boundary of the area. Faulting and folding within these areas are common.



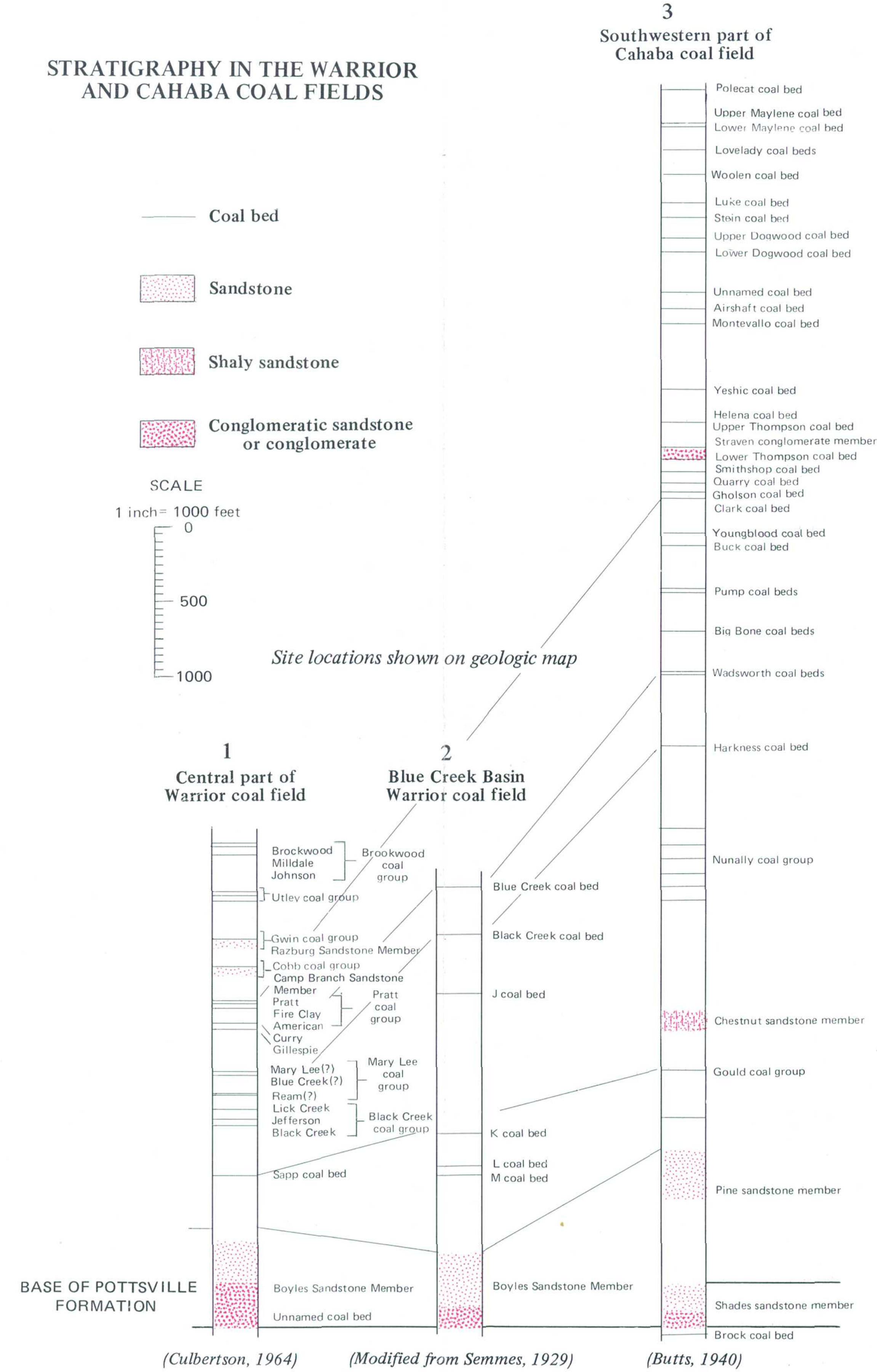
EXPLANATION

Coker Formation *Sand, gravel, and clay, includes younger Cretaceous along western border*	CRETACEOUS	
Pottsville Formation *Sandstone, conglomerate, shale, and siltstone with some coal beds and underclay*	PENNSYLVANIAN	
Pre-Pennsylvanian *Limestone, dolomite, sandstone, chert, and shale*	CAMBRIAN-MISSISSIPPIAN	

Geology from Adams and others (1926)

Figure 2.1-1 Geologic map

STRATIGRAPHY IN THE WARRIOR AND CAHABA COAL FIELDS



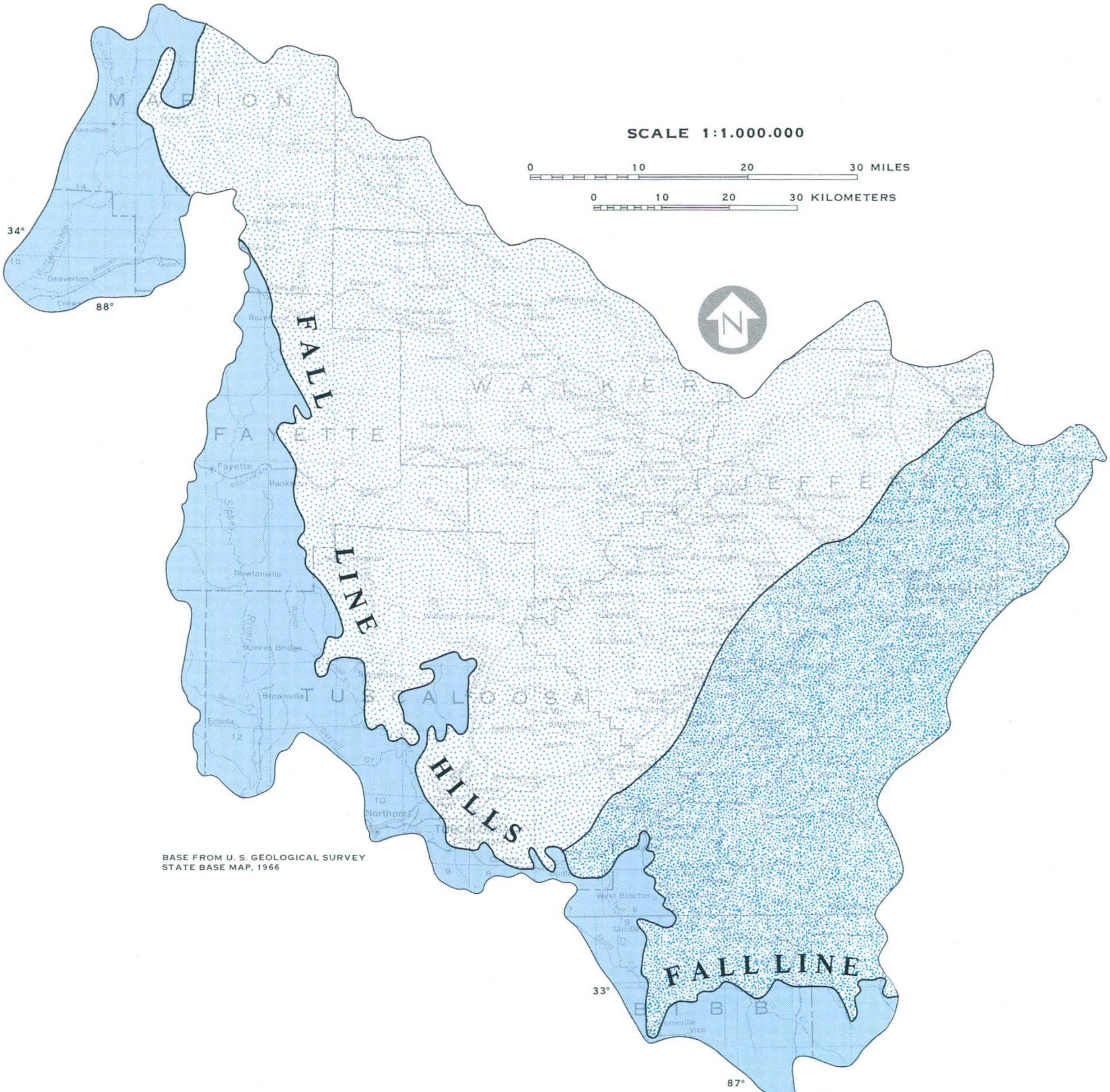
Area 23 Defined by Three Physiographic Provinces

Area 23 lies within three physiographic provinces: Appalachian Plateaus, Coastal Plain, and Valley and Ridge.

The central part of Area 23, underlain by the Pottsville Formation and drained by the Black Warrior River, lies within the Cumberland Plateau section of the Appalachian Plateaus (see fig. 2.2-1). Topographically, this part of the area is a broad plateau where streams flow through steep-sided valleys and the land surface has a characteristically roughened surface.

The Cumberland Plateau section is bordered on the west by the Fall Line Hills of the East Gulf Coastal Plain section of the Coastal Plain province. This part of Area 23 is characterized by maturely eroded uplands and mature stream valleys developed on the Coker Formation and is drained by the Sipsey and Buttahatchee Rivers.

East of the Cumberland Plateau is the Valley and Ridge province, which is characterized by parallel valleys and alternating ridges of resistant rock. This area is drained by the Cahaba River and tributaries to the Black Warrior River.



EXPLANATION

- Cumberland Plateau section
- Valley and Ridge province
- Coastal Plain province

Figure 2.2-1 Physiographic divisions

Four Rivers Drain Area

Most of area is drained by the Black Warrior River. Other major streams draining Area 23 are the Cahaba, Sipsey, and Buttahatchee Rivers.

The areas drained by the Black Warrior, Cahaba, Sipsey, and Buttahatchee Rivers are shown on figure 2.3-1. The area drained by the Black Warrior River is underlain almost entirely by coal-bearing rocks. The principal tributaries to the Black Warrior, Locust and Mulberry Forks, drain areas with coal-bearing rocks to the north of Area 23.

Three of the rivers--the Buttahatchee, Sipsey, and Black Warrior--drain to the Tombigbee River; the Cahaba River drains to the Alabama River. The drainage of all of these rivers eventually reaches the Mobile River that flows to the Gulf of Mexico.

The Cahaba River drains the Cahaba Coal Field, the pre-Pennsylvanian rocks east of the Cahaba Coal Field, and the eastern part of the pre-Pennsylvanian rocks west of the coal field. Its drainage also includes part of the industrial, municipal, and urban area of Birmingham.

The Sipsey River drains a long narrow north-south trending valley, incised in Cretaceous and Pennsylvanian rocks (section 2.1), that marks the western edge of the Warrior Coal Field.

The Buttahatchee River drains the northwest corner of the area, which includes the western fringe of the Plateau Coal Field.

Area 23 has a surface area of 4,716 square miles. In addition, Area 23 receives the drainage from 2,194 square miles of Area 22 by way of Mulberry Fork (1,570 square miles) and Locust Fork (624 square miles). The drainage area of the Black Warrior River within Area 23 is 2,634 square miles. Other major streams having their headwaters within Area 23 and their drainage areas are as follows:

Basin	Area (square miles)
Cahaba River	1,092
Sipsey River	518
Buttahatchee River	472

Drainage areas for selected locations on streams in Area 23 may be found in Geological Survey of Alabama report "Drainage Areas for the Upper Black Warrior River Basin, Alabama," (Scott, 1978), and U.S. Army Engineers District, Mobile Corps of Engineers report titled, "Stream Mileage Tables with Drainage Areas" (1972).

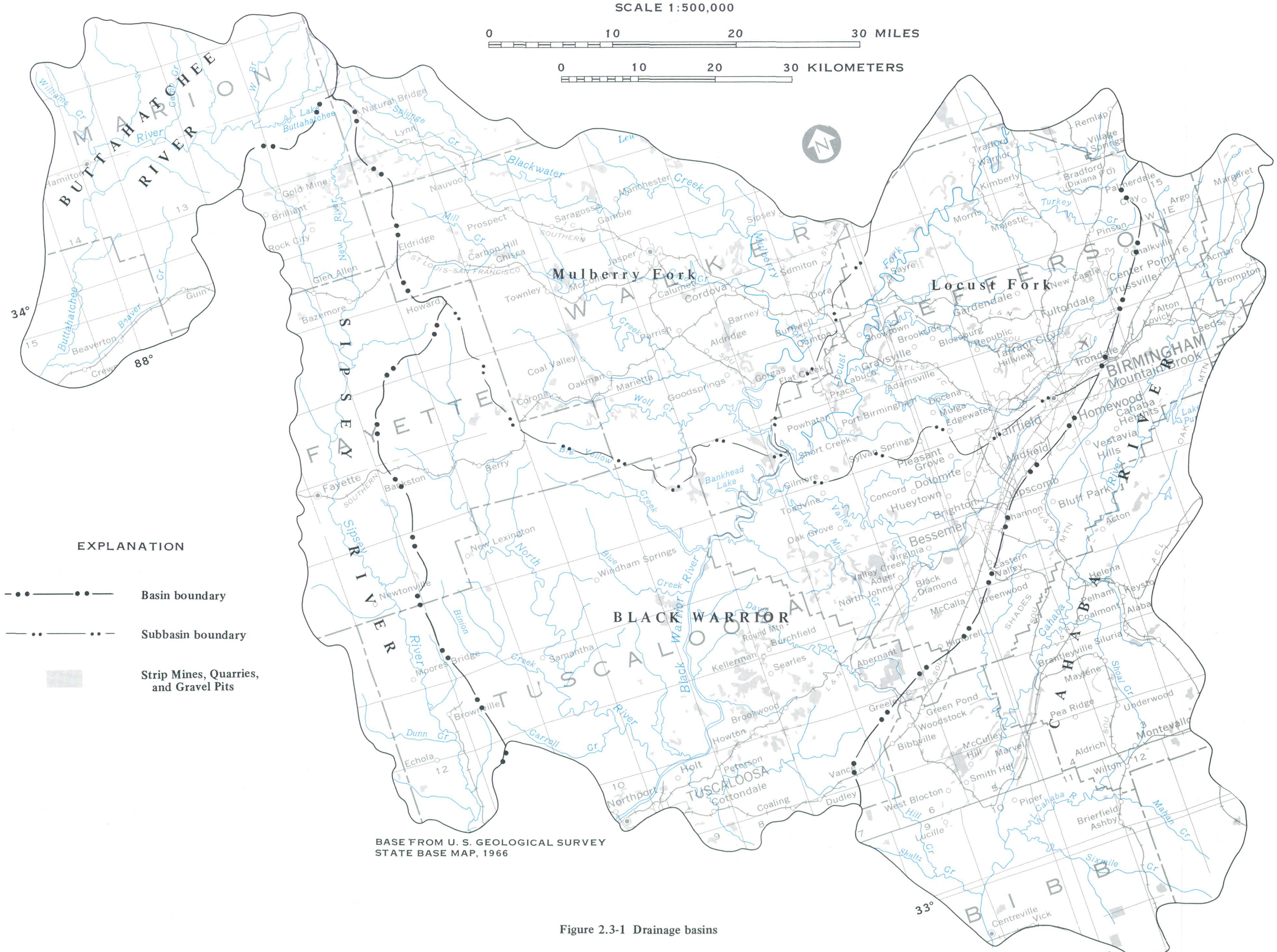


Figure 2.3-1 Drainage basins

Majority of Area is Forest Land

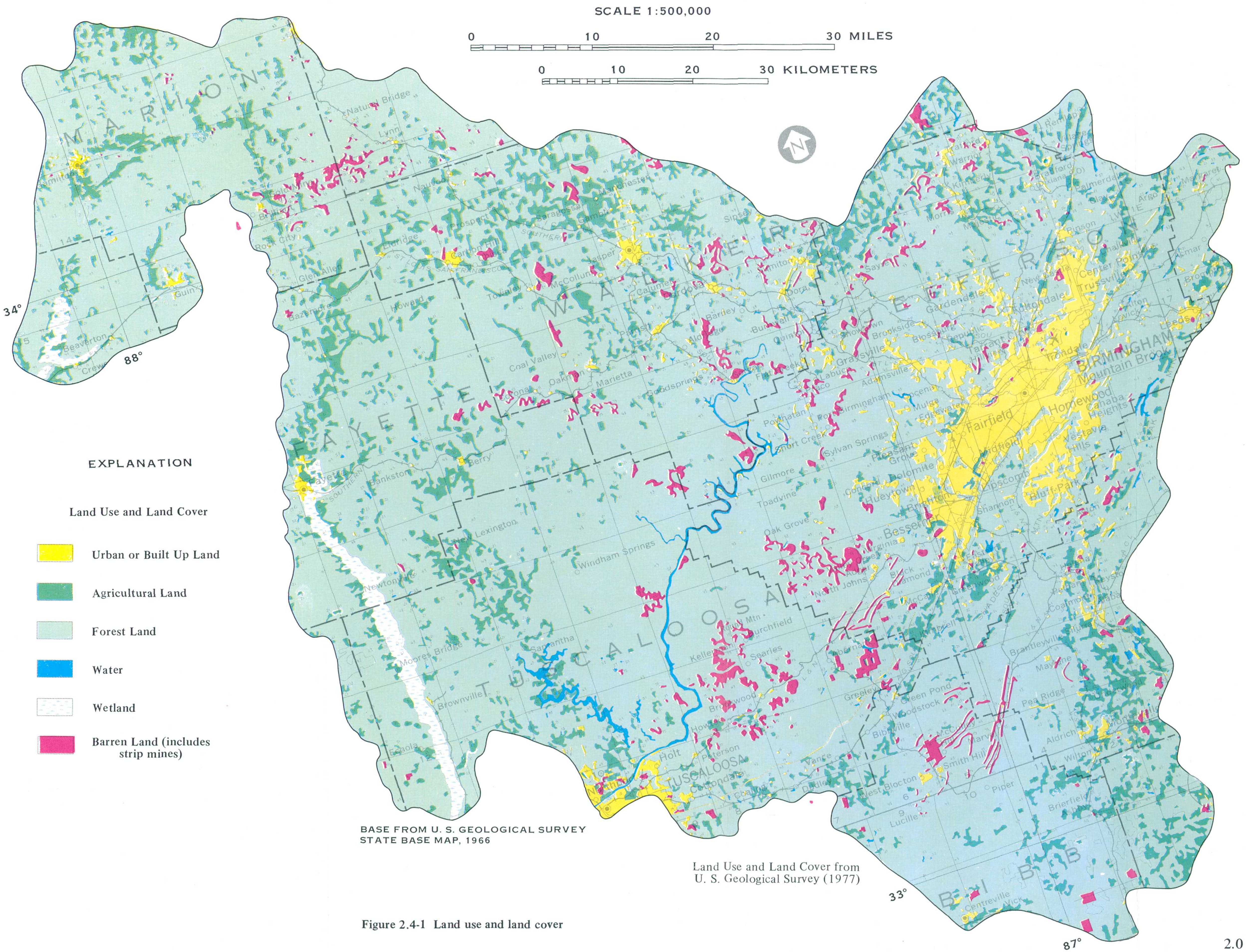
Forest Land covers the majority of Area 23. Urban or Built-Up Land is the second largest land use. The third major land use is for agriculture followed closely by surface mining.

Area 23 was grouped into six land use and land cover categories and these categories are shown on the land-use and land-cover map (fig. 2.4-1).

The regimen of flow is affected by the use of the land surface. Where coal is surface mined the slope and shape of the land surface is changed; great depths of overburden are broken, mixed, and rearranged; and the rate of infiltration is increased or decreased according to the materials at the surface. Generally, the infiltration rate is increased immediately after mining but as water decomposes the material through which it percolates the rate changes. Urban and industrial development of large areas may reduce infiltration rate due to paving, roof tops, and storm sewers. Changes in cultivated land from row crops to pasture or timber also have an effect on infiltration and runoff rates.

Inasmuch as the land surface is the source of sediment, there can be a drastic change in sediment yield when the land surface is changed from forest to bare surface-mined land.

Land-use and land-cover information and maps in greater detail may be found in U.S. Geological Survey open-file reports titled Land Use Series. Information on the Land Use Series is available from the National Cartographic Information Center, U.S. Geological Survey, National Center, Reston, Virginia 22092.



EXPLANATION

Land Use and Land Cover

- Urban or Built Up Land
- Agricultural Land
- Forest Land
- Water
- Wetland
- Barren Land (includes strip mines)

BASE FROM U. S. GEOLOGICAL SURVEY STATE BASE MAP, 1966

Land Use and Land Cover from U. S. Geological Survey (1977)

Figure 2.4-1 Land use and land cover

Soils Are Acidic And Generally Have High Erosion Potential

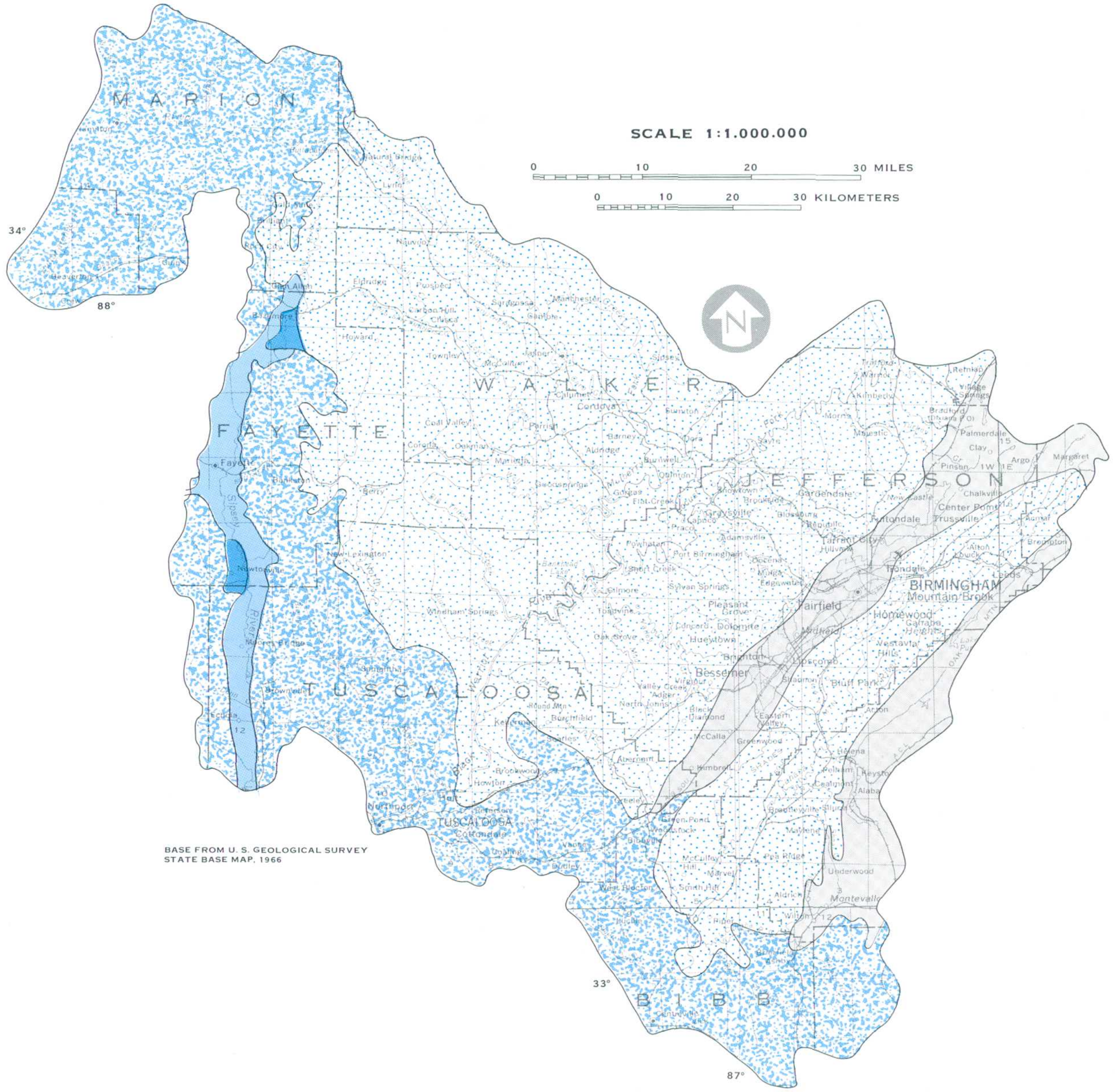
Soils in the area are acidic, with pH ranging from 3.6 to 6.0, and are easily eroded when vegetative cover is removed.

Soils in Area 23 generally have low organic-matter content, moderate permeability rates, high acidity, and high erosion potential. Factors affecting erosion potential include: infiltration and permeability rates, soil texture and stability, soil depth, slope gradient, and vegetative cover. Removal of vegetative cover due to surface mining drastically alters natural erosion in an area as slope gradient increases.

The generalized soil map (fig. 2.5-1) shows the location of five soil associations. These associations are characterized by the U.S. Soil Conservation Service's Established Soil Series Descriptions and are summarized in table 2.5-1.

Factors affecting suitability of the soils for plant growth are listed in table 2.5-2. The Minvale-Fullerton, Ruston-Cuthbert-Shubuta, and Myatt-Stough-Mantachie associations are well suited for use as a plant growth medium. The Savannah-Ora association is less suited for plant growth due to the low pH and low available water capacity. The Montevallo-Enders-Townley association is fairly poor for plant growth purposes due to its shallow soil depth and depth to bedrock, low available water capacity, and steep slopes.

The soils map and descriptions of soil associations are very generalized. Detailed information for individual counties is available from the U.S. Soil Conservation Service.



Soils modified from U. S. Department of Agriculture (1965), and (1974)

EXPLANATION

SOIL ASSOCIATIONS

Minvale-Fullerton
Deep soils over limestone

Montevallo-Enders-Townley
Shallow to moderately deep, well-drained soils over shale and sandstone

Ruston-Cuthbert-Shubuta
Moderately deep and deep, well drained soils over thick beds of sandy and clayey marine sediments

Myatt-Stough-Mantachie
Deep, imperfectly drained and poorly drained soils on flood plains and low stream terraces

Savannah-Ora
Deep, moderately well-drained soils that have a fragipan

Figure 2.5-1 Generalized soil associations

Table 2.5-1 Soil association features

Soil association	Physical description	Soil depth (inches)	Depth to bedrock (feet)	pH	Permeability (inches/hour)	Available water capacity (inches/hour)	Slope (slope)
Minvale-Fullerton	Cherty silt loam underlain by limestone	>80	>6	4.5 - 5.5	0.6 - 2.0	0.09 0.16	2 - 45
Montevallo-Enders Townley	Shaly silt loam underlain by shale and sandstone	10 - 59	1 - 6	3.6 - 6.0	0.06 - 2.0	0.02 - 0.18	2 - 45
Ruston-Cuthbert-Shubuta	Fine sandy loam underlain by sandy or clayey marine sediments	20 - 80	>6	3.5 - 6.5	0.2 - 6.0	0.08 - 0.18	0 -40
Myatt-Stough-Mantachie	Sandy loam on flood plains and low stream terraces	30 - 68	>6	3.6 - 5.5	0.2 - 2.0	0.10 - 0.24	0 - 5
Savannah-Ora	Fine sandy loam with a fragipan*	>70	>6 (16 - 42 inches to fragipan)*	3.5 - 5.5	0.2 - 6.0	0.10 - 0.18 (0.05 - 0.15 in fragipan)*	0 - 12

* Fragipan - Dense and brittle pan or layer in soils that owe its hardness mainly to extreme density or compactness rather than high clay content or cementation - water moves through it very slowly (Buckman and Brady, 1969, 653 p.)

Table 2.5-2 Suitability rating of soil (to a depth of 1 meter) for use as a plant growth medium in drastically disturbed land reclamation

Factors affecting use	Degree of suitability		
	Good	Fair	Poor (essentially unsuitable)
Electrical conductivity EC (umhos/cm)	<8	8 - 16	>16
Sodium adsorption ratio SAR	<2	2 - 12	>12
Exchangeable-sodium-percentage ESP*	<2	2 - 15	>15
pH	5.0 - 8.5	3.5 - 5.0	<3.5;>8.5
Coarse fragments over 3-inch diameter (percent by volume)	< 15	15 - 35	>35
Intermediate textural group	medium moderately fine moderately coarse	fine	coarse
Available water capacity (inches/inch)	>0.1	0.1 - 0.05	< 0.05
Depth to bedrock or cemented pan	> 40 inches	20 - 40 inches	<20 inches
Slope (percent)	<8	8 - 15	>15

* Rate 2:1 Clay texture poor if over 10; sand texture if over 20

Modified from U. S. Department of the Interior (1977)

Area 23 Characterized By Moist Temperate Climate

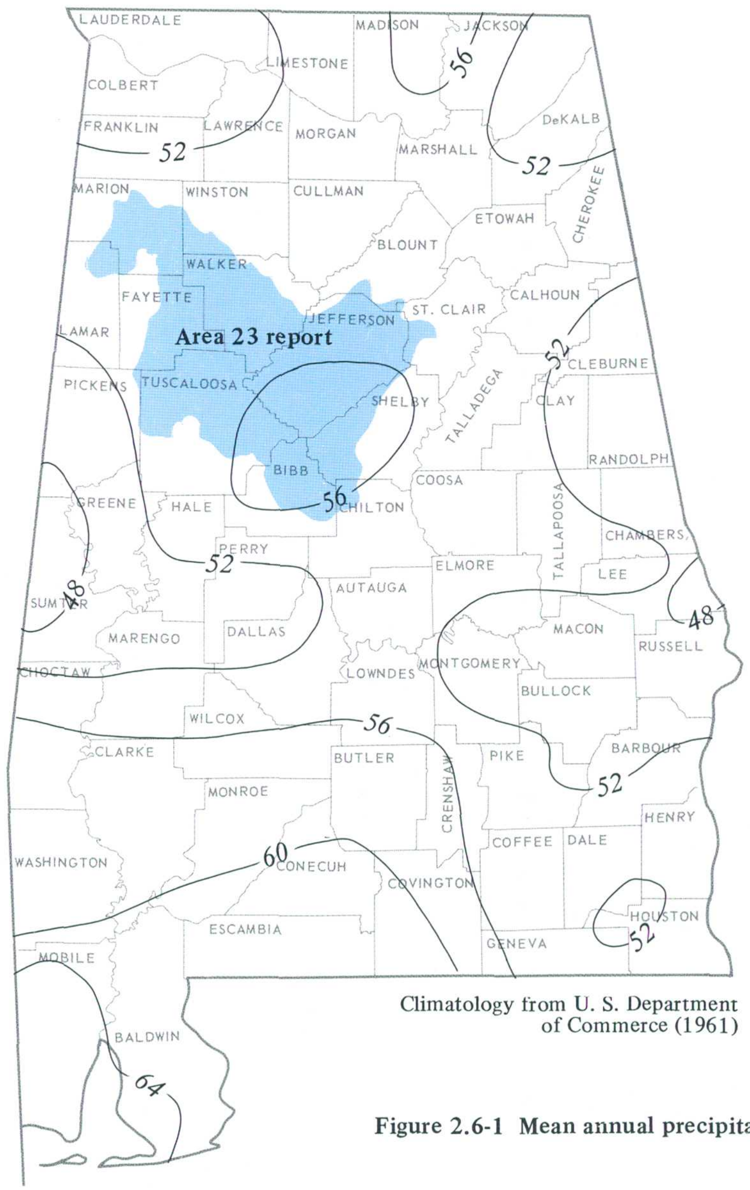
Area 23 has a moist temperate climate with the heaviest rainfall occurring in March and the least rainfall occurring in October.

The location of Area 23 gives it a moist temperate climate, with a mean annual rainfall that ranges from 52 inches along the western side of the area to 56 inches along the eastern side. Rainfall is fairly well distributed throughout the year. Winter is the wettest season and March the wettest month. Thunderstorms occur throughout the year, but are most frequent during the spring and summer months; most of the rainfall in these months occurs during these storms. July has the most rainfall of the spring and summer months. The driest months are in the fall with October being the driest month. Rainless periods lasting more than 2 or 3 weeks are rare.

Mean annual precipitation, in inches, for Alabama is given by isolines on the map of figure 2.6-1. The base period for computation is 1931-55. The distribution of rainfall by months for Birmingham is shown in figure 2.6-2. The extremes (maximums and minimums) are given to show variations above and below the normal for each month.

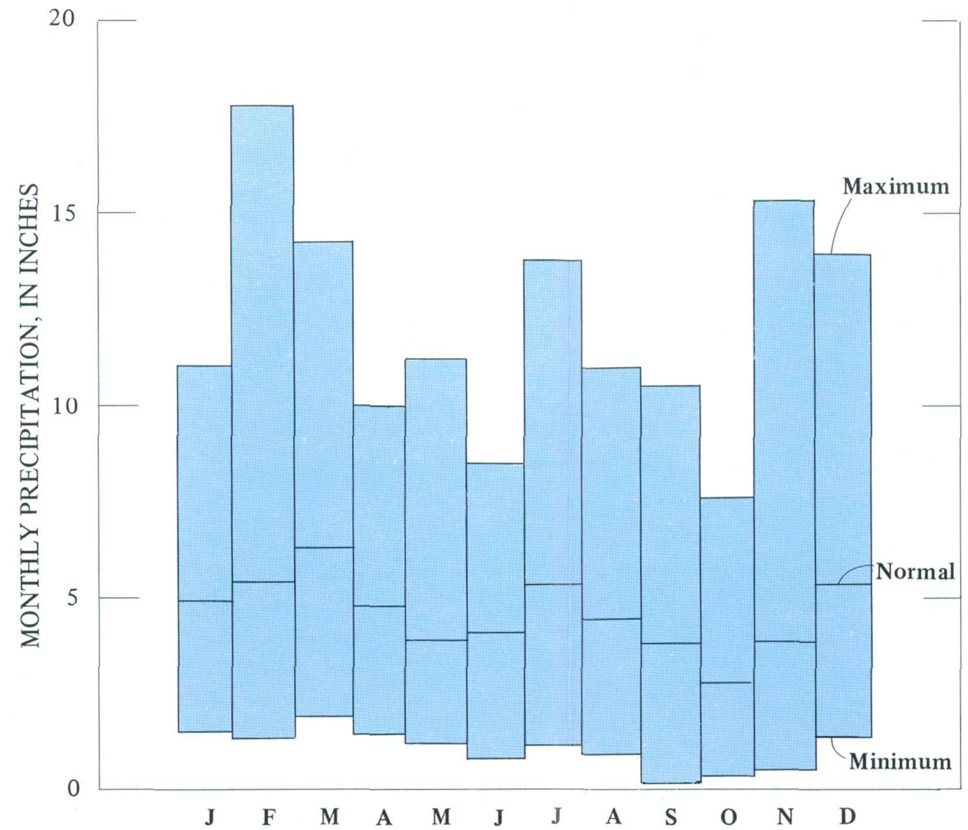
Daily observations of precipitation data may be used to develop various relationships and correlations and for other statistical analyses. The results of an analysis using 24-hour rainfall to compute the 10-year 24-hour rainfall intensities are shown in figure 2.6-3.

Daily precipitation data are published monthly as "Climatological Data for Alabama" by the National Oceanic and Atmospheric Administration, National Climatic Center, Ashville, N. C. Statistical information on analyses and data are presented in U.S. Department of Commerce, Weather Bureau, Technical Paper No. 40 titled, "Rainfall Frequency Atlas of the United States."



Climatology from U. S. Department of Commerce (1961)

Figure 2.6-1 Mean annual precipitation (in inches).

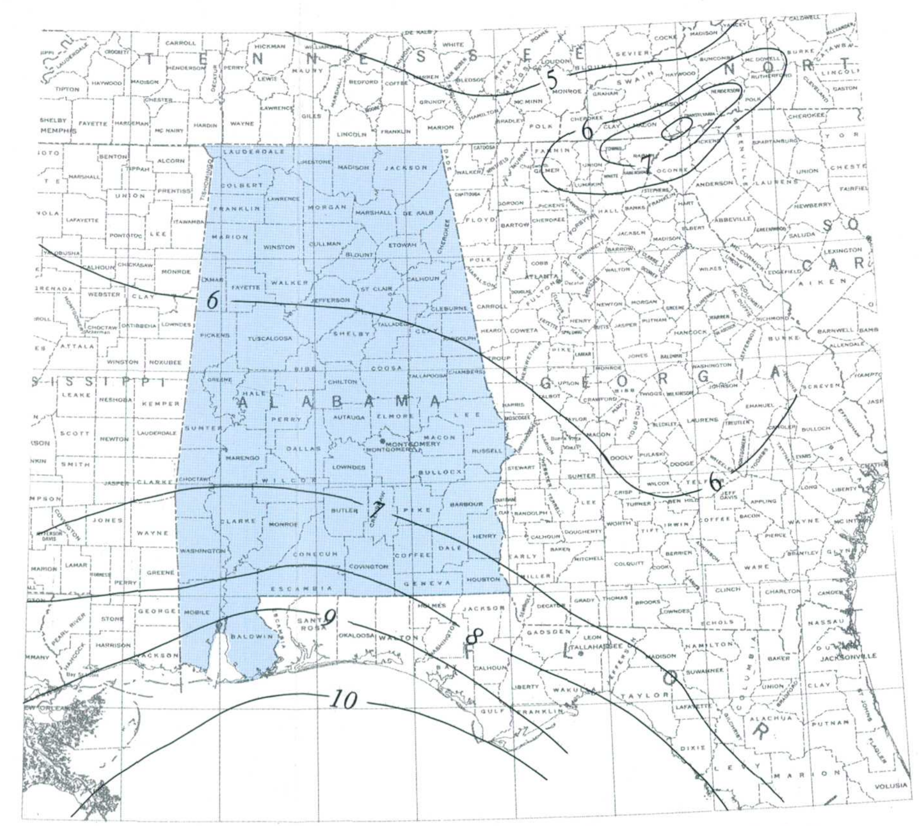


Based on records for the 1941-70 period
Climatological data from NOAA, Birmingham, Alabama(1978)

Extremes of record, in inches

Maximum monthly precipitation	20.12 (July 1916)
Minimum monthly precipitation	0.00 (October 1924)
Maximum precipitation in 24 hours	8.84 (July 1916)
Maximum monthly snowfall	11.8 (January 1936)
Maximum snowfall in 24 hours	11.0 (January 1936)

Figure 2.6-2 Precipitation data for Birmingham (Jefferson County)



Climatology from U. S. Department of Commerce (1961)

Figure 2.6-3 10-year 24-hour rainfall intensities, in inches.

Principal Withdrawal Uses of Water in Area 23 Are for Thermoelectric, Public, And Industrial Supplies

About 1,450 Mgal/d (million gallons per day) was from the Black Warrior River for thermoelectric power generation. Approximately 370 Mgal/d was for public and industrial water supplies--about 95 percent was surface water from streams and lakes and 5 percent was ground water from wells and springs.

Withdrawal use of water in Area 23 in 1975, other than for thermoelectric supplies, was concentrated in the Birmingham area. The Birmingham area used about 228 Mgal/d of surface water and about 17 Mgal/d of ground water for public and industrial supplies or about 67 percent of the total use for these purposes in Area 23. The major sources of surface-water supply are Sipsey Fork just downstream from Lewis Smith Lake, Inland Lake on Blackburn Fork (both in Area 22), and the Cahaba River with releases from Lake Purdy on the Little Cahaba River. Water for public supplies for most municipalities in Area 23 are obtained from surface-water sources, because ground-water supplies generally are not sufficient.

Water withdrawal for cooling water for thermoelectric power generation was about 1,450 Mgal/d at the Gorgas plant on the Black Warrior River. Except for small consumptive losses, the water was returned to the river immediately downstream from the plant. Figure 3.1-1 shows public, industrial, rural, and thermoelectric power generation use.

Nonwithdrawal use was about 5,750 Mgal/d for hydroelectric power generation at the Bankhead and Holt plants and about 560 Mgal/d for navigation at Bankhead, Holt, and Oliver Lock and Dams on the Black Warrior River.

Water withdrawn by rural residents in Area 23 was for domestic purposes (10 Mgal/d), stock watering (1.5 Mgal/d), irrigation (1.2 Mgal/d), and catfish farming (0.5 Mgal/d). Most (85 percent) of the water used rurally, including all water for domestic use, was from ground-water sources.

The data in this report were taken from a report titled "Use of water in Alabama, 1975, with projections to 2020": Alabama Geological Survey Information Series 48. Additional information on water-use is contained in "Estimated use of water in the United States in 1975": U.S. Geological Survey Circular 765.

For 1980 the data will be collected and compiled by State agencies. These data will be available through the National Water Data Exchange (NAWDEX). For details about NAWDEX see section 9 of this report. These data will be published by the U. S. Geological Survey in a report entitled "Estimated water use in the United States in 1980."

Water use, in million gallons per day

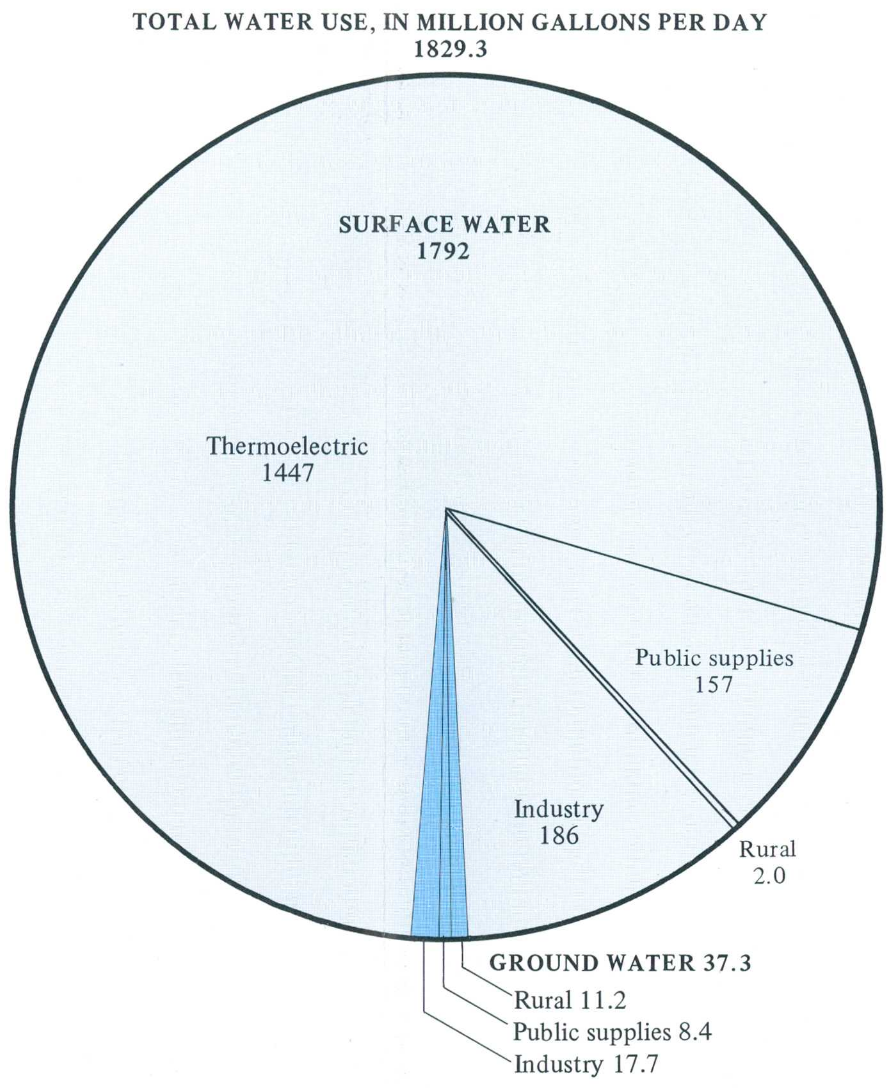


Figure 3.1-1 1975 water use

Most Streams in Area 23 Have Fish and Wildlife or Better-Use Classification

The Alabama Water Improvement Commission has given most streams in Area 23 a Fish and Wildlife or better-use classification.

Stream-use classification of stream reaches is shown in figure 3.2-1. The reaches as classified and published for Area 23 by the Alabama Water Improvement Commission (March 1979), also given in Appendix 1, show most streams are classified as "Fish and Wildlife" or better.

An effort has been made to include all major stream segments and all segments that to the Commission's knowledge are currently recipients of point-source discharges. Some waters are not included by name in the use classification because it would be a tremendous overhead burden. In virtually every instance where a segment is not included by name, the Alabama Water Improvement Commission has no information or stream data on which to base a decision relative to the assignment of a particular classification. However, the assumption was made by the Commission that these unnamed segments could be classified as "Fish and Wildlife" and are so labeled unless it can be demonstrated that it is inappropriate in specific instances.

Although it is not explicitly stated in the classifications, it should also be noted that with the exception of those segments in the "Public Water Supply" classification, every segment in addition to being considered acceptable for its designated use is also considered acceptable for any other use with a less stringent associated criteria.

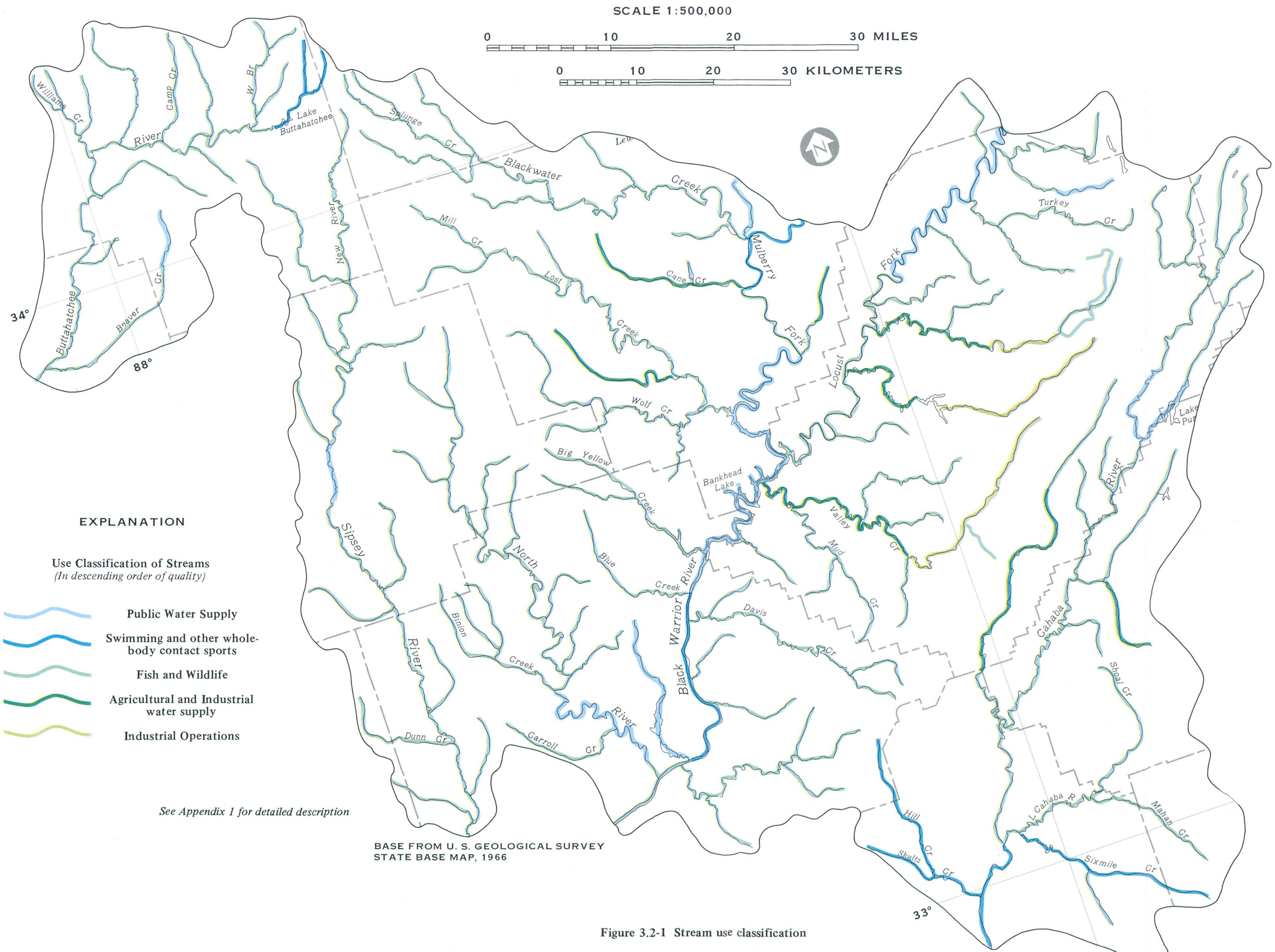


Figure 3.2-1 Stream use classification

3.0 WATER USE (Continued)

3.2 USE CLASSIFICATION OF STREAMS

Information on Surface Water is Available for 180 Locations

The U.S. Geological Survey surface-water data-collection network for Area 23 was intensified in response to the Surface Mining Control and Reclamation Act of 1977 (Public Law 95-87), and information on surface water is now available for 180 locations.

Streamflow and water-quality information is available for 180 sites in Area 23; these surface-water sites are shown on figure 4.1-1, and details for the period of record and type of data available are given in Appendix 2. Before the passage of Public Law 95-87 the network consisted of about 60 stations. The active network has been more than doubled by the Survey to obtain data needed to assess the hydrology of the general area and as an aid to mine owners and operators, consulting engineers, and the Regulatory Authority in evaluating the hydrologic consequences of mining.

Water-quality data are obtained at all of the surface-water stations. Several types of data may be collected at a particular site, but all types of data are not necessarily collected at each site. Details about period of operation and type of data as well as the actual data are available from computer storage through National Water Data Exchange (NAWDEX) and in published annual U.S. Geological Survey reports "Water Resources Data for Alabama."

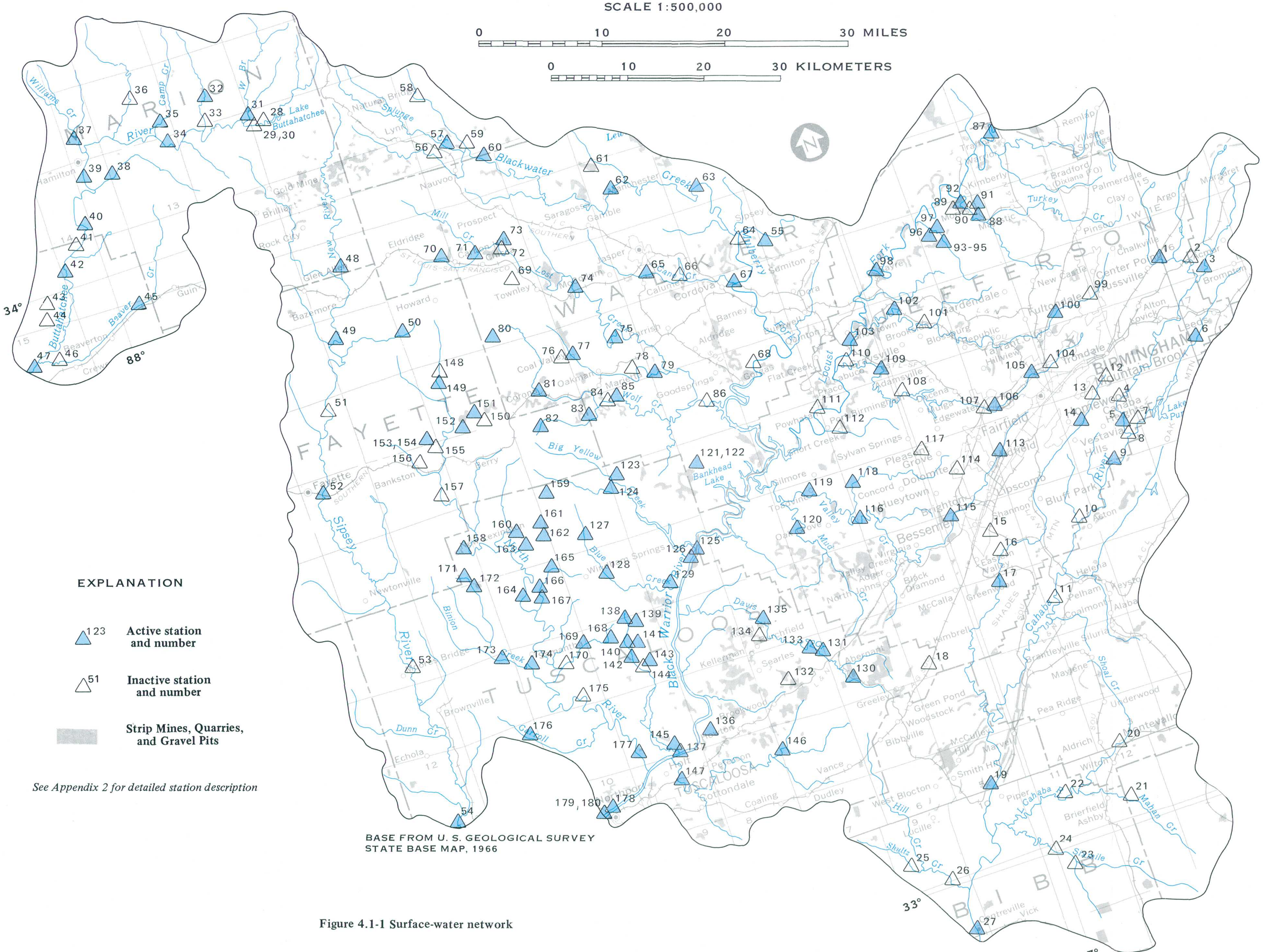


Figure 4.1-1 Surface-water network

Information on Ground Water is Available for 49 Locations

The U.S. Geological Survey ground-water network of 13 monitoring wells in Area 23 was increased in 1977-78 to include 36 additional wells in and near coal-mining areas.

The ground-water network in Area 23 provides the applicant for coal-mining permits with general water-level and ground-water-quality data, as well as aid mine owners and operators, consulting engineers and the Regulatory Authority in determining the impact of coal mining on the ground-water resources of the permit area. The ground-water network, prior to enactment of surface-mining control laws in 1977, was designed to monitor regional fluctuations of water levels. Information on the quality of ground water was derived by sampling selected wells.

Water-level and water-quality information is available for 49 network stations in Area 23. Water-level information has been collected from all network wells either periodically or continuously. Water-quality samples have been collected periodically from some wells and others have only been sampled at time of drilling. The station locations are shown on figure 4.2-1 with their site identification number. Information for each station is given in Appendix 3 as site-identification number, local number, formation tapped, and period of record and frequency of measurement. More information about the type of data, in addition to actual data, are available from computer storage through the National Water Data Exchange (NAWDEX) and in published annual U.S. Geological Survey reports "Water Resources Data for Alabama."

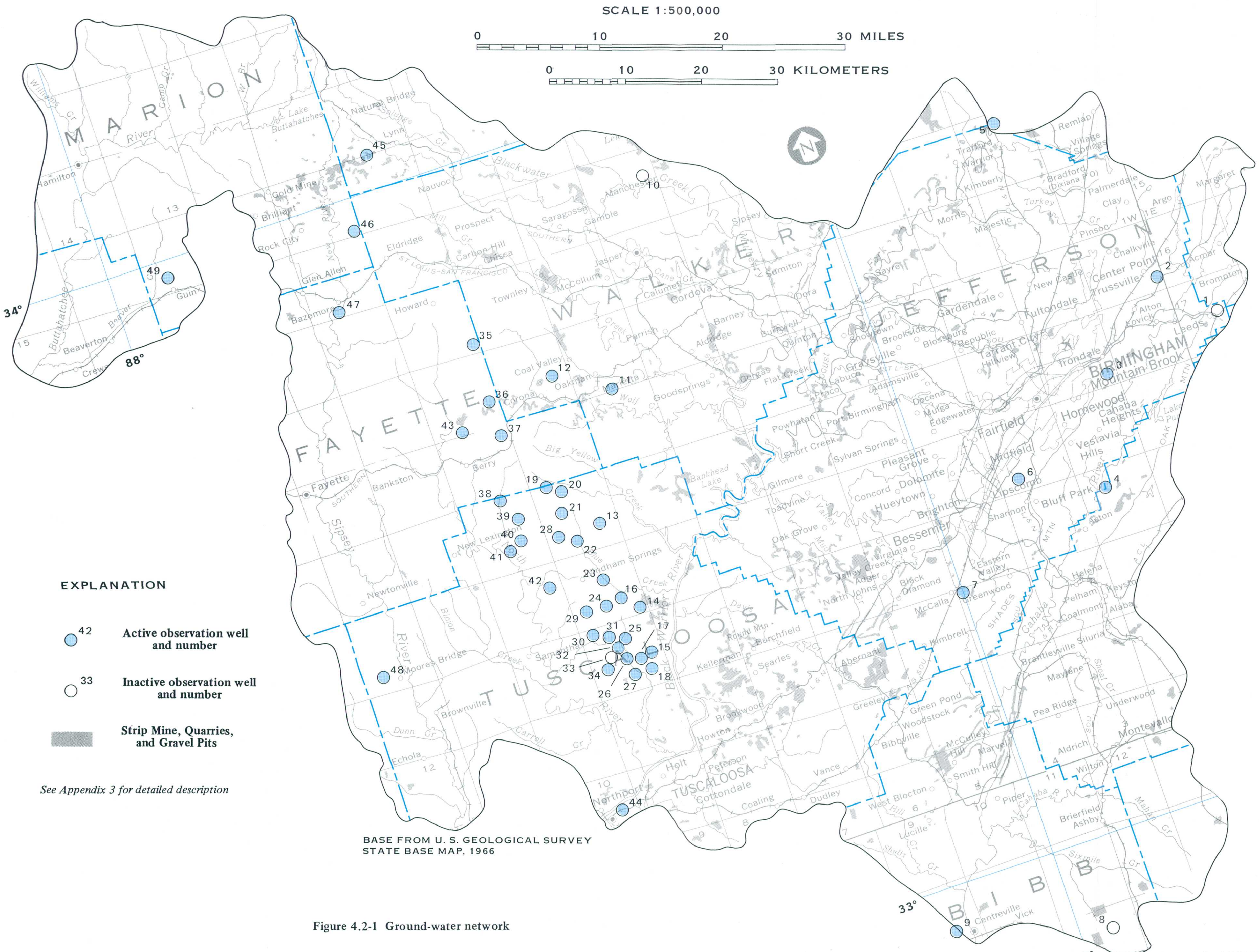


Figure 4.2-1 Ground-water network

Streamflow Varies Seasonally with Rainfall and Evapotranspiration

Variations in streamflow are related to the duration and intensity of rainfall and the seasonal changes in evapotranspiration.

The typical seasonal pattern of streamflow in Area 23 is shown by a typical hydrograph of daily discharge (fig. 5.1-1). This hydrograph was selected because it illustrates all phases of the yearly cycle of streamflow: characteristic low flow of October, the month of lowest average rainfall; increase of flow in November and December as evapotranspiration decreased and the winter rains began; flood season of January to April when heavy general rains fell on wet or saturated soil; recession of flow in May and June as rainfall diminished and evapotranspiration increased; surface runoff and ground-water replenishment by thunderstorm activity in July and early August; and, finally, recession of flow in August and September as rains became less frequent and ground-water outflow becomes the primary source of streamflow.

An outstanding characteristic of streamflow illustrated by the hydrograph is its wide variability above and below the average flow.

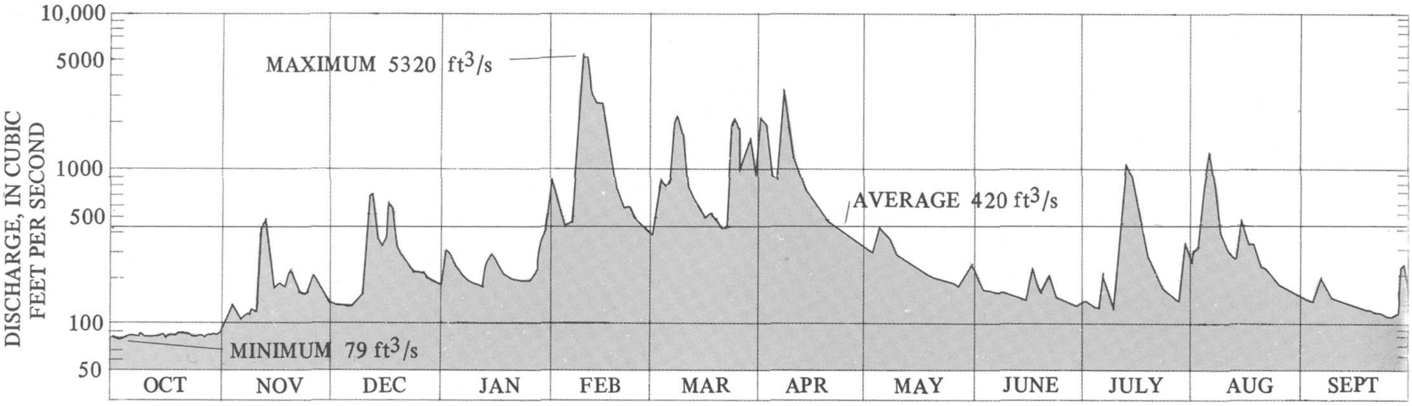


Figure 5.1-1 Typical hydrograph of daily discharge

Aquifers in Area 23 Vary Widely in Their Ability to Store and Release Water to Streams

Aquifers in Area 23 vary widely in their ability to store water and, consequently, in their ability to provide water to streams during periods of no rainfall.

Effective ground-water storage in the Pottsville Formation is small. Thus, discharge of ground water during periods of no rainfall is not sufficient to maintain streamflow and many small streams draining the Pottsville go dry. Conversely the sand and gravel in the Coker Formation contain large quantities of water where the Coker is areally extensive and thick. Streams having small drainage areas draining largely deposits of the Coker have high rates of flow during dry periods. The pre-Pennsylvanian rocks in Area 23 generally contain enough water to maintain high rates of streamflow during dry periods. The contrast in the ability of these aquifers to provide water to maintain dry-period flow in streams is illustrated in figure 5.2-1. The low-flow index number, recession index (Bingham, 1979), shown on the map is related to the rate at which streamflow declines in dry weather.

The index of low flow commonly used is the 7-day Q_2 and 7-day Q_{10}. The 7-day Q_2 is defined as the lowest average rate of flow for 7 consecutive days that occurs at an average interval of 2 years and the 7-day Q_{10} has a recurrence interval of 10 years. The accompanying graphs on figure 5.2-1 show the wide range in the 7-day Q_2 and 7-day Q_{10} and low flow that can be expected to occur in drainage basins of 5 to 2,460 square miles in Area 23. The appropriate graph is selected by determining for the area of interest the low-flow index number, drainage area, and average annual precipitation. The top of the shaded lines on the graphs are used to determine 7-day Q_2 or 7-day Q_{10} for areas with 56 inches of annual precipitation, and the bottom of the shaded lines for areas with 52 inches of annual precipitation. Discharge for drainage basins with intermediate values of annual precipitation can be determined by interpolating in the shaded areas. In the example illustrated for a drainage basin with a low-flow index number of 140, a drainage area of 23 square miles, and annual precipitation of 54 inches, the 7-day Q_2 is 8.5 ft^3/s and the 7-day Q_{10} is 4.2 ft^3/s.

These graphs should not be used to extrapolate beyond the shaded areas nor should they be used for streams where man's activities have substantially affected the flow.

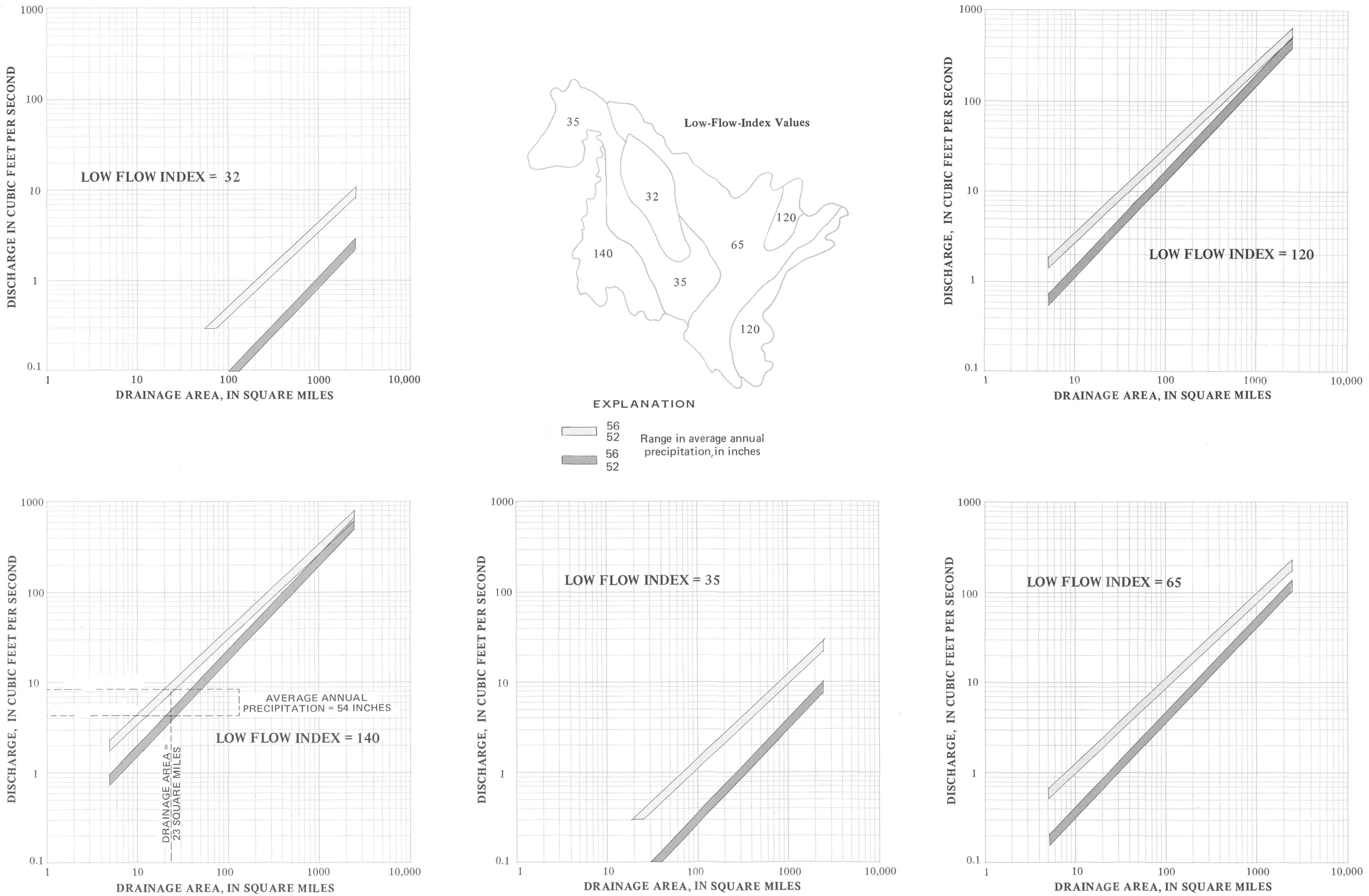


Figure 5.2-1 Relationships between low flow and drainage area

Flooding Chronic in Area 23

Natural conditions and cultural activities contribute to chronic flooding in Area 23.

Chronic flooding as the result of intensive rainfall is a natural characteristic of streams and rivers in Area 23. Floods are influenced by two physiographic factors: those relating to land and those relating to climate. Land factors include elevation, slope, soil composition, drainage pattern, and cultural influences. Climatic factors include seasonal distribution and intensity of storms. The three accompanying hydrographs illustrate the effect of land characteristics on flood flows in response to a storm of unusual intensity which occurred during April 1979.

Narrow flood plains and steep slopes are characteristic of the eastern part of the area. These factors contribute to the rapid accumulation of storm runoff. The flood hydrograph for Valley Creek near Bessemer, Ala. (fig. 5.3-1), shows the rapid change in discharge of a small stream with these basin characteristics.

The western part of the area is characterized by broad flood plains and flat slopes that produce a less rapid accumulation of runoff and a longer duration of flood flow. This is illustrated by the flood hydrograph for Sipsey River near Elrod, Ala. (fig. 5.3-1), which shows a less rapid rise and much less rapid decline than that for Valley Creek.

The flood hydrograph for Black Warrior River at Northport, Ala. (fig. 5.3-1), shows a more rapid rise than that for Sipsey River despite the former's larger contributing area. Tributaries to the Black Warrior River in Area 23 typically have narrow flood plains and relatively steep slopes. Consequently inflow to the river from its tributaries is rapid.

Frequency and seasonal distribution of floods are generally related to climatic factors. Analyses of these characteristics for which data are applicable to Area 23 are contained in reports by Peirce (1954), Gamble (1965), Hains (1973), and Olin and Bingham (1977). Equations for estimating flood frequency for ungaged natural basins of 1 to 15 square miles in Alabama are contained in "Flood Frequency of Small Streams in Alabama" HPR No. 83 (Olin and Bingham, 1977).

Most of the flood damage occurs in valleys of streams and rivers with narrow flood plains and steep slopes due to encroachment on the flood plain by industrial, commercial, and residential developments. Flood plain encroachment is most prevalent in and near Birmingham and Tuscaloosa. Flood damage to farm lands, roads, and bridges occurs in rural areas. Areas where flooding may produce significant damage are referred to as "flood-prone areas." Maps showing flood-prone areas are available for most of Area 23. The maps prepared by the Survey are available from U.S. Geological Survey, P. O. Box V, University, Ala. 35486. Those prepared for the Alabama Office of State Planning and Federal Programs are available from Alabama State Planning Division, State Capitol, Montgomery, Ala. 36130. Available maps are shown in figure 5.3-2.

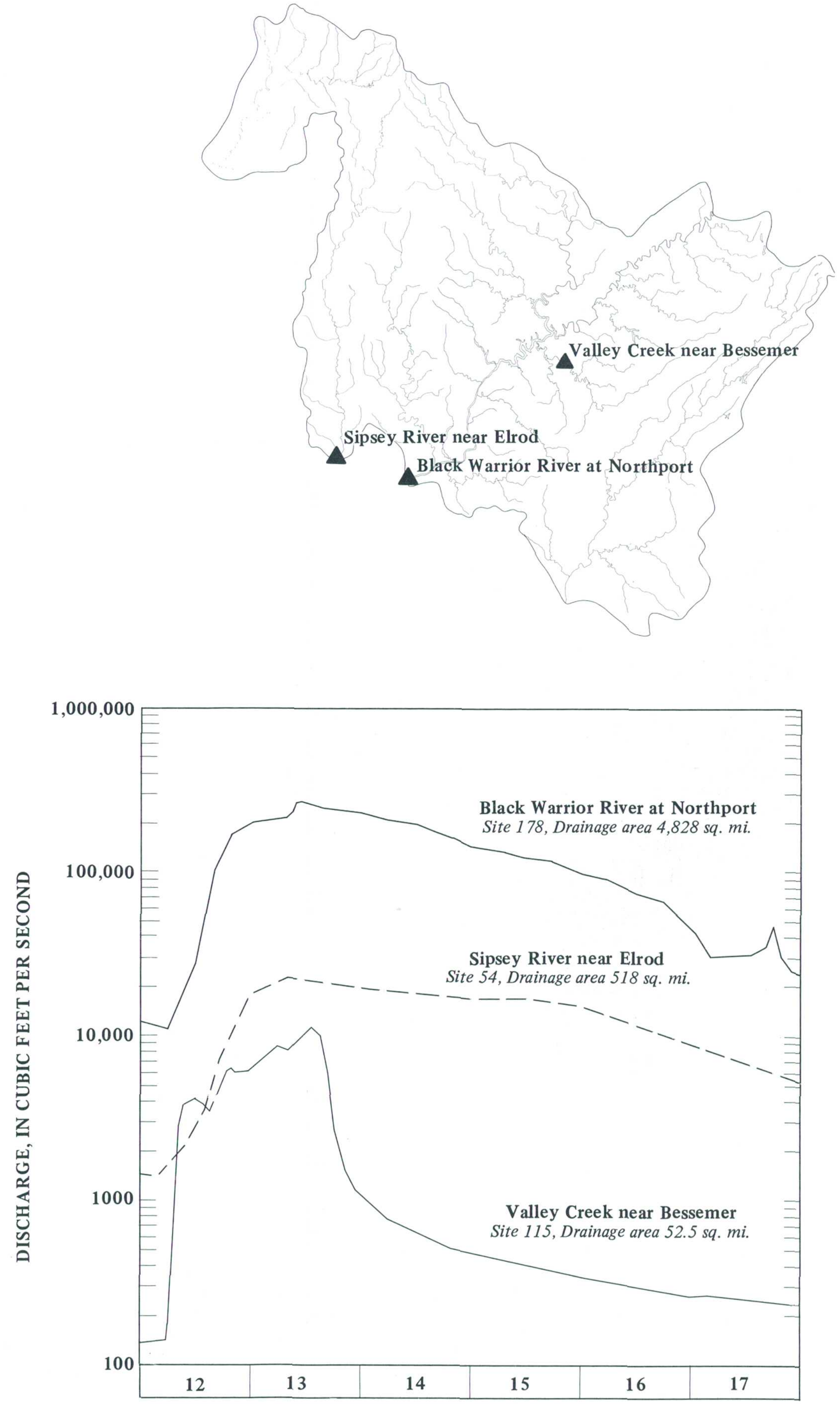


Figure 5.3-1 Flood hydrographs, April 12 to 17, 1979

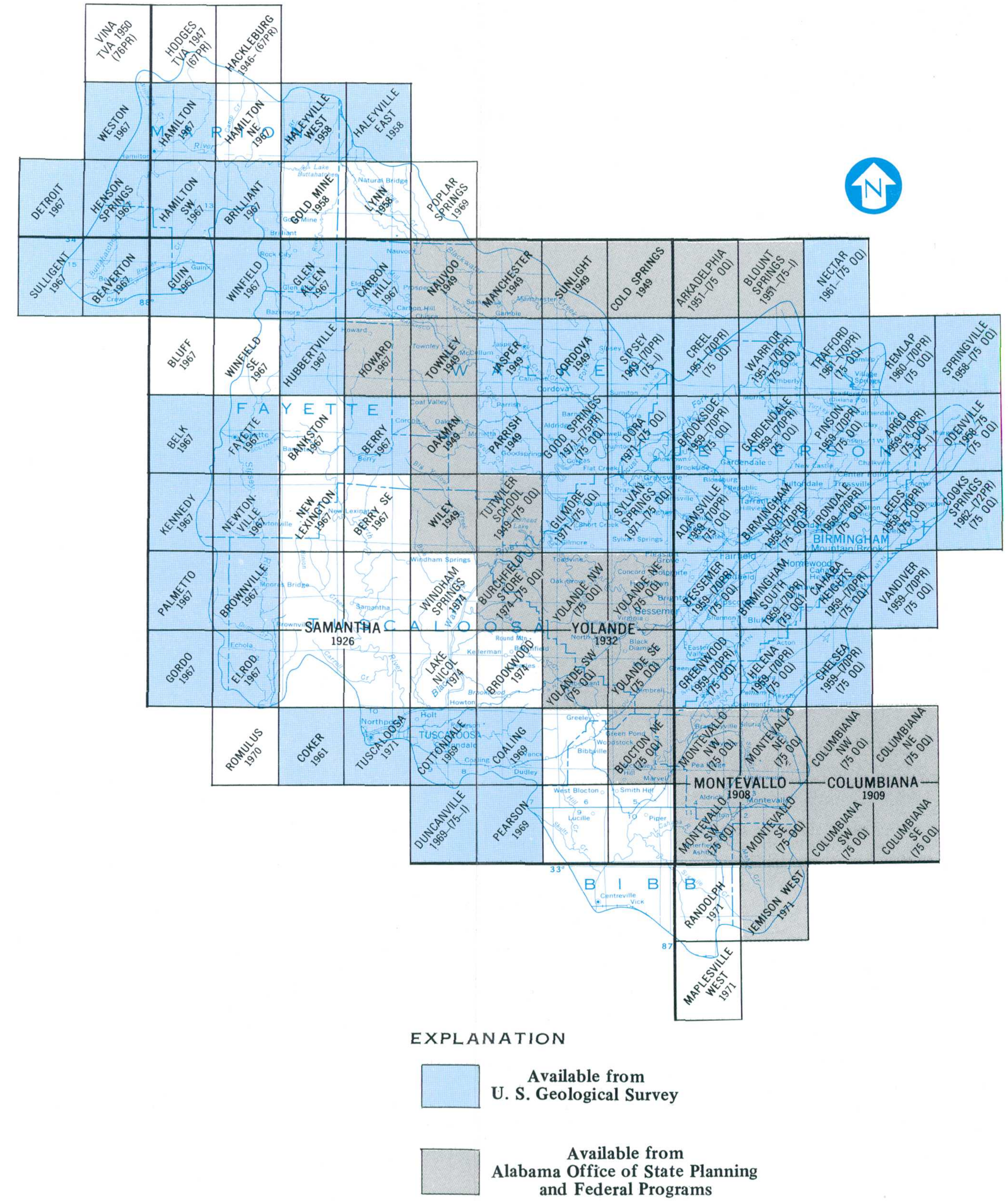


Figure 5.3-2 Maps of flood-prone areas

Streams Draining Outcrop Areas of Pottsville Are Poorly Sustained

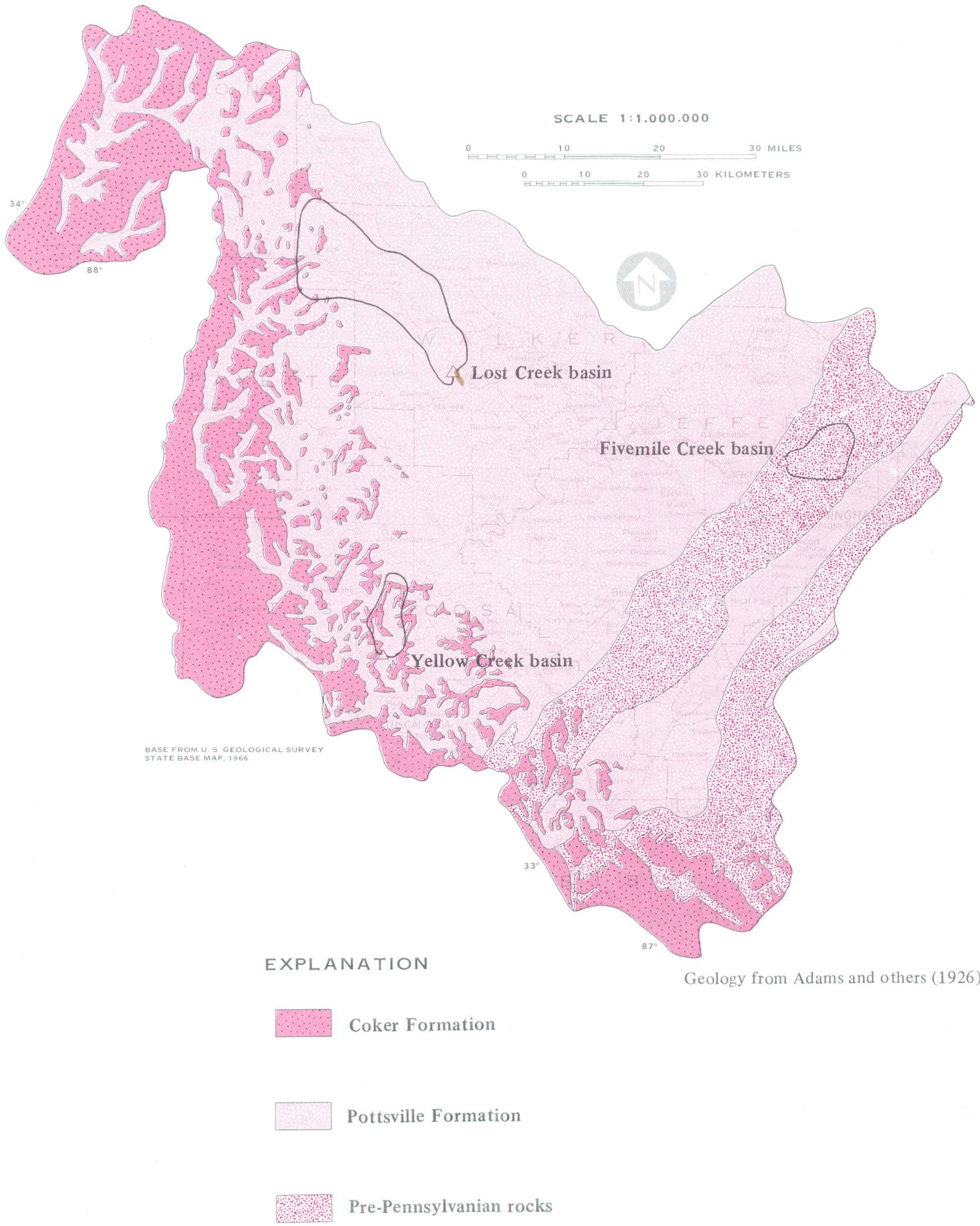
Streams draining outcrop areas of the Pottsville Formation are poorly sustained in comparison with those draining areas of outcrop of the Coker Formation and pre-Pennsylvanian rocks.

Differences in dry-weather streamflows are illustrated by the flow-duration curves on figure 5.4-1. These curves, based on the period of record at a site, show the percentage of time that a specific discharge can be expected to be equaled or exceeded. For example, a discharge of about .08 $(ft^3/s)/mi^2$ at Yellow Creek near Tuscaloosa (see fig. 5.4-1) is expected to be equaled or exceeded about 50 percent of the time.

Hydrologic and geologic characteristics of a drainage basin are generally the major factors that determine the shape of the flow-duration curve. A curve with a steep slope throughout denotes highly variable streamflow that is mainly from direct surface runoff, whereas a curve with a flat slope indicates streamflow that is from delayed surface runoff and ground-water storage. A flat slope at the lower end of the curve indicates sustained base flow, whereas a steep slope indicates a negligible base flow (Searcy, 1959).

Three major geologic units cropping out in the area are undifferentiated pre-Pennsylvanian rocks, the Pottsville Formation, and the Coker Formation (see fig. 5.4-1). The Pottsville Formation consists of relatively impermeable shale, siltstone, and sandstone. In contrast, the Coker Formation contains permeable beds of sand and gravel and the pre-Pennsylvanian rocks consist largely of permeable limestone and dolomite. Because of their permeability, strata in the Coker Formation and pre-Pennsylvanian rocks will store and yield large quantities of base flow to streams in dry weather, whereas relatively impermeable strata in the Pottsville Formation will not.

Permeability and resulting streamflow variations are reflected by the shape of flow-duration curves for representative sites in each geologic environment. The curves are nearly parallel in the high-discharge range, but contrast greatly in the lower range. Flat slopes at the lower ends of the curves reflect the contribution of base flow from the permeable rocks. The steep slope of the curve for Lost Creek near Oakman indicates highly variable streamflow that is mainly from surface runoff and lack of base flow contributed by the relatively impermeable rocks of the Pottsville Formation. The curves for Yellow Creek near Tuscaloosa and Fivemile Creek at Ketona indicate streamflow from surface runoff and base flow from ground-water storage in the Coker Formation and the pre-Pennsylvanian rocks.



Geology from Adams and others (1926)

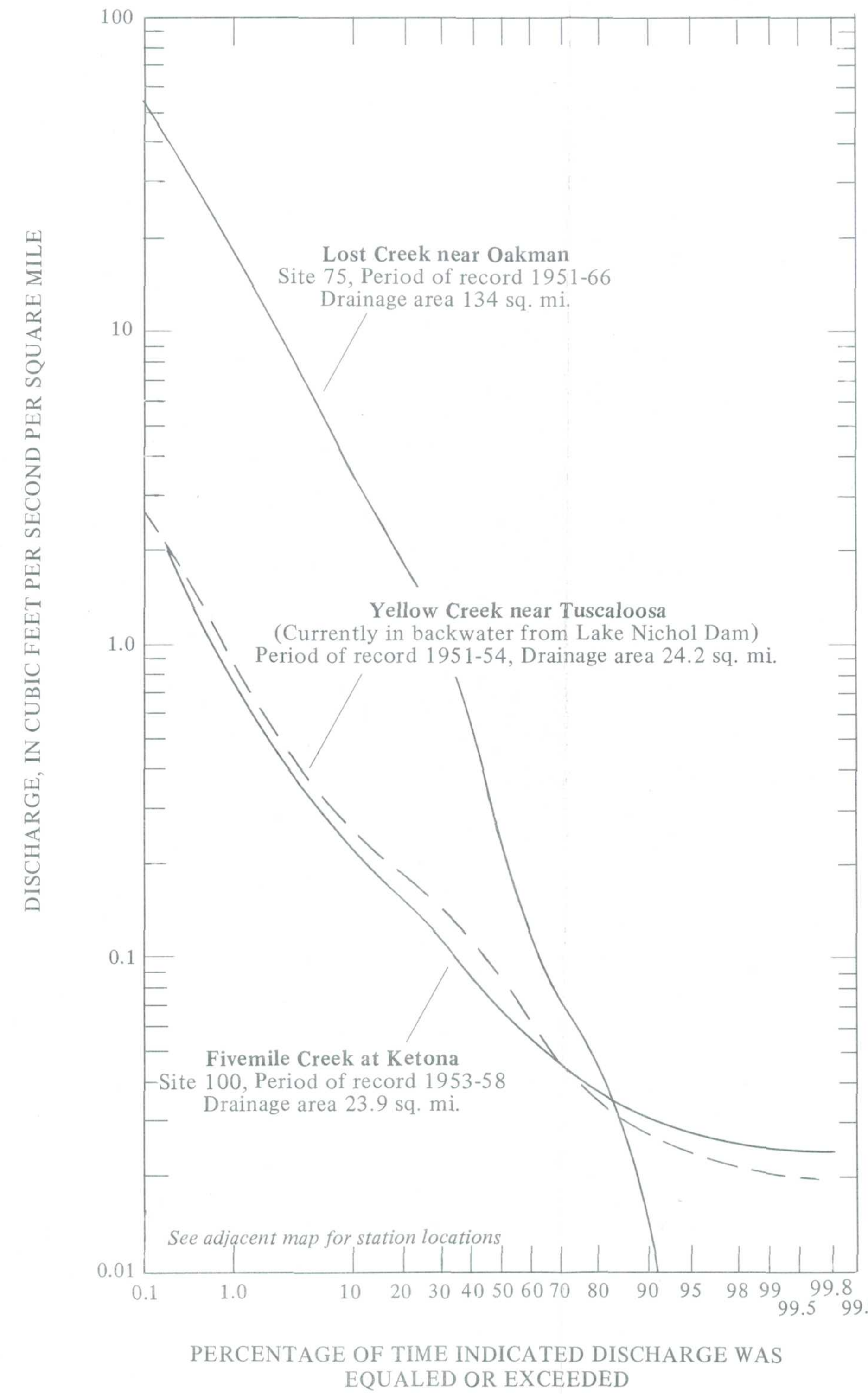


Figure 5.4-1 Representative flow-duration curves

Time-of-Travel Data Used to Estimate Transport of Soluble Material

Data for time of travel can be used to estimate the arrival and time of passage of a solute between selected points.

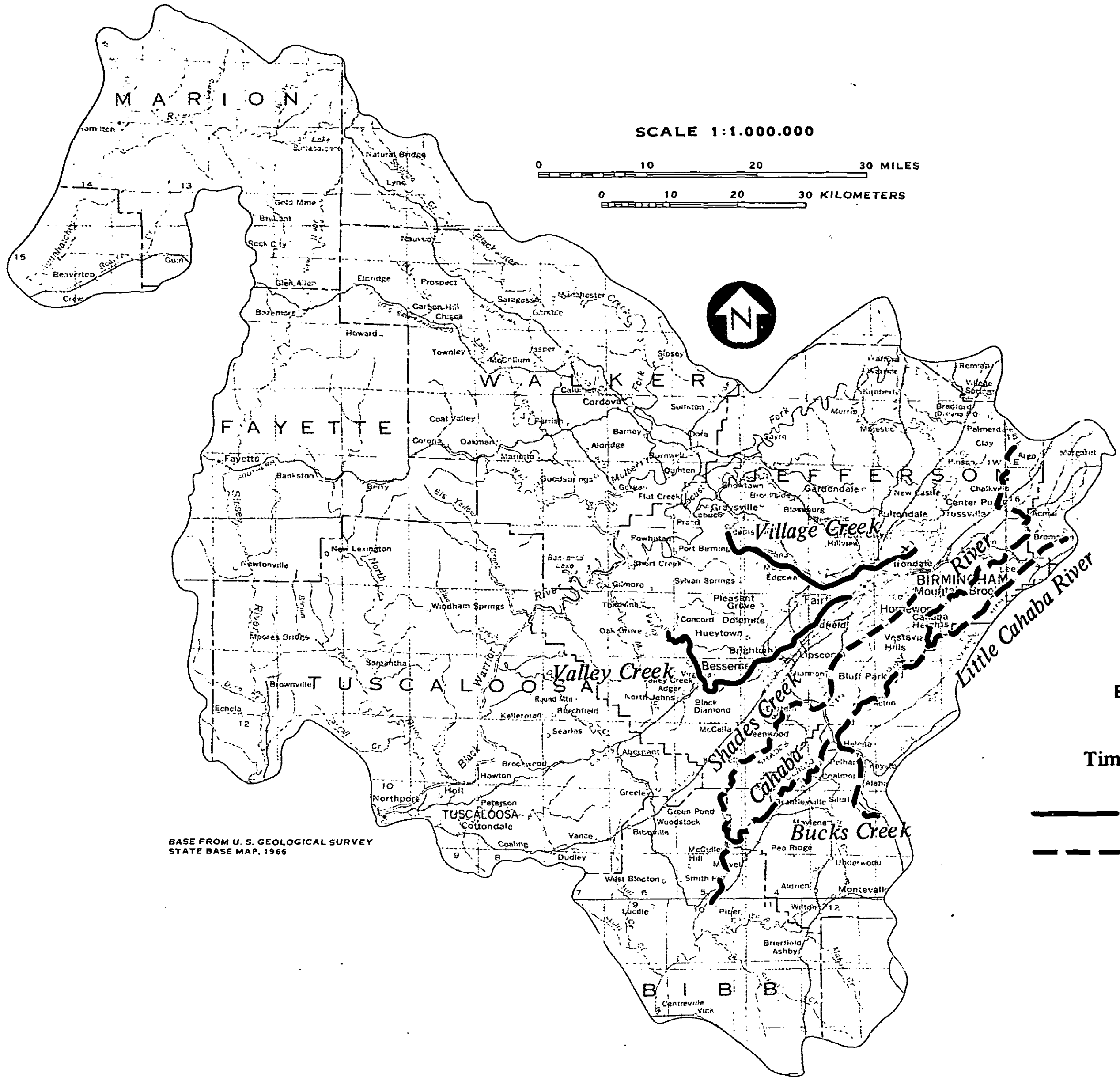
Measurements of time of travel, dispersion, and concentration of tracers can give insight to the transport of soluble contaminates that may enter a stream. Accurate data for time of travel are needed to estimate the arrival and time of passage of a solute.

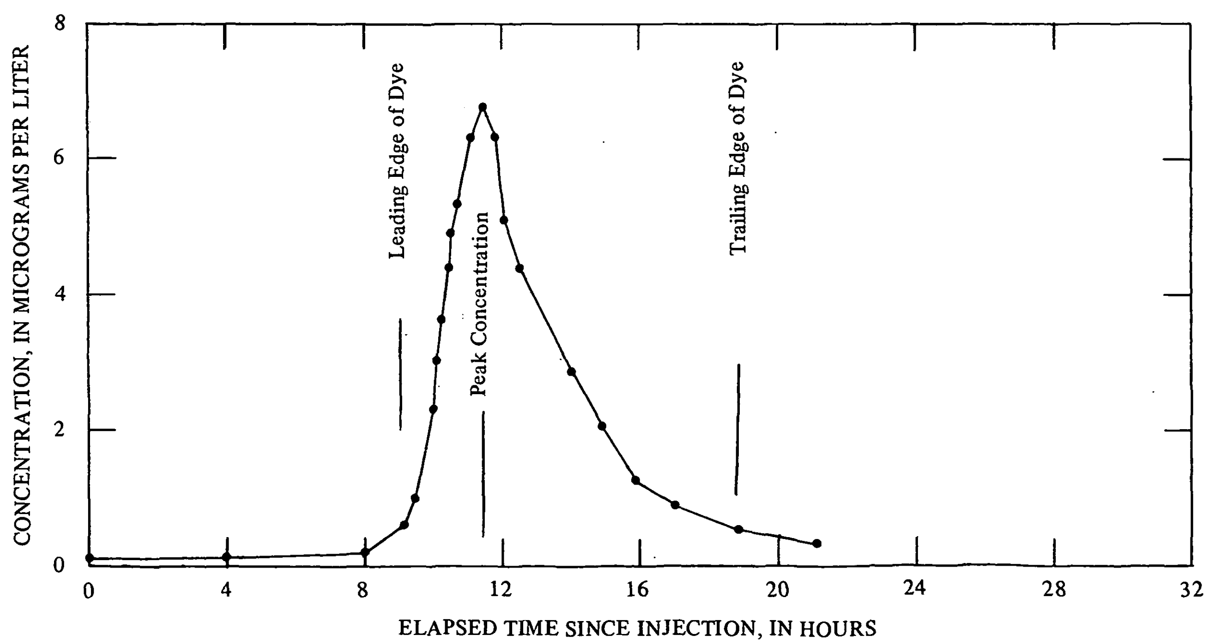
Segments of streams for which time-of-travel data are available in the area are shown on figure 5.5-1. The streams, all located in the eastern one-third of the area, are Valley, Village, Bucks, and Shades Creeks, and Little Cahaba and Cahaba Rivers. The segments of these streams for which data are available are primarily restricted to urban or industrial areas. Headwaters of these streams originate in urban areas, generally flow through industrial areas, and enter rural areas in their downstream reaches.

The curves show the time of travel for Valley Creek during low- and medium-flow conditions for a single-dye injection. The traveltimes of leading edge, peak concentration or centroid, and trailing edge of the tracer cloud are given so that the length of the tracer cloud at any given time and the time required for the tracer cloud to pass a given site may be readily determined. A time-concentration curve is also shown for one data-collection point during medium flow. The curve illustrates the leading edge, peak concentration, and trailing edge of the dye cloud.

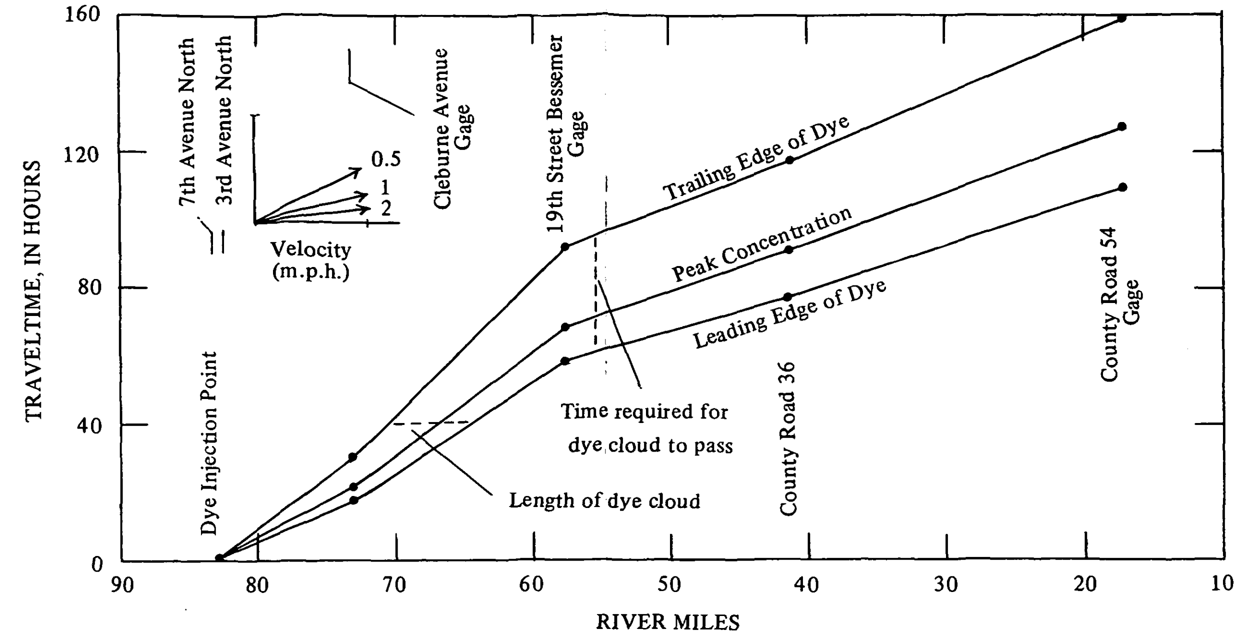
Data-collection and analysis methods used in the Valley and Village Creeks time-of-travel studies followed the standard techniques utilized in water-resources investigations of the U.S. Geological Survey (Wilson, 1968; Kilpatrick and others, written commun., 1970).

Available data for time of travel were collected by two agencies. Data for Valley and Village Creeks were collected by the U. S. Geological Survey, and data collected on Shades and Bucks Creeks and Little Cahaba and Cahaba Rivers were collected by Barton Laboratory. These data are available from U. S. Geological Survey, P. O. Box V, University, Ala. 35486, and Jefferson County, Barton Laboratories, 1290 Oak Grove Road, Homewood, Ala. 35209.

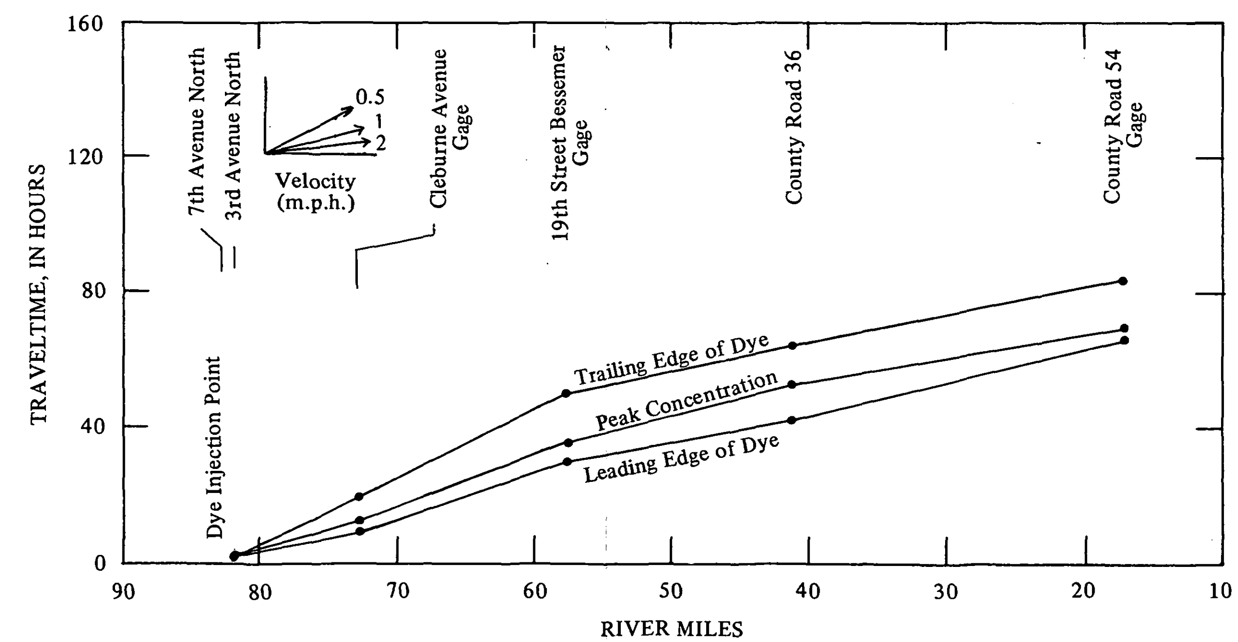




Time-concentration curve for Valley Creek at Cleburne Avenue



Traveltime-distance curves for a single-dye injection at low flow conditions, Valley Creek



Traveltime-distance curves for a single-dye injection at medium flow conditions, Valley Creek

Figure 5.5-1 Time-of-travel studies

Specific Conductance of Water is High in Coal-Mine and Industrialized Areas

Mineralization of surface water resulting from coal-mining and industrial activity is reflected by high specific conductance

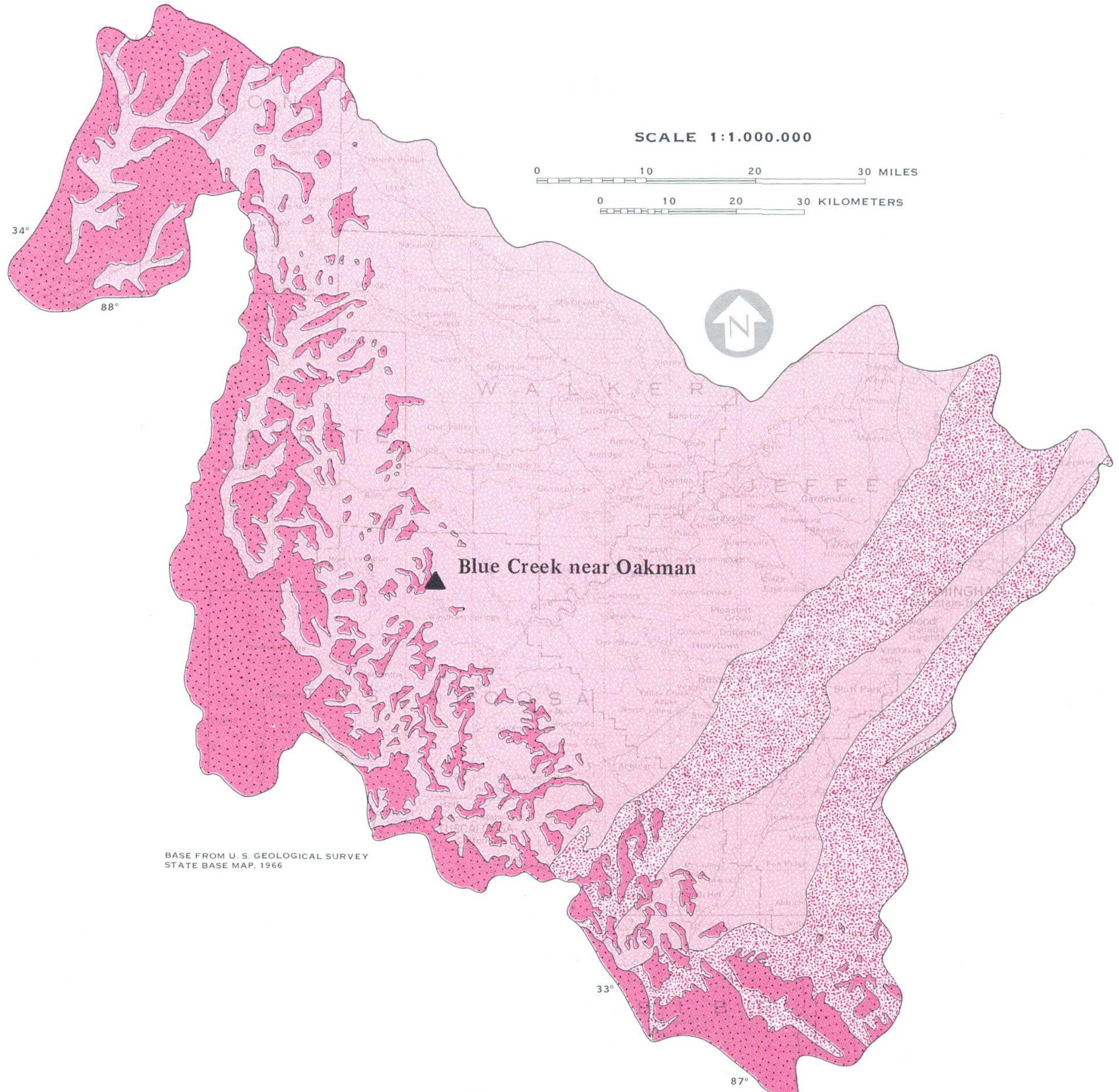
Specific conductance of surface water in Area 23 usually is low, except locally in areas of industrialization and coal mining. Larger streams in and near the city of Birmingham and surrounding communities typically have higher specific conductances that reflect industrial-waste discharges. In other areas, higher specific conductance generally indicates coal-mine drainage.

Specific conductance of water is a measure of the ability of water to transmit an electric current and is usually expressed in micromhos per centimeter at 25°C. Because it is directly related to dissolved-solids content, it serves as an indicator of the degree of mineralization in water and commonly is used to estimate specific ion concentrations.

Dissolved-solids content of water in streams usually is derived from soluble-mineral salts in soil and geologic strata underlying the basin. Figure 6.1-1 shows the range of specific conductance generally observed in streams draining relatively undisturbed basins in the area. It also shows factors that, when multiplied by specific conductance, provide an estimate of dissolved-solids concentration in milligrams per liter. Factors shown were determined in a previous investigation (Cherry, 1963). Water in streams draining the Coker and Pottsville Formations (fig. 6.1-1) are very low in mineral content, reflecting the relatively insoluble strata (unconsolidated sand and gravel and indurated sandstone and shale) underlying them. Higher mineral content of water in streams draining the pre-Pennsylvanian rocks is due to the higher solubility of carbonate strata (limestone and dolomite) that underlies the area.

Accelerated weathering of pyritic minerals present in spoil in coal-mine areas results in production of sulfuric acid and large quantities of soluble-mineral salts that are contributed to streamflow draining mined areas. The acidic water reacts with other minerals and produces water with high dissolved-solids concentrations. Specific conductance observed in streams draining coal mine areas in Area 23 generally ranged from 30 to 3000 micromhos. In general highly mineralized water draining mined areas is local and usually decreases in downstream areas because of dilution by receiving streams.

Specific conductance of water draining mined areas is highly variable and depends on such factors as: (1) the presence of reactive minerals in spoil material, (2) the length of time of exposure of these minerals to weathering by air and water, and (3) the quantity of water leaving the mined area. For instance, the specific conductance in Blue Creek near Oakman (fig. 6.1-2) during low flow (less than 1.0 ft^3/s) increased from 58 micromhos in November 1976 to 956 micromhos in June 1979. The increase shows the effect of continuing exposure of minerals to weathering on specific conductance in streams draining mined areas. Relations between specific conductance and stream discharge draining undisturbed basins in the area are illustrated on figure 6.1-3. The relations may be used for estimating specific conductance in streams draining unmined basins in the study area. Specific conductance is generally higher during low-flow periods because of prolonged water contact with soluble minerals in soils, and rocks. During high-flow periods specific conductance is generally lower because of the shorter contact time with soluble minerals and dilution.



EXPLANATION

Specific Conductance *In micromhos per centimeter at 25° Celsius*	Geologic Formation	Factor applied to specific conductance for estimating dissolved-solids concentrations *In milligrams per liter*
10 - 30	Coker Formation	0.90
20 - 120	Pottsville Formation	0.68
80 - 350	Pre-Pennsylvanian rocks	0.60

Figure 6.1-1 Specific conductance in streams draining undisturbed areas

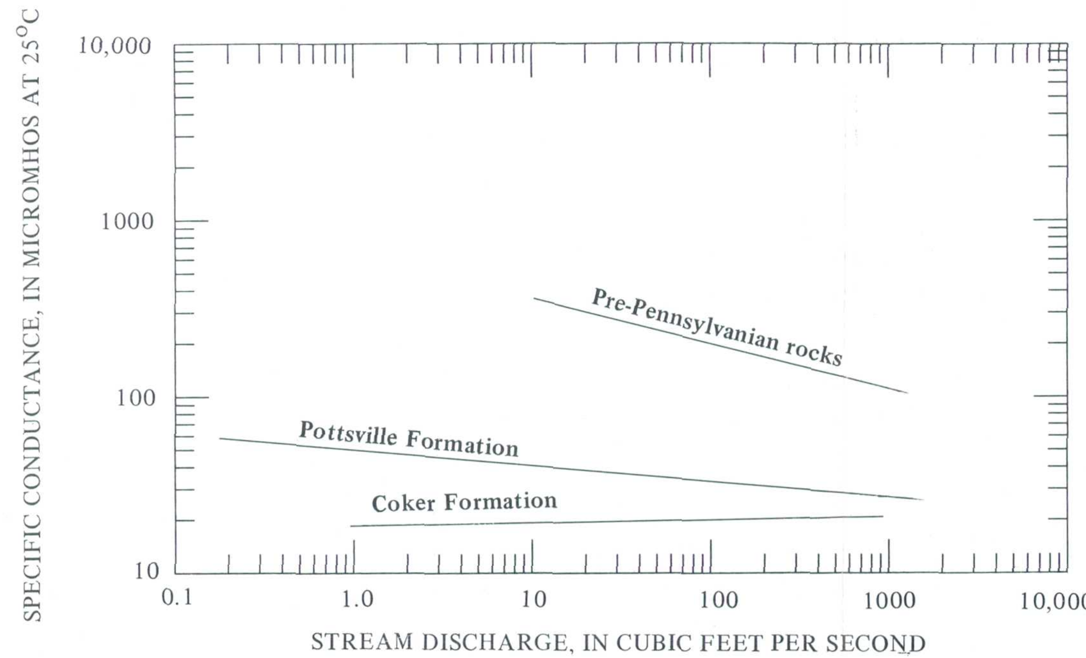


Figure 6.1-3 Relationship between stream discharge and specific conductance in undisturbed basins

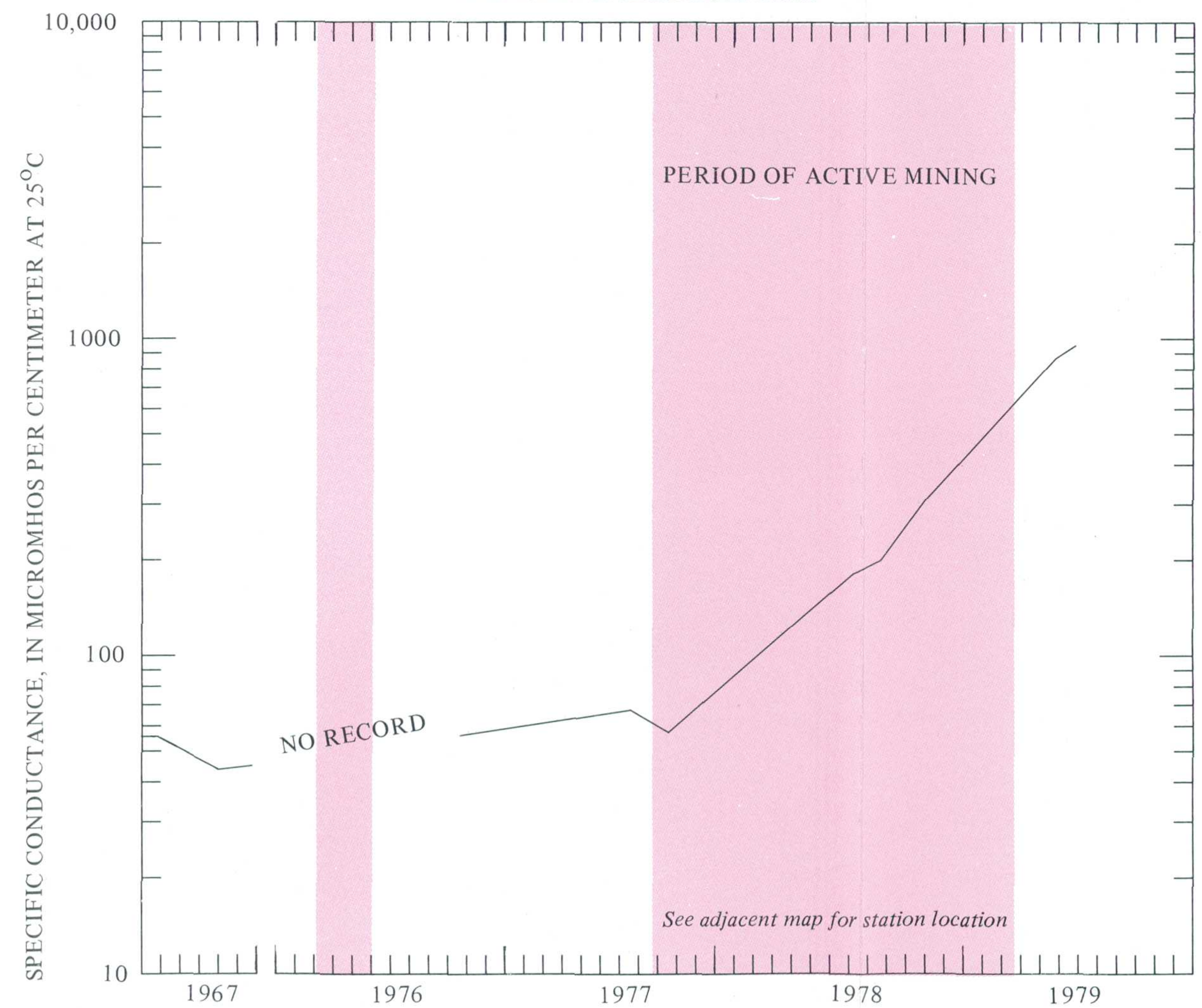


Figure 6.1-2 Specific conductance in Blue Creek near Oakman, Ala. (site 127) during low flow

pH of Streamflow Usually in Near-Neutral Range

The pH of water in streams usually fluctuates in the near-neutral range (6.0-8.0) and generally is not lowered by surface coal-mining operations.

Acidity of water generally is expressed in pH units. A pH value of 7.0 represents neutral water. Values less than 7.0 denote acidic water and values greater than 7.0 denote alkaline water. Natural acidity usually is caused by the presence of dissolved carbon-dioxide and/or hydrolysis of salts of weak acids and strong bases. Sources of these substances include rainfall, weathered geologic strata, and organic matter in soils.

The range of pH values generally observed in streams draining relatively undisturbed basins is shown on figure 6.2-1. Although the pH of water in streams varies widely, pH is usually in the near-neutral range (6.0-8.0). The highest pH values generally occur in streams primarily underlain by carbonate strata such as limestone and dolomite of the pre-Pennsylvanian rocks, figure 6.2-1; water in these streams usually is alkaline with a high neutralization capacity. The lowest pH values generally occur in streams underlain by unconsolidated sand and gravel strata of the Coker Formation; water in these streams usually is acidic with a low neutralization capacity. Near-neutral pH values generally occur in streams in the Pottsville Formation, an area primarily underlain by sandstone and shale strata.

The acidity of water draining coal-mine areas is affected dramatically by the chemical character of spoil. In some areas, weathering of pyrite and other iron-bearing minerals in the spoil results in the production of sulfuric acid. Acid-mine drainage may have pH values that range from 2.0 to 5.0. In other areas, calcareous minerals such as siderite, calcite, and ankarite commonly occur in large quantities in spoil. In these areas, acidic mine drainage is neutralized rapidly and frequently is near neutral or alkaline (pH greater than 8.0). For example, the low pH of water in a tributary draining a subsurface mine in Cane Creek basin near Oakman (fig. 6.2-2) is quickly neutralized by highly alkaline mine drainage in Shelton Branch. The pH of water in streams draining much of the study area generally is near neutral or higher in mined areas than the pH of the water in unmined areas.

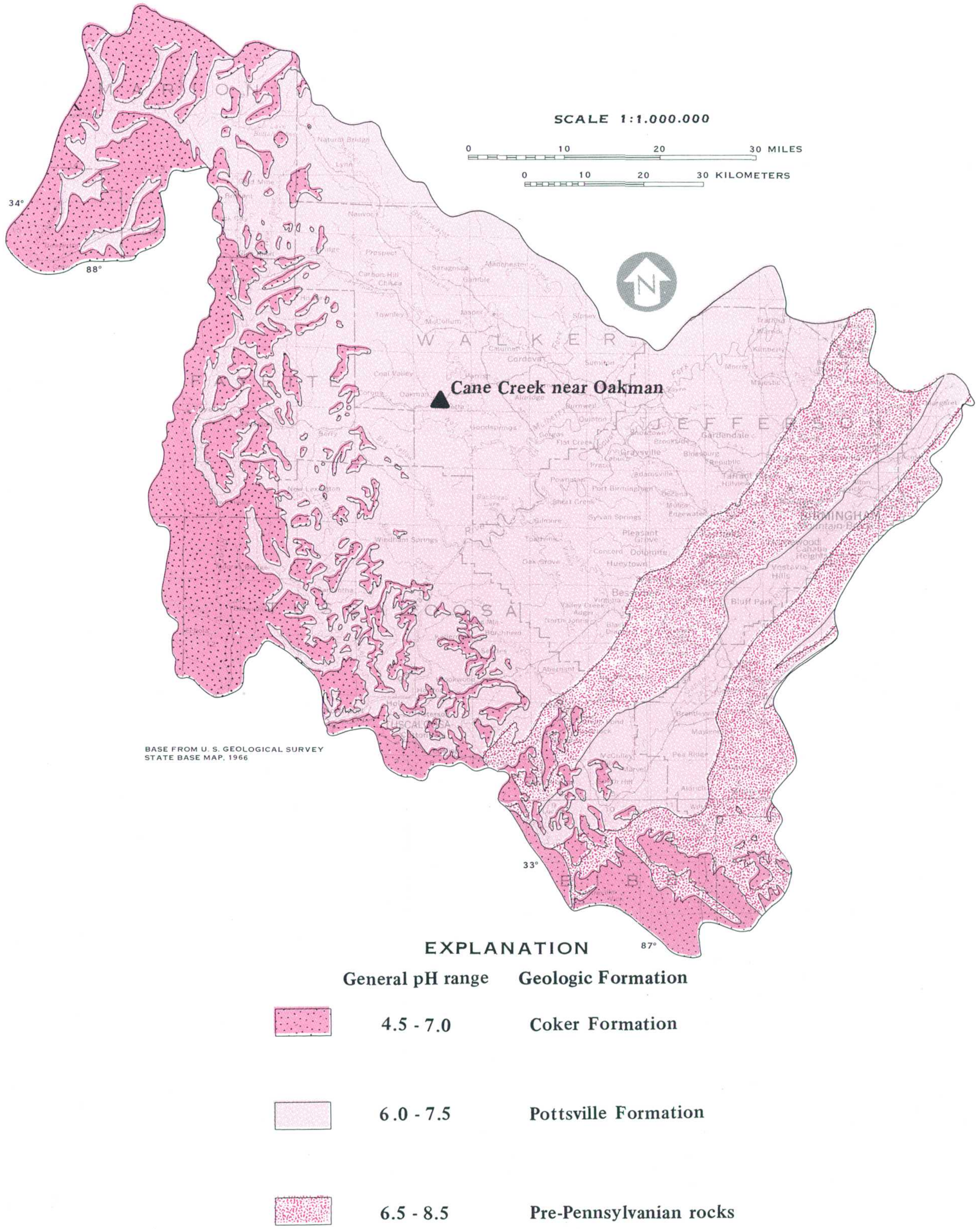


Figure 6.2-1 pH in streams draining undisturbed basins

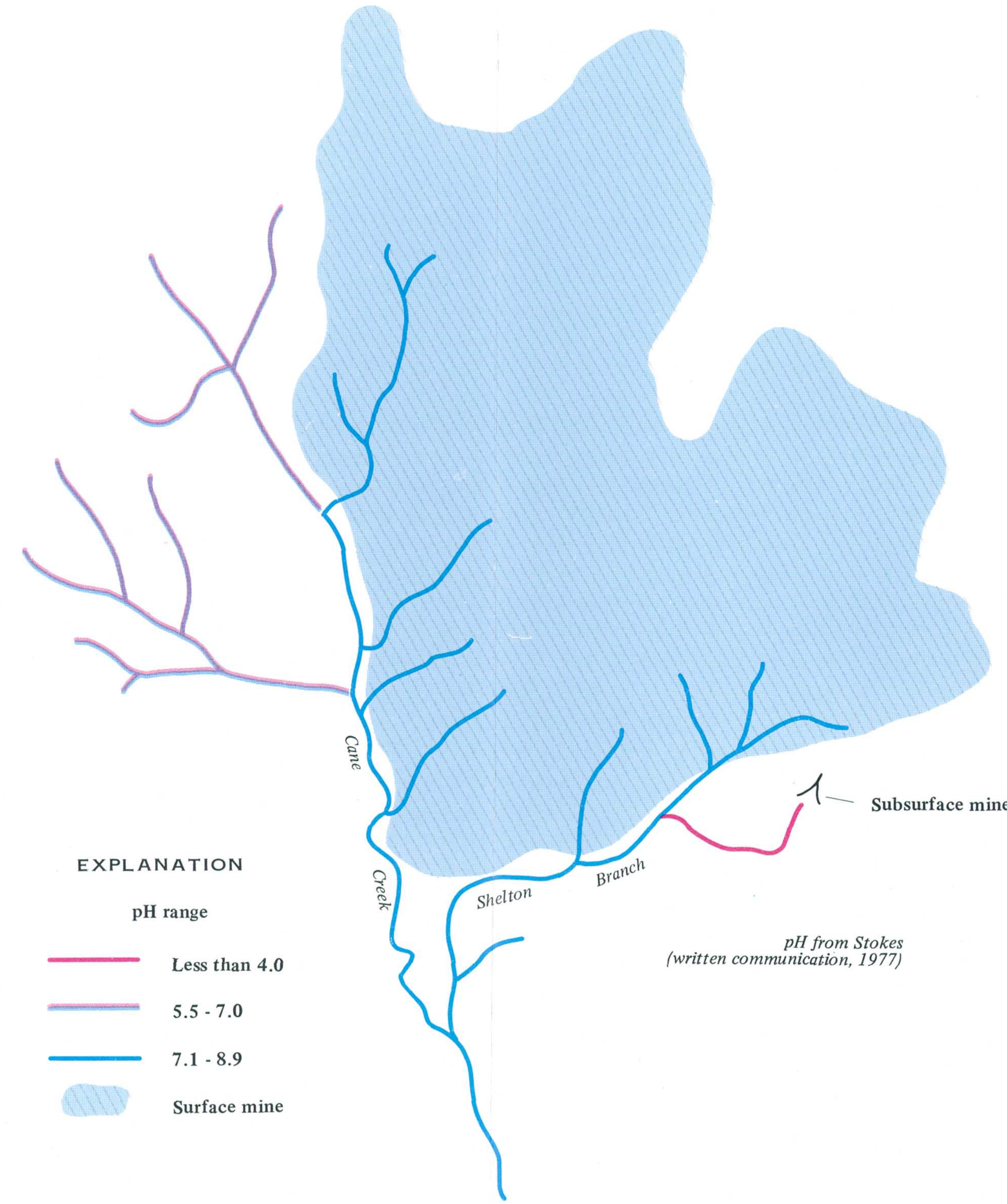


Figure 6.2-2 pH of streams from mined and unmined areas in Cane Creek basin near Oakman

Sediment Yields Generally High in Surface-Mined Areas

Sediment yields resulting from surface mining can be high locally; however, high yields generally are of short duration.

Sediment yields of streams are affected by numerous factors including physiography, soils, climate, and land use. Land-use activities such as forest clearing, cultivation, road construction, and surface mining drastically alter natural erosion and sediment yields. During surface mining, large volumes of exposed unconsolidated spoil may be a major source of sediment.

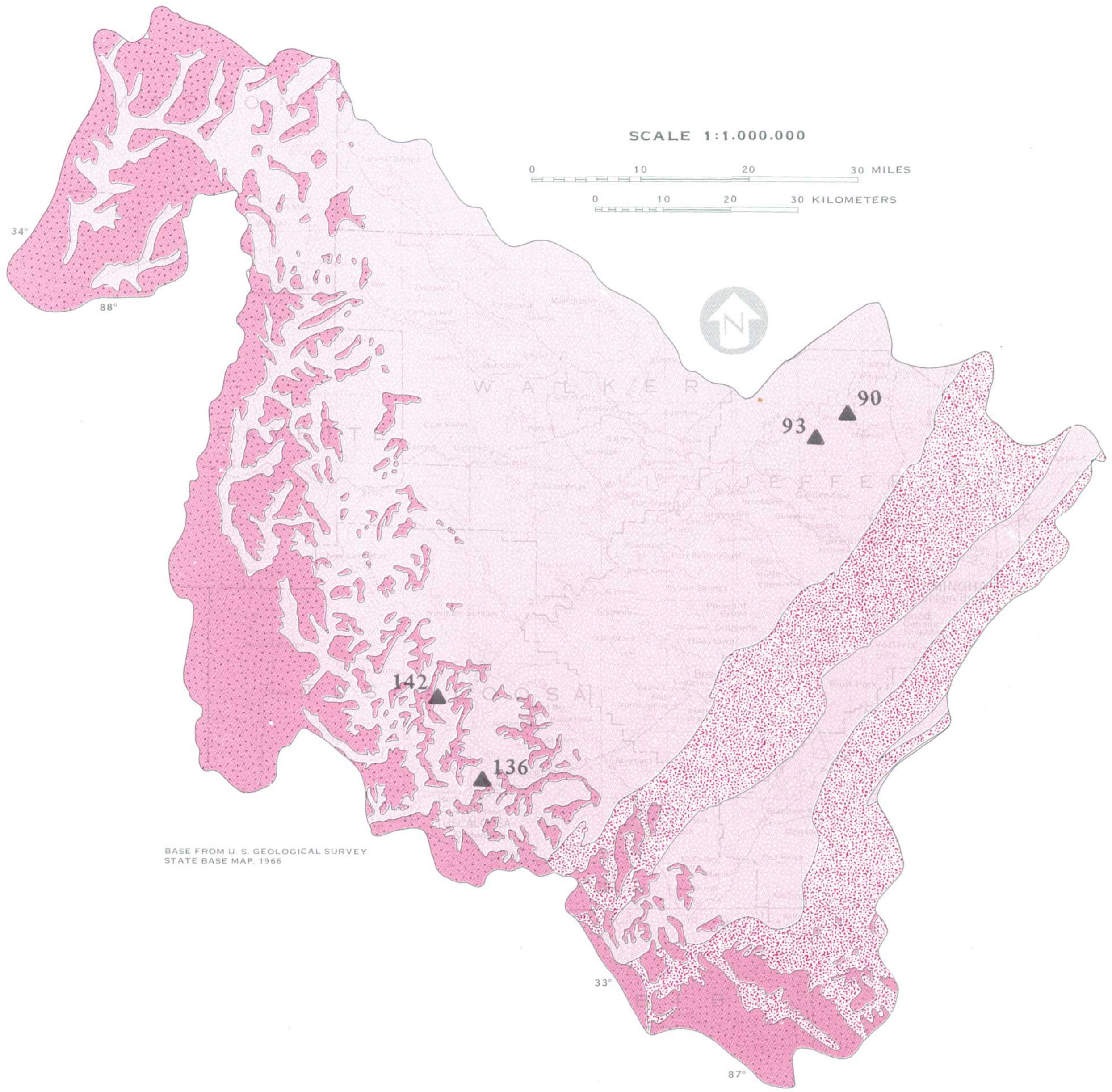
Average annual sediment yields for streams draining unmined and relatively undisturbed basins in Area 23 generally range from 20 to 800 (tons/mi^2)/yr. In contrast, annual sediment yields for streams draining mined basins generally range from 1,000 to 300,000 (tons/mi^2)/yr. Suspended-sediment concentrations and sediment yields increase as a result of surface mining and may be a problem locally. Yield increases are generally of short duration as a result of reclamation. Sediment concentrations are generally lowered by dilution by larger receiving streams. The lowest suspended-sediment concentrations usually occur during low flow and the highest during high flow.

Suspended-sediment concentration ranges, estimated average annual sediment yields, and sediment-yield curves for selected sites in the area are shown in figure 6.3-1. Sites 90 and 93 drain mined and unmined basins, respectively, and are located in an area primarily underlain by shale, siltstone, and fine-grained sandstone in the Pottsville Formation. Sites 136 and 142 drain mined and unmined basins, respectively, and are underlain by similar strata in the Pottsville and by unconsolidated sand and gravel in the Coker Formation. The suspended-sediment concentrations, sediment yields, and yield curves in figure 6.3-1 show large increases in sediment production that have resulted from surface mining. Average annual sediment yield at site 90 is about 19 times greater than at site 93 and 180 times greater than at site 142.

Particle-size distribution of suspended sediment transported during high flows at sites 90 and 93 was predominantly in the clay and silt size range (finer than 0.062 mm), while that at sites 136 and 142 was about 50 percent clay and silt and 50 percent sand. Particle-size distribution at sites 90 and 93 reflects the dominant rock types in the Pottsville Formation and that at sites 136 and 142 reflects the dominant rock types in the Coker Formation.

Bed-material size composition for streams in the Pottsville area averaged 0 percent for clay and silt, 20 percent for sand (0.06-2.0 mm), and 80 percent for gravel (2.0-6.4 mm). Bed-material size composition for streams draining Coker areas average 0 percent for clay and silt, 80 percent for sand, and 20 percent for gravel.

Bedload, the sediment transported along and immediately adjacent to the streambed, is unmeasured and not included in reported sediment yields.



EXPLANATION

Geologic Formation

- Coker Formation
- Pottsville Formation
- Pre-Pennsylvanian rocks

▲ Gaging station and number

	90	93	136	142
Period of record	1976-77	1975-76	1977	1977-79
Suspended-sediment concentration range, in milligrams per liter	1-44,500	1-1,320	1-54,300	1-1,600
Estimated average annual sediment yield, in tons per square mile per year	14,600	770	---	80
Drainage area, in square miles	0.50	11.6	0.11	8.23
Percent of basin mined	23	Unmined	40	Unmined

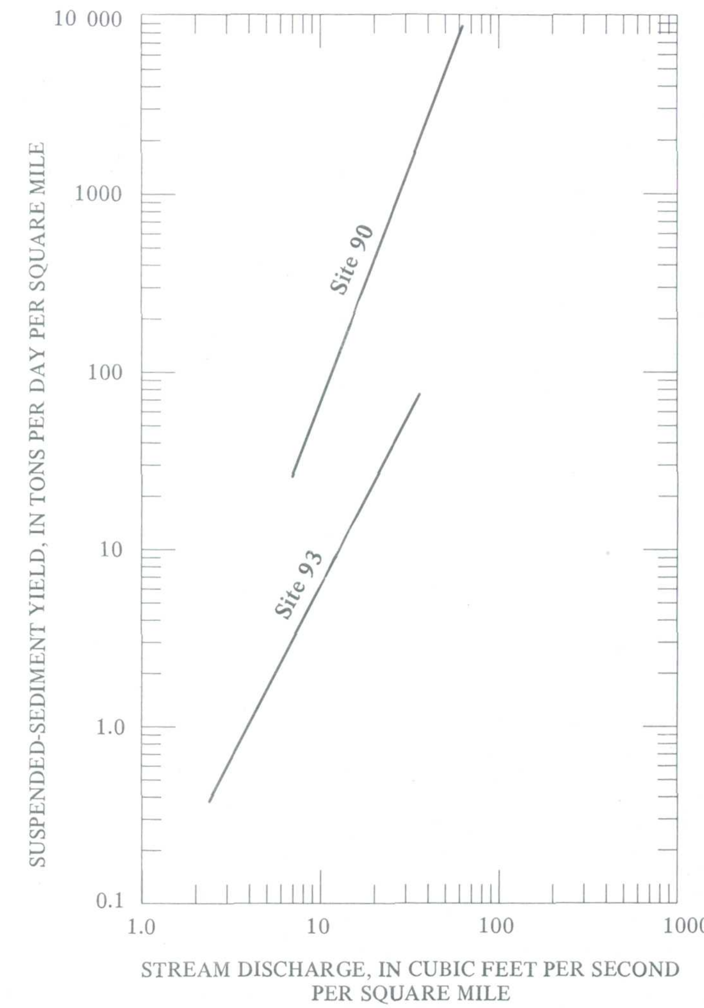
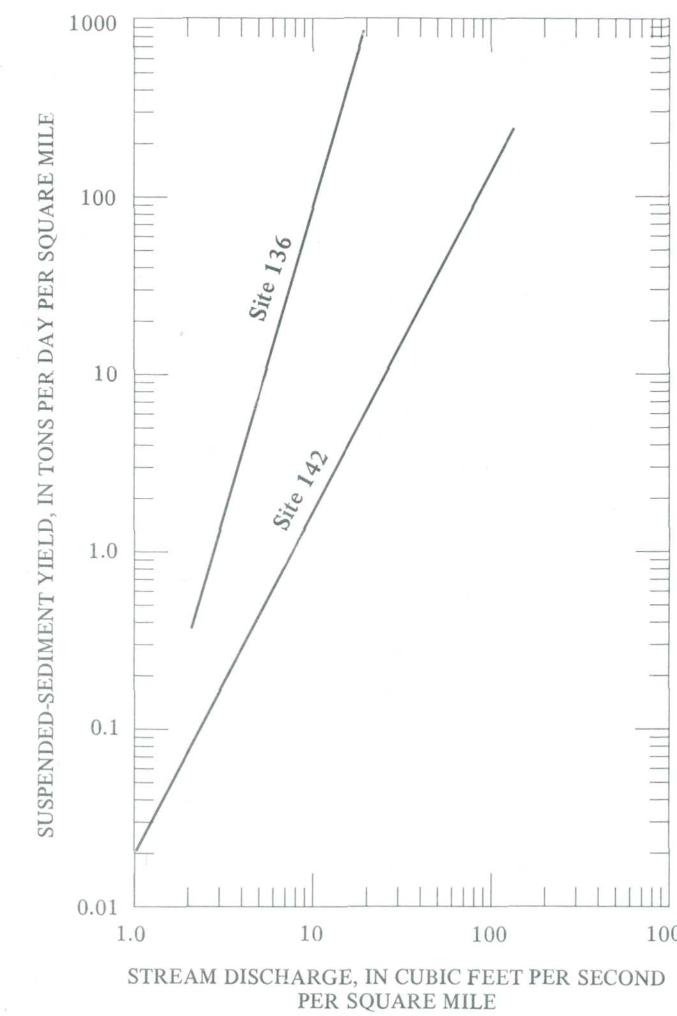


Figure 6.3-1 Relationship between stream discharge and suspended sediment



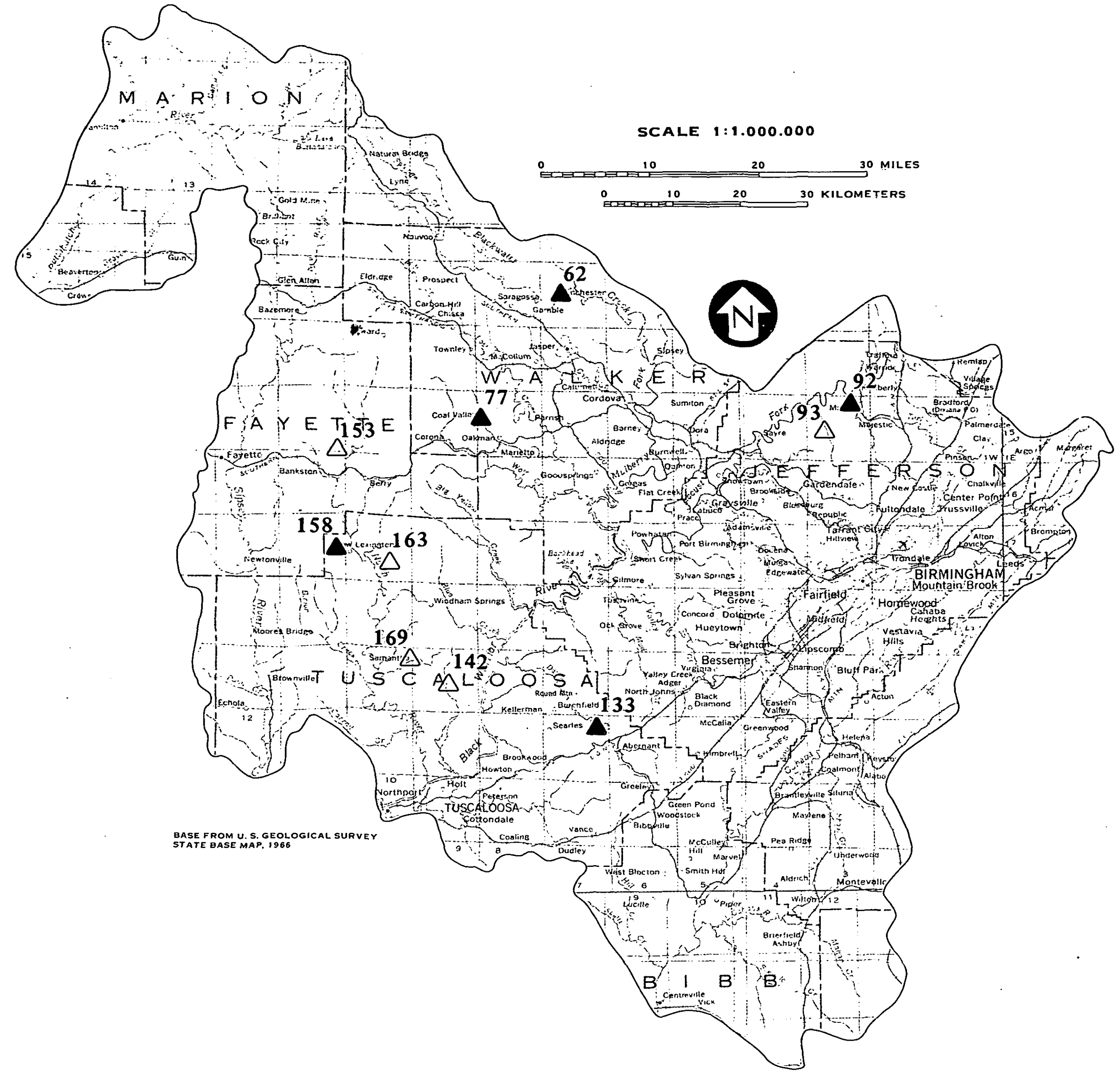
Iron Concentrations Are High in Streams Draining Mined Areas

Locally, dissolved-iron concentrations in streams draining coal-mine areas are high, commonly exceeding 1,000 micrograms per liter.

Dissolved-iron concentrations exceeding 300 micrograms per liter (μg/L) impart an objectional taste to water, cause staining, and generally limit the water's use for many domestic and industrial purposes. Sources of iron in water generally include soils rich in organic material and iron-bearing minerals in geologic strata underlying the basins. Dissolved-iron concentrations in streams draining relatively undisturbed basins in Area 23 are generally less than 300 μg/L. In contrast, dissolved concentrations in streams draining coal-mine areas are high and commonly exceed 1,000 μg/L. Accelerated weathering of iron bearing minerals (pyrite and marcasite) present in coal-mine spoils produces large quantities of soluble iron salts that are contributed to streamflow draining mine areas. Dissolved-iron concentration observed in mine drainage generally varied from less than 10 to 40,000 μg/L.

Ranges and mean values of dissolved-iron concentrations in streams draining mined and unmined basins are shown on figures 6.4-1 and 6.4-3. High dissolved-iron concentrations observed in streams draining mined basins vary widely and contrast sharply with concentrations observed in streams draining unmined basins (fig. 6.4-1). Although dissolved-iron concentrations are high in and near coal-mine areas, aeration and dilution rapidly decrease the high dissolved iron. In nearby downstream areas dissolved-iron concentrations are generally similar to those in streams draining unmined areas.

Aeration of mine drainage with high dissolved iron concentrations results in the formation of insoluble iron precipitates ("Yellow Boy") that can be observed coating stream bottoms and banks in many mined areas. Sorption of these precipitates on stream sediments results in high total recoverable-iron concentrations (dissolved and suspended in a water-suspended sediment solution). Relations between total recoverable-iron concentrations and suspended-sediment concentrations in streams draining mined and unmined basins are shown on figure 6.4-3. The relations may be used for estimating iron loads leaving mined and unmined basins in the study area. Total recoverable-iron concentrations are higher in streams draining mined areas and increase with increases in suspended-sediment concentrations. High suspended-sediment concentrations generally occur during high streamflow periods and low concentrations occur during low flow. During low flow, total recoverable-iron concentrations are nearly the same as dissolved concentrations.



EXPLANATION

169 △ Unmined site and number

77 ▲ Mined site and number

Figure 6.4-2 Location of selected sites for iron concentrations

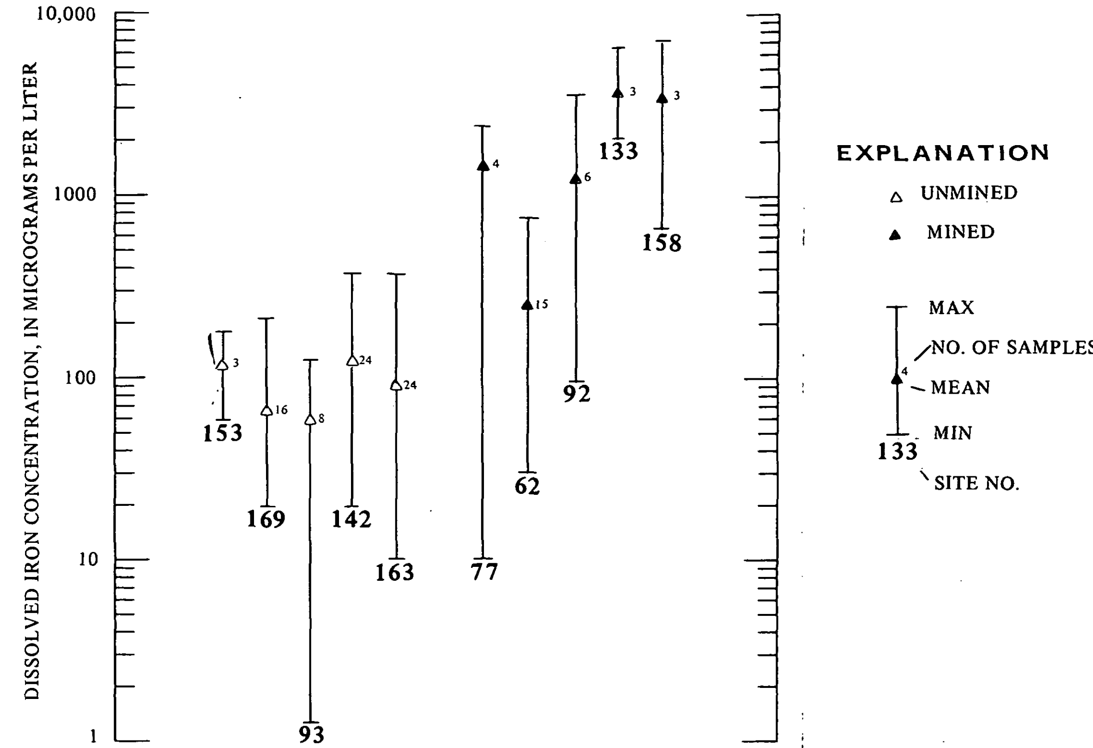


Figure 6.4-1 Mean and range of dissolved-iron concentrations at mined and unmined sites

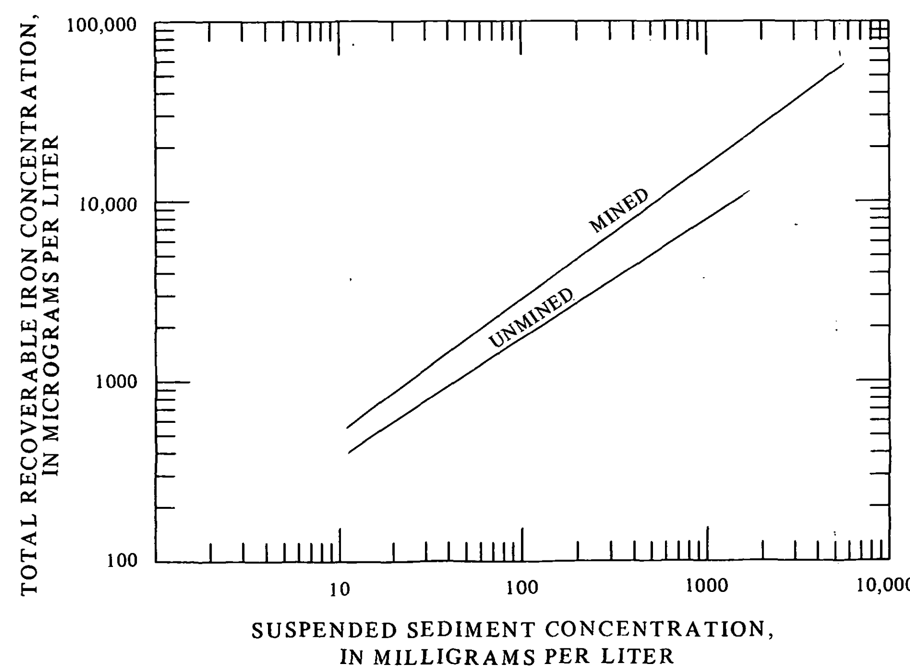


Figure 6.4-3 Relationship between total recoverable iron and suspended sediment at mined and unmined sites

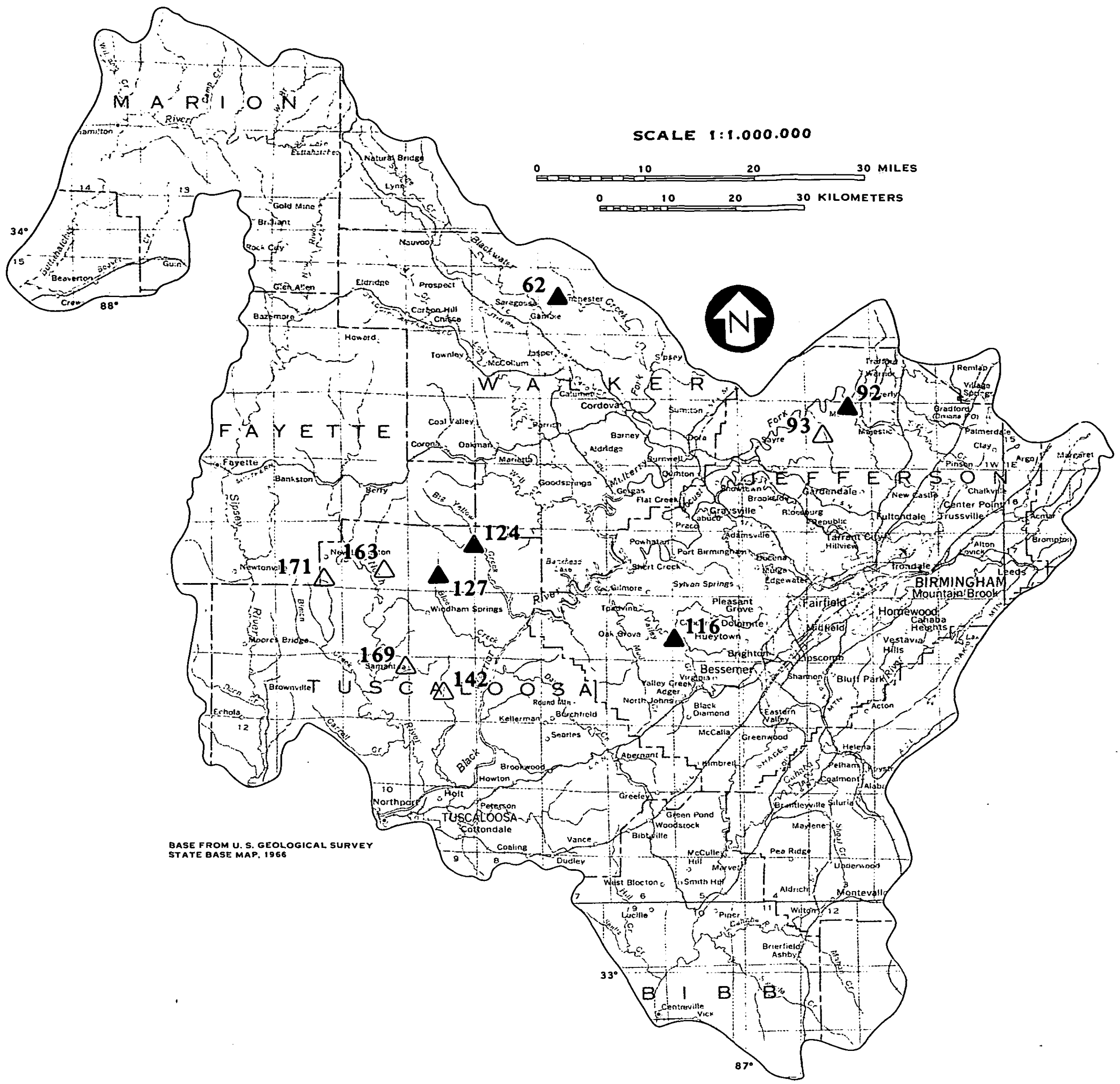
Manganese Concentrations Are High in Streams Draining Mined Areas

Locally, dissolved-manganese concentrations in streams draining coal-mine areas are high, commonly exceeding 100 micrograms per liter.

Dissolved-manganese concentrations exceeding 50 μg/L (micrograms per liter) impart an objectional taste to water, cause staining, and limit the water's use for many domestic and industrial purposes. Manganese normally occurs in small quantities in water and generally is derived from soils rich in organic material and geologic strata underlying the basins. Dissolved concentrations in streams draining relatively undisturbed basins are generally less than 50 μg/L. In contrast, dissolved-manganese concentrations in streams draining mined areas are high and commonly exceed 100 μg/L. Accelerated weathering of manganese minerals present in coal-mine spoils produces large quantities of soluble manganese salts that are contributed to streamflow draining mine areas. Dissolved concentration observed in mine drainage generally ranged from less than 10 to 20,000 μg/L.

Ranges and mean values of dissolved-manganese concentrations for selected sites on streams draining mined and unmined basins are shown in figure 6.5-1 and their locations are shown on figure 6.5-2. High dissolved-manganese concentrations observed in streams draining mined areas vary widely and contrast sharply with concentrations observed in streams draining unmined areas (fig. 6.5-1). Although dissolved-manganese concentrations are high in and near coal-mine areas, aeration and dilution by alkaline streams (pH greater than 8.0) rapidly decrease the high concentrations. Dissolved-manganese concentrations in acidic or near neutral streams draining mined areas generally remain higher than those in streams draining unmined areas.

Aeration of alkaline mine drainage usually increases the formation of insoluble manganese precipitates. Sorption of these precipitates on stream sediments results in high total recoverable manganese (dissolved and suspended in a water-suspended sediment solution). Relations between total recoverable-manganese concentrations and suspended-sediment concentrations in streams draining mined and unmined basins are shown in figure 6.5-3. The relations shown in the figure 6.5-3 may be used for estimating manganese loads leaving mined and ummined basins in the study area. Total recoverable-manganese concentrations are high in streams draining mined areas and increase with increases in suspended-sediment concentrations. High suspended-sediment concentrations generally occur during high streamflow and low concentrations during low flow. During low flow, total recoverable-manganese concentrations are nearly the same as dissolved concentrations.



EXPLANATION

△142 Unmined site and number

▲116 Mined site and number

Figure 6.5-2 Location of selected sites for manganese concentrations

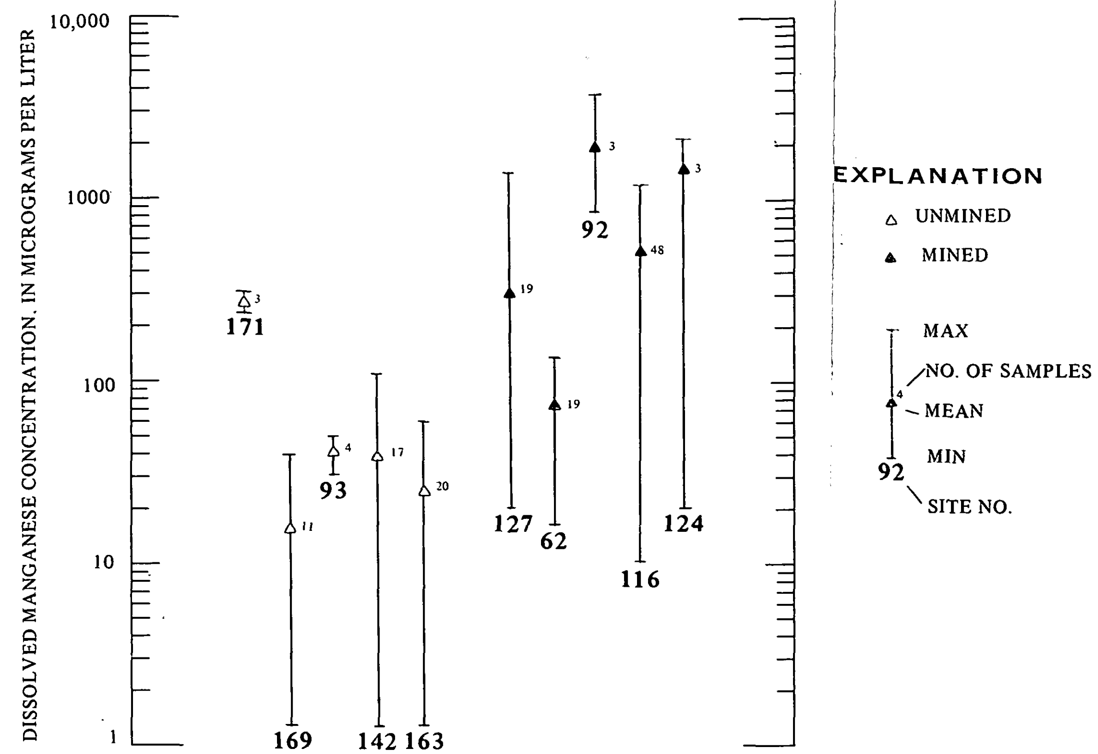


Figure 6.5-1 Mean and range of dissolved-manganese concentrations at mined and unmined sites.

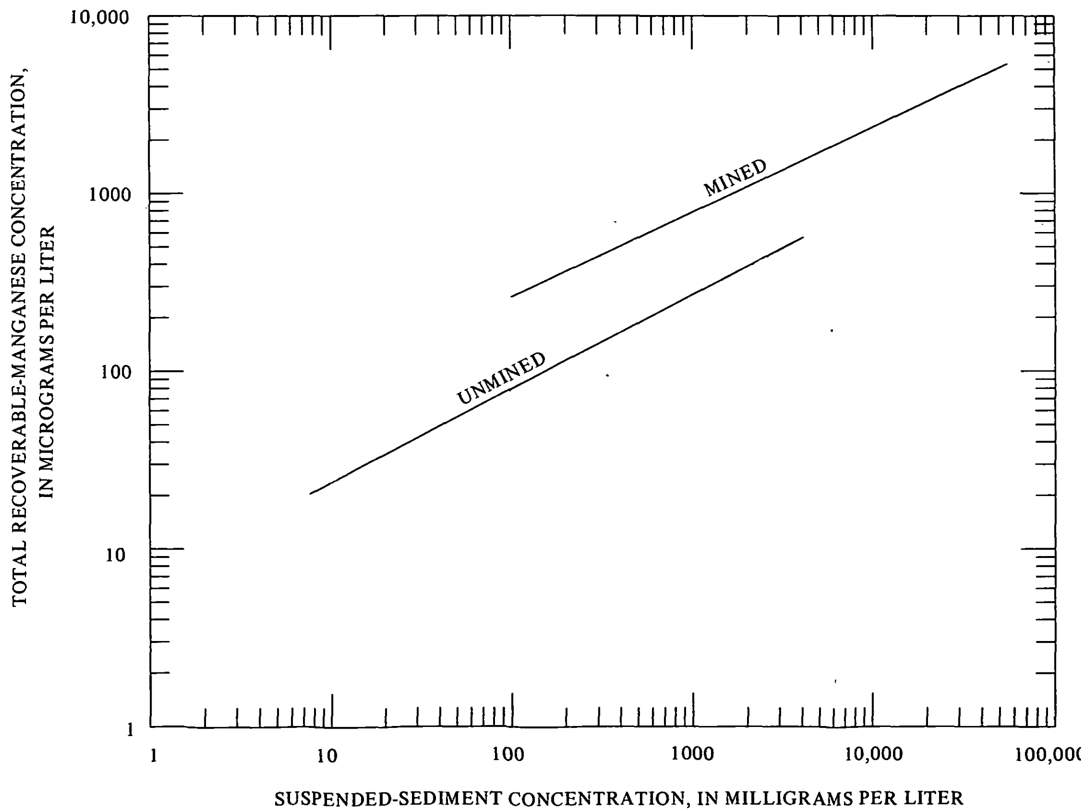


Figure 6.5-3 Relation between total recoverable manganese and suspended sediment

Sulfate Concentrations Are High in Streams Draining Mined Areas

Sulfate is usually the highest in concentration and the most persistently present dissolved constituent in coal-mine drainage.

The sulfate content of streams in Area 23 generally is low and reflects relatively insoluble geologic strata underlying the area. Concentrations in streams draining relatively undisturbed basins usually range from 1 to 20 mg/L (milligrams per liter). In contrast, sulfate concentrations in streams draining mined areas are highly variable and generally range from 20 to 2,000 mg/L.

Accelerated weathering of iron-bearing minerals (pyrite and marcasite) in coal-mine spoil produces large quantities of soluble mineral salts that are contributed to streamflow draining mined areas. Sulfate is usually the highest in concentration and the most persistent dissolved constituent in the water; it commonly is used as an indicator of mine drainage. Range and mean values of sulfate concentrations in selected streams draining mined areas are shown on Table 6.6-1. Some of the larger streams in and near Birmingham and surrounding communities have high sulfate concentrations, reflecting industrial-waste discharges.

Variability of sulfate concentrations in streams draining mined areas is primarily due to: (1) the presence of reactive minerals in spoil materials, (2) the length of time of exposure of these minerals to weathering, and (3) the quantity of water leaving the mined area. Figure 6.6-2 showing sulfate concentrations in Blue Creek near Oakman (site 127) shows the effect of continuing exposure of minerals to weathering on sulfate concentrations in streams draining mined areas. The sulfate concentration at this site increased from 12 mg/L in November 1976 to 470 mg/L in June 1979. In general sulfate concentrations are highest during low flow, reflecting longer residence time of the water in spoil areas and the lack of dilution by rainfall. In downstream areas sulfate concentrations decrease due to dilution by larger receiving streams.

Sulfate concentrations relate directly to specific conductance, an indicator of the degree of mineralization in water. Because of this relation, specific conductance may be used to estimate the concentration of sulfate. The accompanying graph (fig. 6.6-3) is useful for estimating sulfate concentrations in streams draining mined and unmined basins in the area. The relative positions of the lines indicate significant differences in sulfate concentration in water between streams draining mined and unmined areas. High specific conductance generally occurs during low flow; low specific conductance generally occurs during high flow.

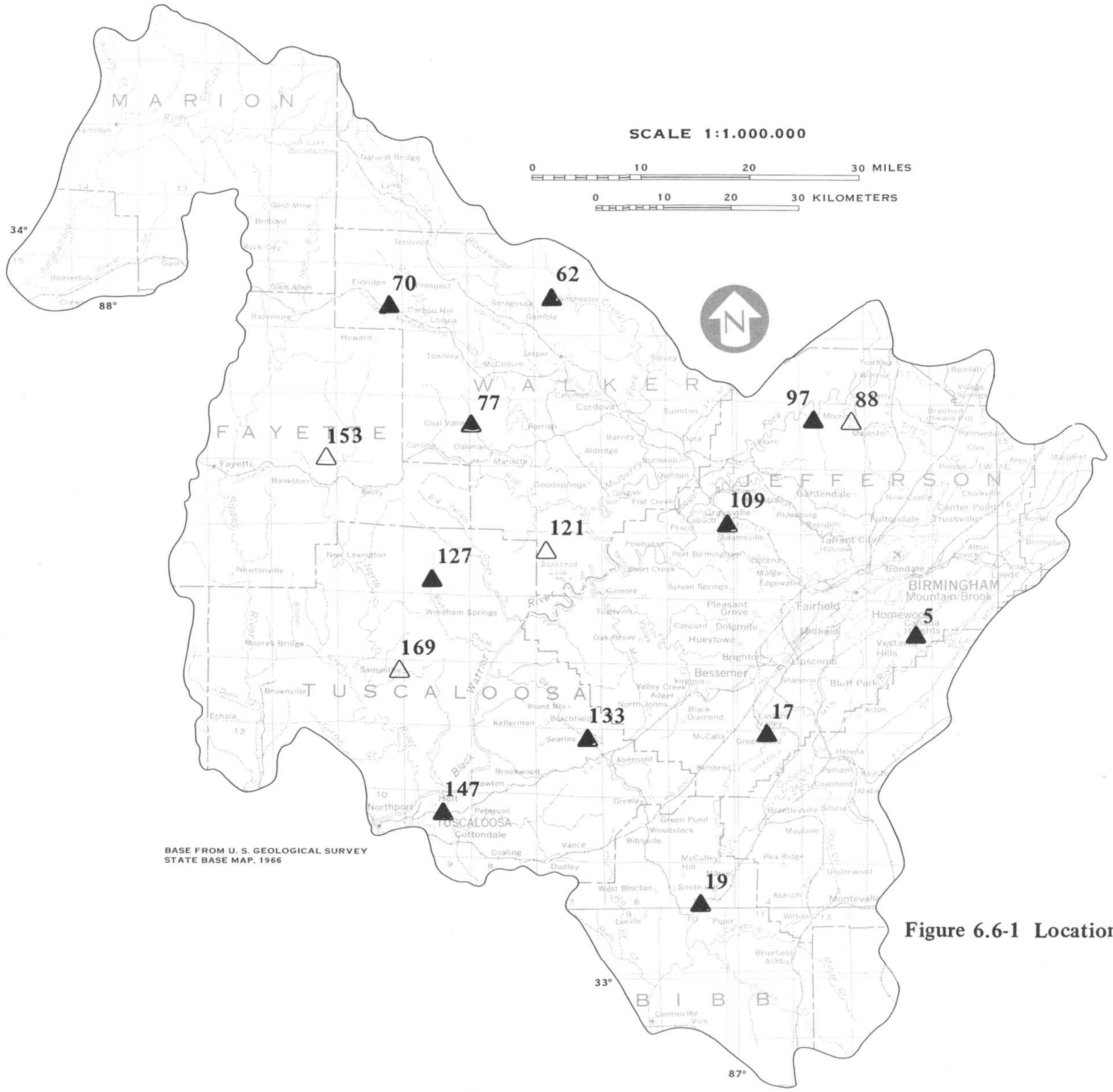


Figure 6.6-1 Location of selected sites

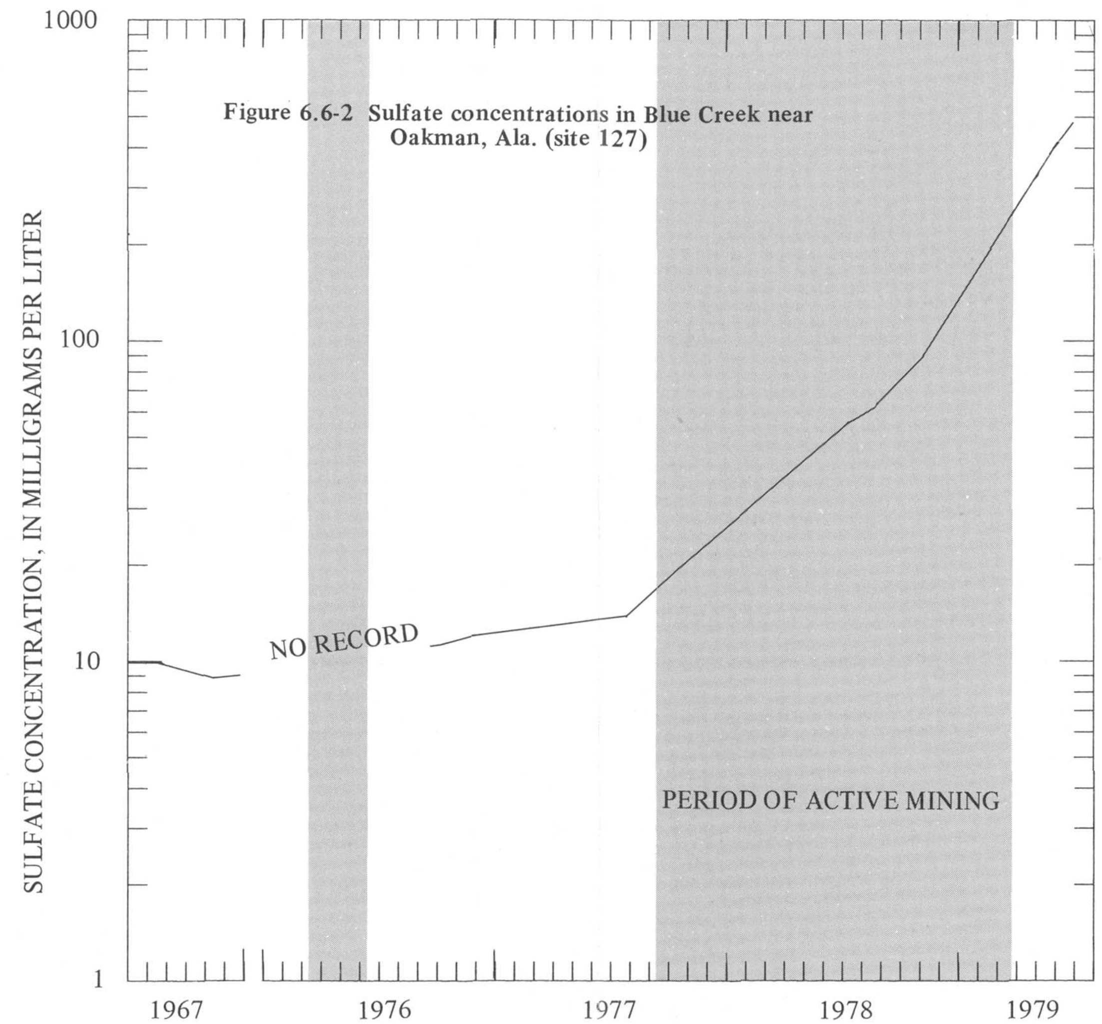


Figure 6.6-2 Sulfate concentrations in Blue Creek near Oakman, Ala. (site 127)

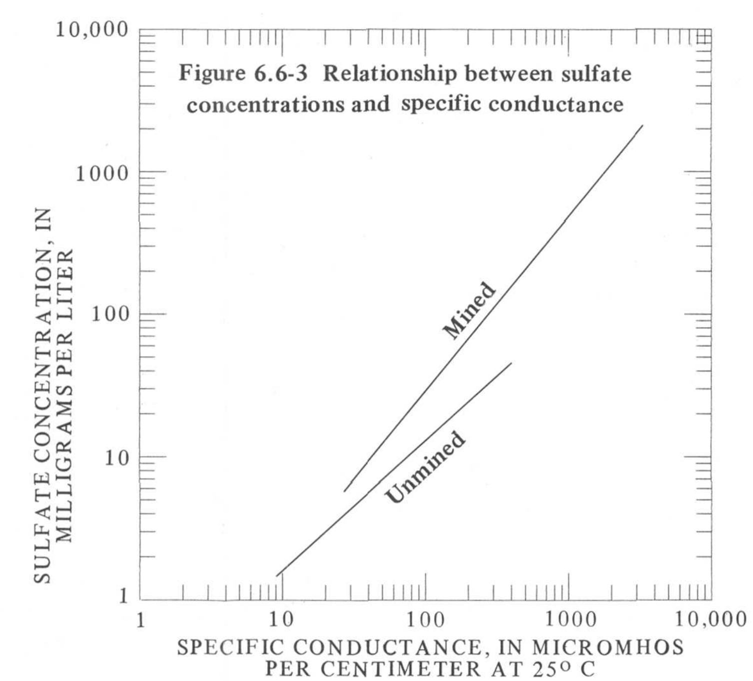


Figure 6.6-3 Relationship between sulfate concentrations and specific conductance

Table 6.6-1 Sulfate concentrations at selected sites

EXPLANATION

Gaging station and number

▲ 5 Mined △ 169 Unmined

	5	17	19	62	70	77	88	97	109	121	127	133	147	153	169
Range in sulfate concentrations, in milligrams per liter	7.4-35	14-46	5.8-38	9-46	79-770	380-1100	15-40	59-1400	23-98	5.6-7.3	4-470	380-520	12-64	8-19	0.8-4.9
Mean value	17	27	28	21	262	642	23	225	64	6.4	54	467	34	12	2.6
Number of samples	27	65	9	20	13	4	5	43	35	2	43	2	6	3	36

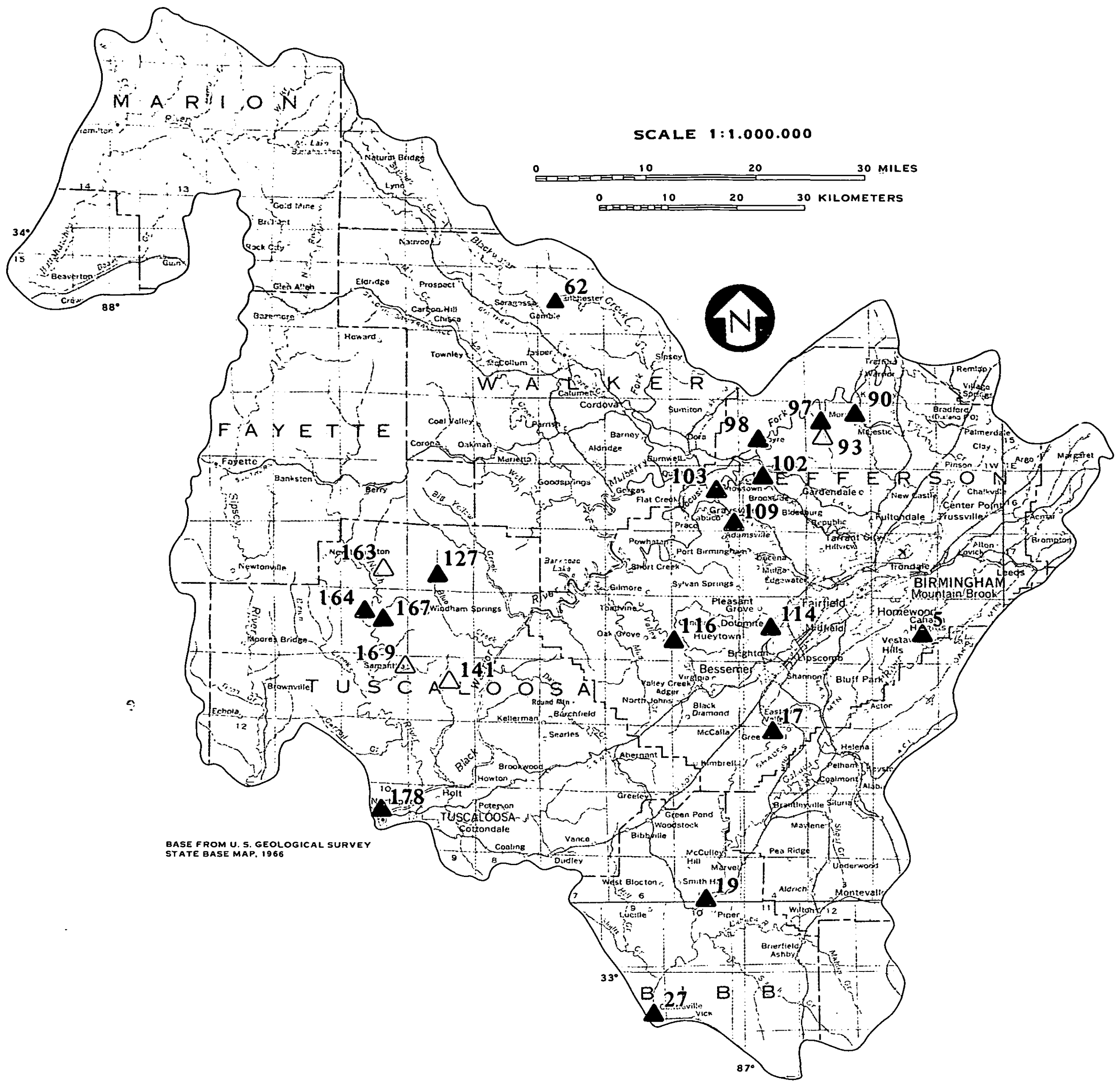
Trace Elements Occur in Low Concentrations

Trace elements normally occur in low concentrations and generally are not a water-quality problem.

Trace elements normally occur in small quantities in most streams. Major sources of these substances generally include soils, geologic strata underlying the basin and atmospheric fallout. In low concentrations trace elements are essential to life. In higher concentrations, some can be toxic to plants and animals. High concentrations in streams can occur naturally; however, most high concentrations generally are associated with industrial-waste discharges. In coal-mine areas accelerated weathering of pyritic minerals present in coal-mine spoils produces acids and large quantities of soluble mineral salts that are contributed to streamflow. The acid water reacts with other minerals and can produce adverse concentrations of trace elements in mine drainage.

In Area 23, however, concentrations of most dissolved trace elements observed in streams draining mined basins generally are low and comparable to streams draining unmined basins. Concentrations of selected elements at sites shown in figure 6.7-1 are summarized in table 6.7-1. With the exception of mercury, the concentrations of all trace elements listed in the table are within maximum limits recommended by the U.S. Environmental Protection Agency (1977). Only one sample at sites 5, 98, and 109 exceeded the recommended limits. Maximum cadmium concentrations at some sites appear to exceed the recommended limits; however, these values represent the lowest detection level at the time of analysis.

Trace elements that may occur in concentrations exceeding U.S. Environmental Protection Agency recommended limits (1977) in and near surface mines, usually decrease rapidly in nearby downstream reaches owing to chemical reactions and precipitation.



EXPLANATION

▲178 Mined site and number

△93 Unmined site and number

Figure 6.7-1 Location of sampling sites for trace elements

Table 6.7-1 Summary of selected trace element concentrations, in micrograms per liter, at selected sites.

Site No.	ALUMINUM				ARSENIC				CADIUM				CHROMIUM				COBALT			
	N[1]	$\bar{x}$[2]	Min	Max	N[1]	$\bar{x}$[2]	Min	Max	N[1]	$\bar{x}$[2]	Min	Max	N[1]	$\bar{x}$[2]	Min	Max	N[1]	$\bar{x}$[2]	Min	Max
5	-	-	-	-	27	3	0	10	28	2	0	<12	24	<1	0	3	24	1	0	8
17	2	100	30	200	45	3	0	48	51	1	0	<16	51	1	0	7	49	<1	0	2
19	-	-	-	-	7	1	0	3	6	1	0	2	7	0	0	0	2	2	1	3
27	3	30	20	40	41	1	0	4	50	2	0	<25	50	1	0	8	48	1	0	11
62	5	40	20	60	6	3	0	13	12	2	0	<15	11	<1	0	3	11	<1	0	3
90	4	60	20	100	-	-	-	-	1	0	0	0	1	0	0	0	1	20	20	20
93	4	30	20	50	-	-	-	-	1	0	0	0	1	0	0	0	1	0	0	0
97	7	60	40	80	-	-	-	-	1	0	0	0	1	0	0	0	1	0	0	0
98	3	100	60	200	43	1	0	3	50	1	0	<15	50	<1	0	8	48	2	0	10
102	-	-	-	-	-	-	-	-	4	<1	0	1	4	2	1	4	4	2	0	5
103	3	200	40	400	-	-	-	-	2	4	0	9	4	2	0	3	2	3	2	4
109	-	-	-	-	32	2	0	5	34	<1	0	1	33	1	0	3	29	1	0	4
114	-	-	-	-	1	1	1	1	1	1	1	1	1	1	1	1	1	5	5	5
116	-	-	-	-	42	2	0	7	47	<1	0	3	47	1	0	9	46	5	0	24
127	24	40	<10	100	4	<1	0	1	5	1	0	3	5	3	0	10	5	3	0	11
141	12	60	10	200	5	<1	0	1	6	0	0	0	6	2	0	10	6	0	0	0
163	23	30	<10	90	6	<1	0	1	5	<1	0	1	6	5	0	30	6	<1	0	2
164	-	-	-	-	40	<1	0	3	40	<1	0	2	40	<1	0	5	38	1	0	2
167	15	70	<10	500	4	<1	0	1	5	2	0	9	5	4	0	20	5	4	0	12
169	15	30	<10	80	7	<1	0	1	7	1	0	5	7	2	0	10	7	<1	0	3
178	4	30	20	40	39	1	0	4	49	2	0	<25	49	2	0	20	47	1	0	5

Site No.	COPPER				LEAD				MERCURY				SELENIUM				ZINC			
	N[1]	$\bar{x}$[2]	Min	Max	N[1]	$\bar{x}$[2]	Min	Max	N[1]	$\bar{x}$[2]	Min	Max	N[1]	$\bar{x}$[2]	Min	Max	N[1]	$\bar{x}$[2]	Min	Max
5	12	5	0	15	26	2	0	4	25	.3	0	2.1	2	0	0	0	25	20	5	140
17	36	3	0	8	51	2	0	8	44	.3	0	1.2	2	0	0	0	46	40	0	660
19	4	3	2	5	6	6	1	24	7	.2	.2	.2	4	0	0	0	7	10	0	40
27	38	4	0	92	50	2	0	9	40	.2	0	1.2	2	0	0	0	44	30	0	230
62	13	3	0	7	13	<1	0	2	6	.2	0	.5	-	-	-	-	8	20	<5	60
90	1	0	0	0	1	0	0	0	-	-	-	-	-	-	-	-	1	80	80	80
93	1	0	0	0	1	0	0	0	-	-	-	-	1	0	0	0	1	10	10	10
97	1	0	0	0	1	0	0	0	-	-	-	-	1	0	0	0	1	0	0	0
98	36	2	0	8	50	1	0	6	43	.3	0	2.2	2	0	0	0	46	60	0	1900
102	4	2	0	5	4	1	0	2	1	0	0	0	-	-	-	-	1	30	30	30
103	2	2	1	3	3	2	1	4	1	0	0	0	-	-	-	-	3	10	9	10
109	19	3	10	18	34	2	0	10	31	.5	0	4.4	3	0	0	0	31	40	0	120
114	1	5	5	5	1	1	1	1	1	.2	.2	.2	-	-	-	-	1	170	170	170
116	32	2	0	5	47	2	0	9	43	.3	0	1.5	1	0	0	0	43	30	5	250
127	5	<1	0	3	5	8	0	24	5	.4	.1	.5	5	<1	0	1	5	10	0	20
141	6	<1	0	2	6	6	0	15	6	.2	0	.5	6	0	0	0	6	8	0	20
163	6	2	0	7	5	1	0	5	6	.4	0	.5	6	0	0	0	6	8	0	20
164	28	2	0	8	39	1	0	7	39	.2	0	1.4	2	0	0	0	40	40	0	480
167	5	2	1	4	4	2	0	5	4	.5	.5	.5	5	<1	0	1	5	10	0	50
169	7	1	0	3	7	9	0	36	7	.3	0	.5	7	0	0	0	7	6	0	10
178	36	4	0	19	49	2	0	13	37	.2	0	1.3	1	0	0	0	42	30	<5	280

1/ N--number of samples

2/ $\bar{x}$--Mean

Recharge Areas of Three Aquifer Systems in Area 23

The Coker and Pottsville Formations and pre-Pennsylvanian rocks outcrop and receive direct recharge in Area 23. The movement of water in these aquifers is generally to the southwest.

The source of ground water in Area 23 is precipitation chiefly in the form of rain. Part of the precipitation returns to the atmosphere through evaporation and transpiration, part flows into streams and lakes as runoff, and part seeps downward through the soils and rocks to the zone of saturation (fig. 7.1-1).

Direct infiltration of precipitation into the aquifers is the major means of recharge, although some aquifers receive recharge indirectly by leakage from adjacent aquifers. Recharge also may result from streams flowing over the outcrop of the aquifer. Where the water level in the aquifer is below that of the stream, water may percolate through the stream channel and into the aquifer. The rate at which this percolation may occur is dependent on the permeability of the material below the stream channel. Studies indicate that nearly 5 percent of the average annual precipitation of 54 inches recharges the ground-water reservoirs.

Almost all ground water is in motion from areas of recharge to areas of discharge. The rate of movement in most aquifers is slow and depends on the size and degree of interconnection of the water-bearing openings and the hydraulic gradient. Rocks that transmit water readily are said to have high permeability or to be permeable. Among the more permeable rocks are well sorted sand and gravel and fractured sandstone and limestone. Rocks that do not transmit water readily are said to have low permeability or to be impermeable. Among the low permeable rocks are clay, shale, and unfractured sandstone and limestone.

Ground-water movement in Area 23 generally is to the southwest. The Coker Formation dips toward the southwest about 30 feet per mile and the water moves through the more permeable lower part which contains sand and gravel beds and overlies the Pottsville Formation. Little is known concerning the recharge to and movement of ground water in the Pottsville Formation. Most of the water is derived directly from precipitation on the areas of outcrop. Substantial quantities of water may be contributed by streams where they flow across extensively fractured rocks in areas where the water table is below stream levels. The main direction of movement is downdip to the southwest along bedding planes, however, water may move in other directions because of topographic influence and the orientation of fracture systems. The most productive aquifers in the pre-Pennsylvanian rocks are the beds of limestone and dolomite. Ground water in limestone and dolomite occurs in solution openings developed along fractures and bedding planes. Interconnected solution openings in these rocks form a system of conduits that permits relatively free movement of large quantities of ground water. The beds of sandstone and conglomerate allow water movement but in smaller quantities because the water-bearing openings have not been enlarged by solution.

The potentiometric surfaces of water in the three aquifers are generally highest in the spring and lowest during the late fall and early winter.

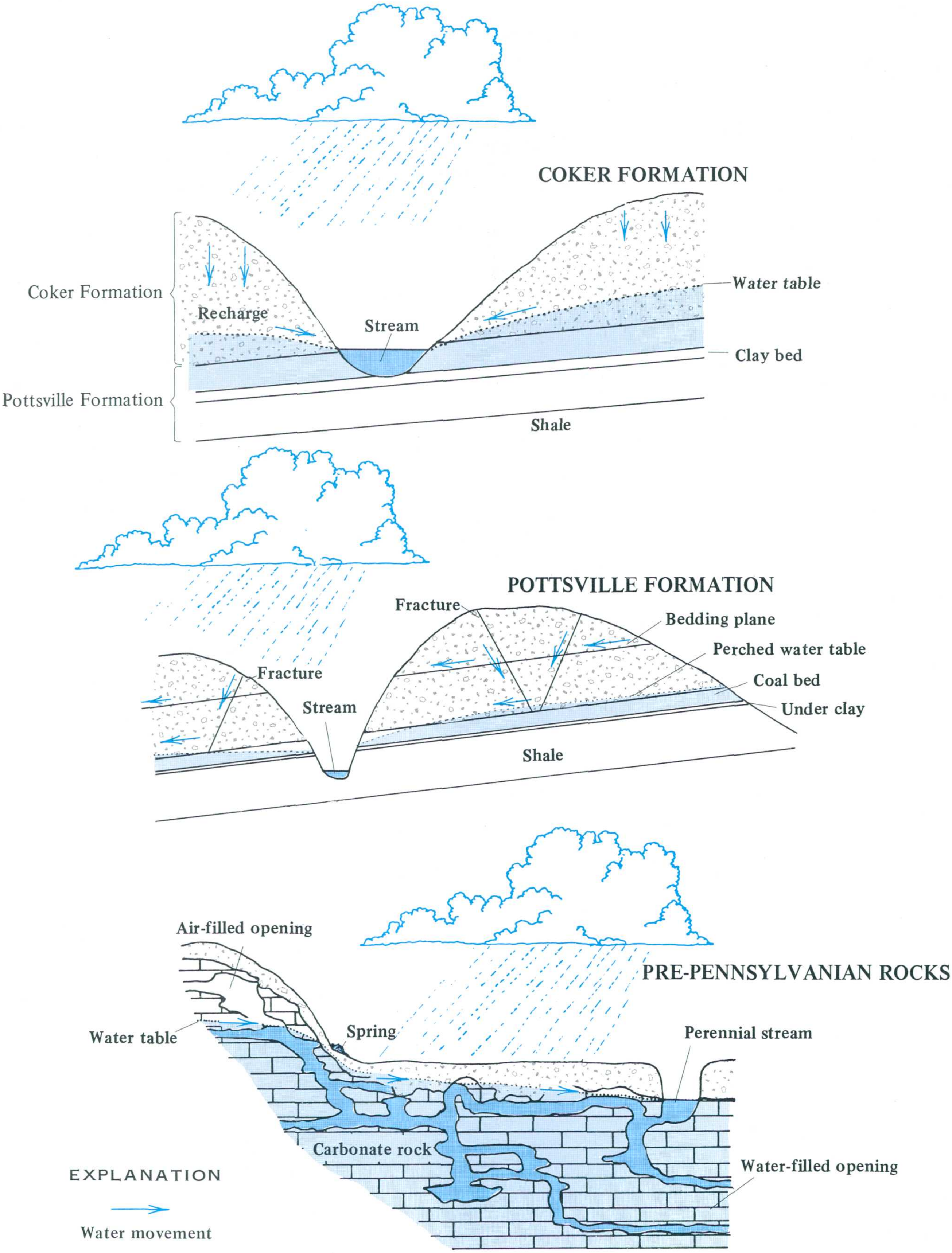


Figure 7.1-1 Water movement in aquifers

Water Levels in Area 23 Fluctuate Seasonally

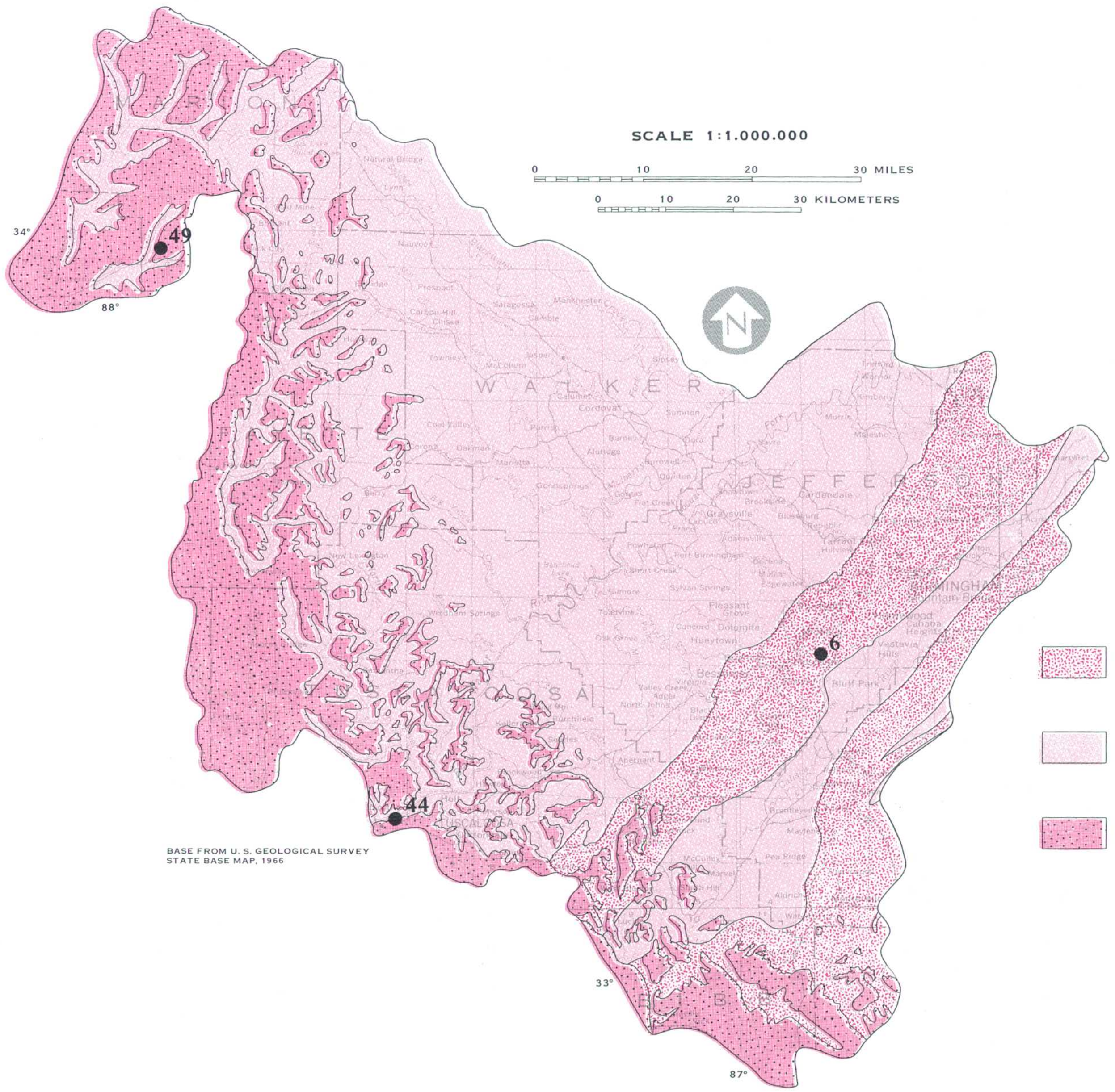
The cyclic water-level fluctuations reflect seasonal variations in the rate of recharge to, and discharge from, the ground-water reservoirs.

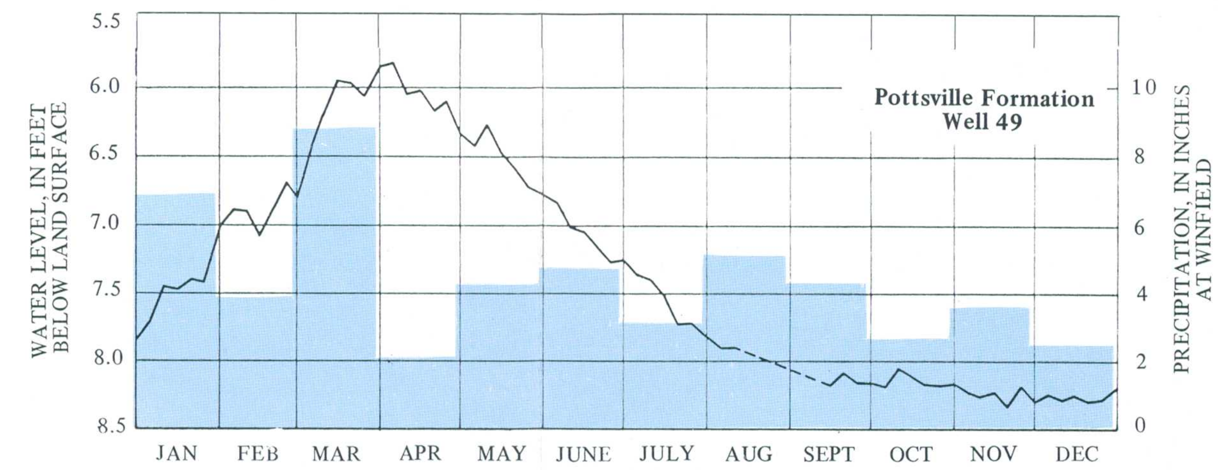
Water levels in Area 23 fluctuate seasonally, as shown in figure 7.2-1. The highest water levels occur in the spring prior to the onset of the growing season in response to recharge from precipitation. The lowest levels occur in the fall prior to the first killing frost as a result of discharge by gravity flow and evapotranspiration.

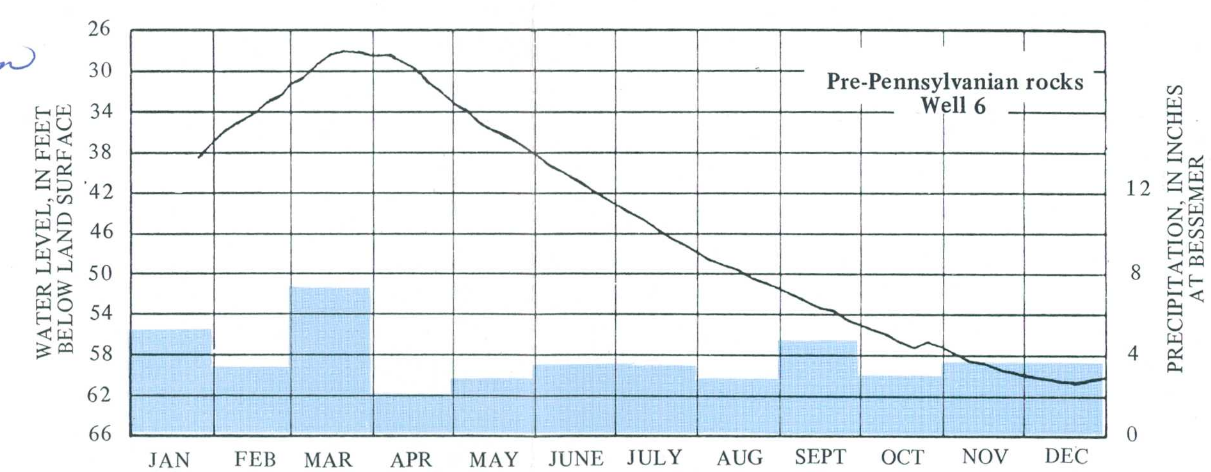
The water level in well No. 44, which taps the Coker Formation in the southern part of Area 23, ranged from 27.9 feet below land surface in 1955 to 21.7 feet below land surface in 1976. The water level in well No. 49, which taps the Pottsville Formation in the northwestern part of the area, ranged from 11.8 feet in 1954 to 3.6 feet in 1972. Generally the Coker and Pottsville Formations show variation in water levels of less than 10 feet. In contrast, the water level in well No. 6, which taps pre-Pennsylvanian rocks, ranged from 83.0 feet in 1954 to 9.3 feet in 1977. In this rock type, water levels typically are more variable due to faults and solution cavities. Water-level fluctuations in these three wells are fairly representative of fluctuations in other wells in Area 23 tapping similar formations.

Records of water levels from numerous wells in the same aquifer or formation may be used to construct regional water-table or potentiometric maps or for other areal correlation purposes. However, because of the occurrence of perched water tables and the irregular lensing properties of the aquifers, water levels in wells tapping the Pottsville Formation are unpredictable and areal correlations are possible only within short distances.

Water-level records for semiannual and continuous-recorded observation wells in Area 23 may be obtained from the U.S. Geological Survey at Tuscaloosa or from the annual report "Water Resources Data for Alabama," published by the U.S. Geological Survey. Monthly and annual precipitation and air temperature records may be found in U.S. Department of Commerce Climatological Data reports for Alabama.







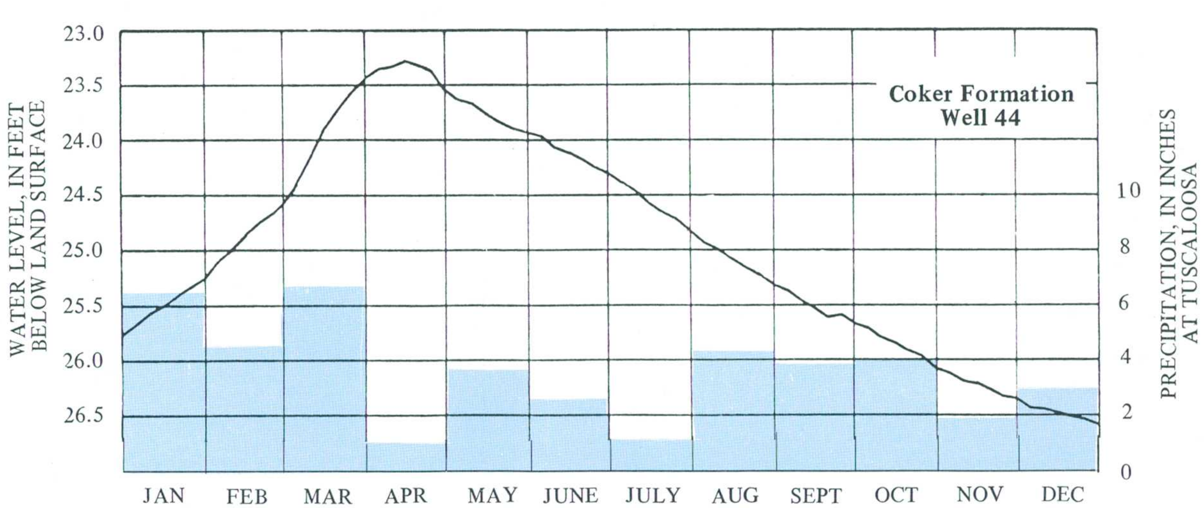


Figure 7.2-1 Seasonal water-level fluctuations

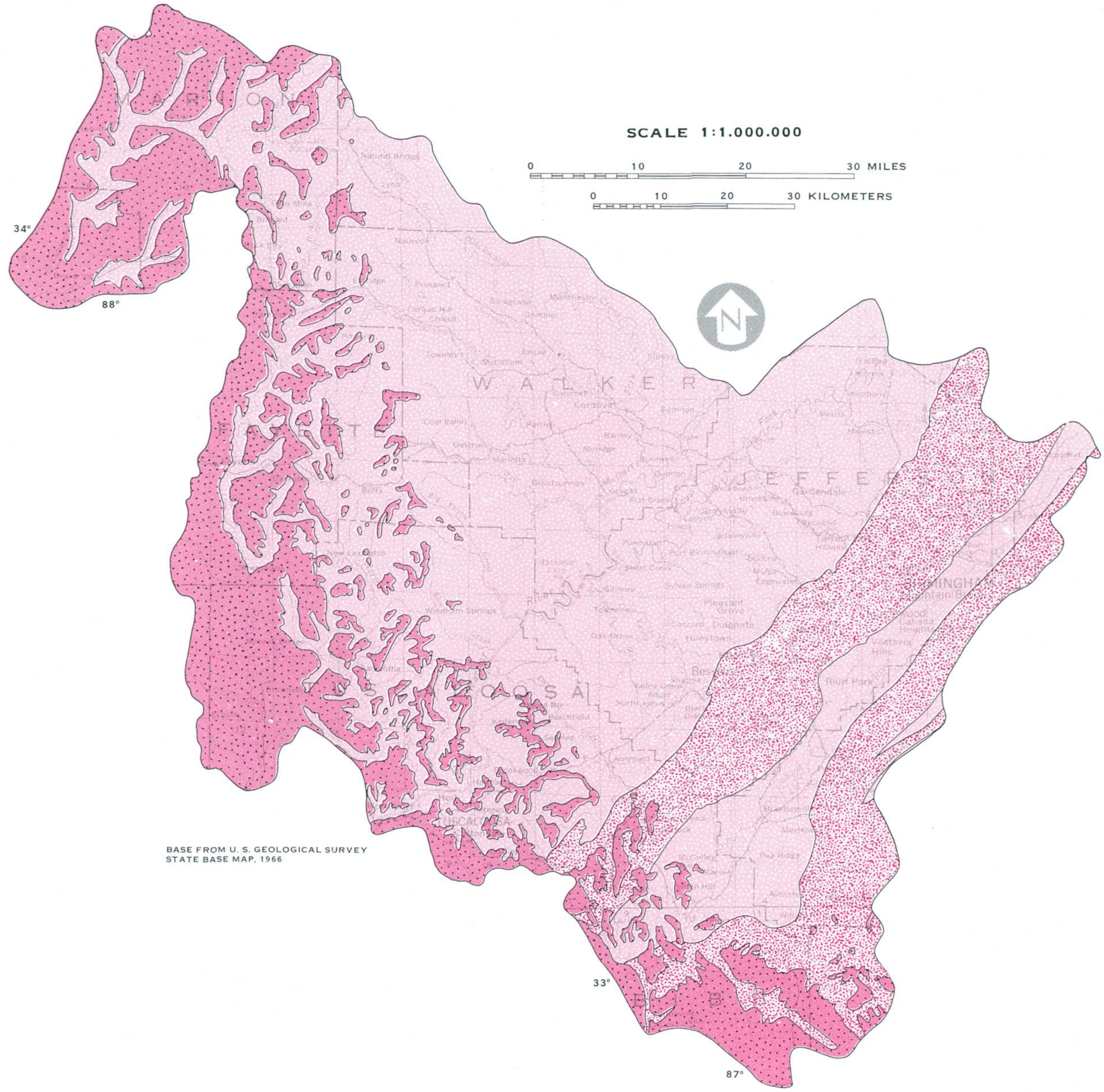
Three Major Rock Units Underlying Area 23 Have Diverse Water-Bearing Characteristics

Wells tapping aquifers in the three major rock units in Area 23 yield from less than 10 to more than 1,000 gallons per minute.

The principal source of ground-water supplies in most of Area 23 is the Pottsville Formation, which consists of alternating beds of sandstone and shale. Ground water in the Pottsville occurs in sandstone beds and in fractures and bedding planes. The openings generally are small, and yields to wells range from less than 10 gal/min (gallons per minute) to as much as 50 gal/min. The depth to water generally is less than 30 feet in stream valleys and terraces and more than 50 feet in hills and ridges.

The Coker Formation is a major source of water where it is present in the southern and southwestern part of Area 23. Ground water occurs principally in the basal sand and gravel beds. Yields to most wells tapping the Coker are from 10 to 15 gal/min; however, wells producing 100 gal/min or more can be constructed in the southern part of the area where the Coker is of sufficient saturated thickness.

The availability of ground water in the pre-Pennsylvanian rocks is related to the topography, depth and extent of weathering and fracturing, existence of solution cavities, and rock type. The more important aquifers in these rocks are interconnected, solutionally-enlarged openings in the carbonate rocks, such as limestone and dolomite. These openings are potential sources of large supplies of more than 350 gal/min per well and locally yield more than 1,000 gal/min (Knight, 1976). Where these openings are absent, yields to wells may not be sufficient for domestic supplies.



EXPLANATION

YIELDS TO WELLS

In gallons per minute

Coker Formation
From 10 to more than 100

Pre-Pennsylvanian rocks
From 10 to more than 1,000

Pottsville Formation
From less than 10 to 50

Figure 7.3-1 Sources of ground water

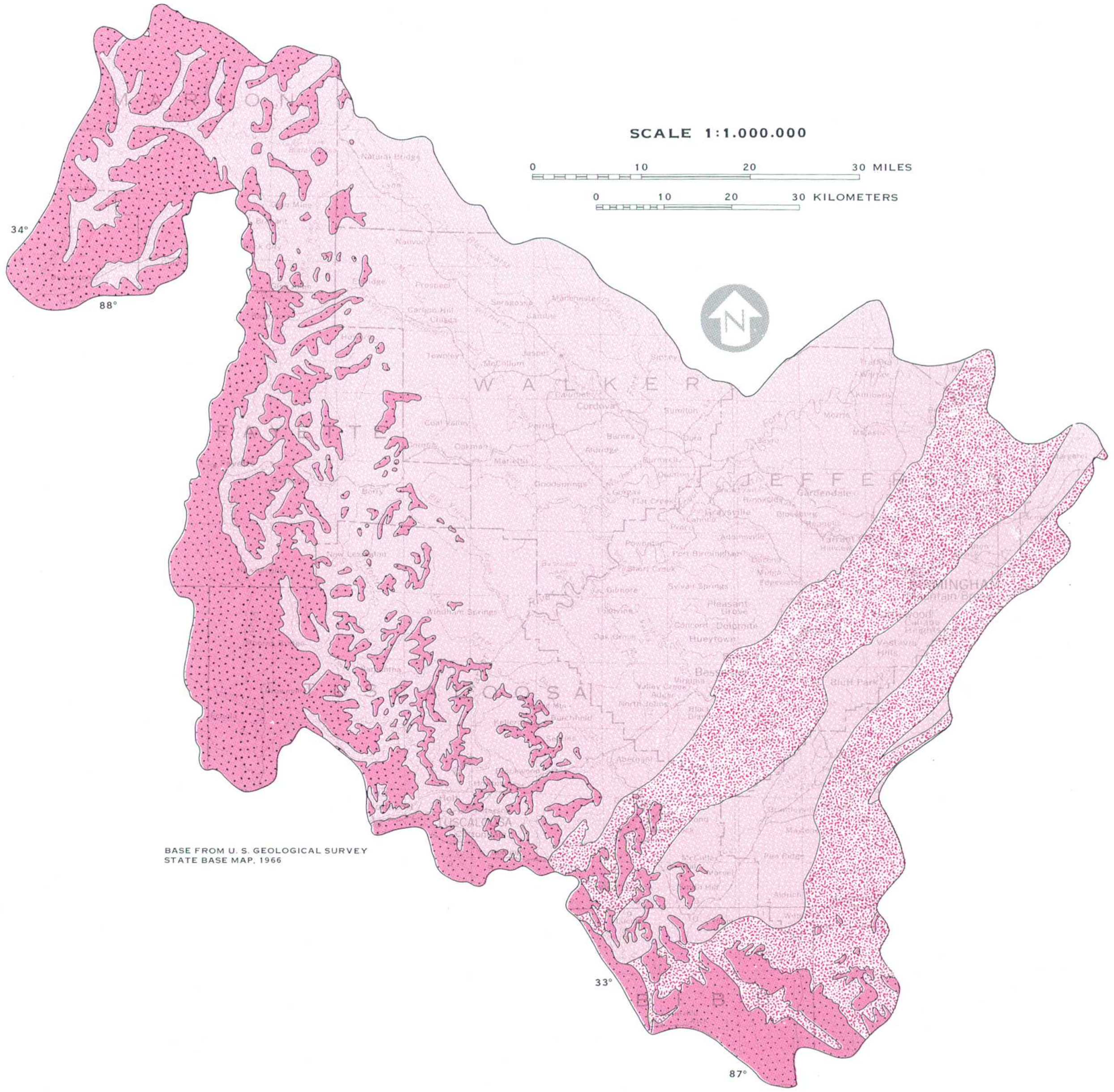
8.0 QUALITY OF GROUND WATER

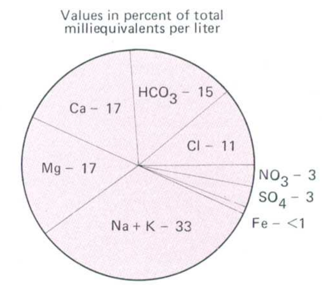
Chemical Quality of Ground Water is Variable, but Generally Good

Ground water is suitable for most domestic uses, except in local areas.

Quality of ground water in Area 23 is highly variable, but is generally good and suitable for most uses. Average chemical quality by water-bearing units is shown in figure 8.0-1. The pie diagrams show percentages of total ion concentrations (milliequivalents per liter) of water from wells in each unit. Generally, the most undesirable constituent is iron, which locally exceeds the 0.3 mg/L (milligrams per liter) recommended limit (U.S. Environmental Protection Agency, 1977). As shown in figure 8.0-1, ground water in the Coker Formation has the lowest median pH (6.6) and lowest average specific conductance (83 micromhos), owing to the relative insolubility of the rock. High pH and specific conductance of water from the Pottsville Formation and pre-Pennsylvanian rocks are related to increased rock solubility. In the Pottsville Formation, ground water has a median pH value of 8.4, with an average specific conductance of 504 micromhos. Ground water in pre-Pennsylvanian rocks has a median pH of 7.4 and an average specific conductance of 304 micromhos. Generally, the increased solubility in the Pottsville Formation and pre-Pennsylvanian rocks, with resulting increases in dissolved-solids concentration, does not present a water-quality problem.

Factors affecting ground-water quality include rock types and residence time or duration of contact between water and rock. A calcium-magnesium-bicarbonate type of water is characteristic from pre-Pennsylvanian carbonate rocks (limestone and dolomite), and also characteristic of water from the Pottsville Formation, which consists of shale, sandstone, and clay. Hardness ($CaCO_3$) of ground water in these geologic units varies from soft to very hard. Dissolved-solids concentrations are generally greater than 100 mg/L. A calcium-magnesium-sulfate type water is characteristic from the Coker Formation, which consists chiefly of insoluble siliceous materials. Ground water in this formation is soft; dissolved-solids concentrations are generally less than 100 mg/L.

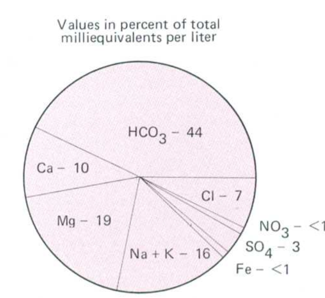




Coker Formation

(Concentrations in milligrams per liter unless otherwise specified)

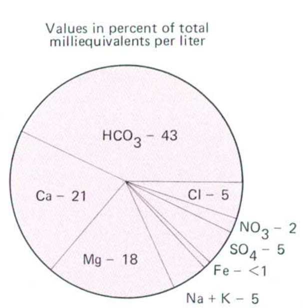
Constituent	Range	Average	Number of samples
Iron (Fe)	0.0 - 21	0.28	54
Calcium (Ca)	1.0 - 35	9.3	72
Magnesium (Mg)	.2 - 12	3.6	15
Sodium (Na)	1.1 - 50	9.0	20
Potassium (K)	.7 - 2.4	1.4	8
Bicarbonate (HCO_3)	.0 - 93	17	72
Sulfate (SO_4)	.0 - 12	2.9	23
Chloride (Cl)	.1 - 88	7.0	75
Nitrate (NO_3)	.1 - 28	- 3.3	28
pH (units)	3.6 - 7.8	6.6 (median)	68
Specific conductance (micromhos per centimeter ar 25° C)	16. - 359	83	61
Hardness ($CaCO_3$)	2.0 - 161	30	103



Pottsville Formation

(Concentrations in milligrams per liter unless otherwise specified)

Constituent	Range	Average	Number of samples
Iron (Fe)	0.1 - 7.4	0.89	10
Calcium (Ca)	.4 - 45	21	19
Magnesium (Mg)	.9 - 85	17	14
Sodium (Na)	.6 - 54	23	14
Potassium (K)	.2 - 17	4.5	10
Bicarbonate (HCO_3)	6. - 706	193	80
Sulfate (SO_4)	.2 - 37	11	13
Chloride (Cl)	.4 - 245	18	82
Nitrate (NO_3)	.0 - 6.3	1.0	16
pH (units)	6.4 - 9.4	8.4 (median)	100
Specific conductance (micromhos per centimeter ar 25° C)	37. - 1,750	504	99
Hardness ($CaCO_3$)	2.0 - 450	83	100



Pre-Pennsylvanian rocks

(Concentrations in milligrams per liter unless otherwise specified)

Constituent	Range	Average	Number of samples
Iron (Fe)	0.0 - 1.4	0.18	85
Calcium (Ca)	.1 - 100	37	49
Magnesium (Mg)	.9 - 66	13	49
Sodium (Na)	.2 - 61	6	35
Potassium (K)	.4 - 3.24	1.1	24
Bicarbonate (HCO_3)	7. - 323	153	49
Sulfate (SO_4)	1.2 - 120	15	42
Chloride (Cl)	2.8 - 112	11	28
Nitrate (NO_3)	.0 - 20	5.9	22
pH (units)	6.3 - 7.9	7.4 (median)	64
Specific conductance (micromhos per centimeter ar 25° C)	99. -751	304	63
Hardness ($CaCO_3$)	48. - 390	154	97

Figure 8.0-1 Chemical composition of ground water

8.0 QUALITY OF GROUND WATER

NAWDEX, WATSTØRE, OWDC Have Water Data Information

Water data are collected in coal areas by large number of organizations in response to a wide variety of missions and needs.

Within the U.S. Geological Survey there are three activities that help to identify and improve access to the vast amount of existing water data.

(1) The National Water Data Exchange(NAWDEX), which indexes the water data available from over 400 organizations and serves as a central focal point to help those in need of water data to determine what information already is available.

(2) The National Water Data Storage and Retrieval System (WATSTØRE),which serves as the central repository of water data collected by the U.S. Geological Survey and which contains large volumes of data on the quantity and quality of both surface and ground waters.

(3) The Office of Water Data Coordination (OWDC), which coordinates Federal water-data acquisition activities and maintains a "Catalog of Information on Water Data." To assist in identifying available water-data activities in coal provinces of the United States special indexes to the Catalog are being printed and made available to the public.

A more detailed explanation of these three activities are given in sections 9.2, 9.3, and 9.4.

NAWDEX Simplifies Access to Water Data

The National Water Data Exchange (NAWDEX) is a nationwide program managed by the U.S. Geological Survey to assist users of water data or water-related data in identifying, locating, and acquiring needed data.

NAWDEX is a national confederation of water-oriented organizations working together to make their data more readily accessible and to facilitate a more efficient exchange of water data.

Services are available through a Program Office located at the U.S. Geological Survey's National Center in Reston, Virginia, and a nationwide network of Assistance Centers located in 45 States and Puerto Rico, which provide local and convenient access to NAWDEX facilities (see fig. 9.2-1). A directory is available on request that provides names of organizations and persons to contact, addresses, telephone numbers, and office hours for each of these locations [Directory of Assistance Centers of the National Water Data Exchange (NAWDEX), U.S. Geological Survey Open-File Report 79-423 (revised)].

NAWDEX can assist any organization or individual in identifying and locating needed water data and referring the requester to the organization that retains the data required. To accomplish this service, NAWDEX maintains a computerized Master Water Data Index (fig. 9.2-2), which identifies sites for which water data are available, the type of data available for each site, and the organization retaining the data. A Water Data Sources Directory (fig. 9.2-3) also is maintained that identifies organizations that are sources of water data and the locations within these organizations from which data may be obtained. In addition NAWDEX has direct access to some large water-data bases of its members and has reciprocal agreements for the exchange of services with others.

Charges for NAWDEX services are assessed at the option of the organization providing the requested data or data service. Search assistance services are provided free by NAWDEX to the greatest extent possible. Charges are assessed, however, for those requests requiring computer cost, extensive personnel time, duplicating services, or other costs encountered by NAWDEX in the course of providing services. In all cases, charges assessed by NAWDEX Assistance Centers will not exceed the direct costs incurred in responding to the data request. Estimates of cost are provided by NAWDEX upon request and in all cases where costs are anticipated to be substantial.

For additional information concerning the NAWDEX program or its services contact:

Program Office
National Water Data Exchange (NAWDEX)
U.S. Geological Survey
421 National Center
12201 Sunrise Valley Drive
Reston, VA 22092

Telephone: (703) 860-6031
FTS 928-6031

Hours: 7:45 - 4:15 Eastern Time

or

NAWDEX ASSISTANCE CENTER

ALABAMA

U.S. Geological Survey
Water Resources Division
Room 202, Oil & Gas Board Bldg.
P. O. Box V
University, AL 35486

Telephone: (205) 752-8104
FTS 229-2957

Hours: 7:30 to 4:00 Central Time

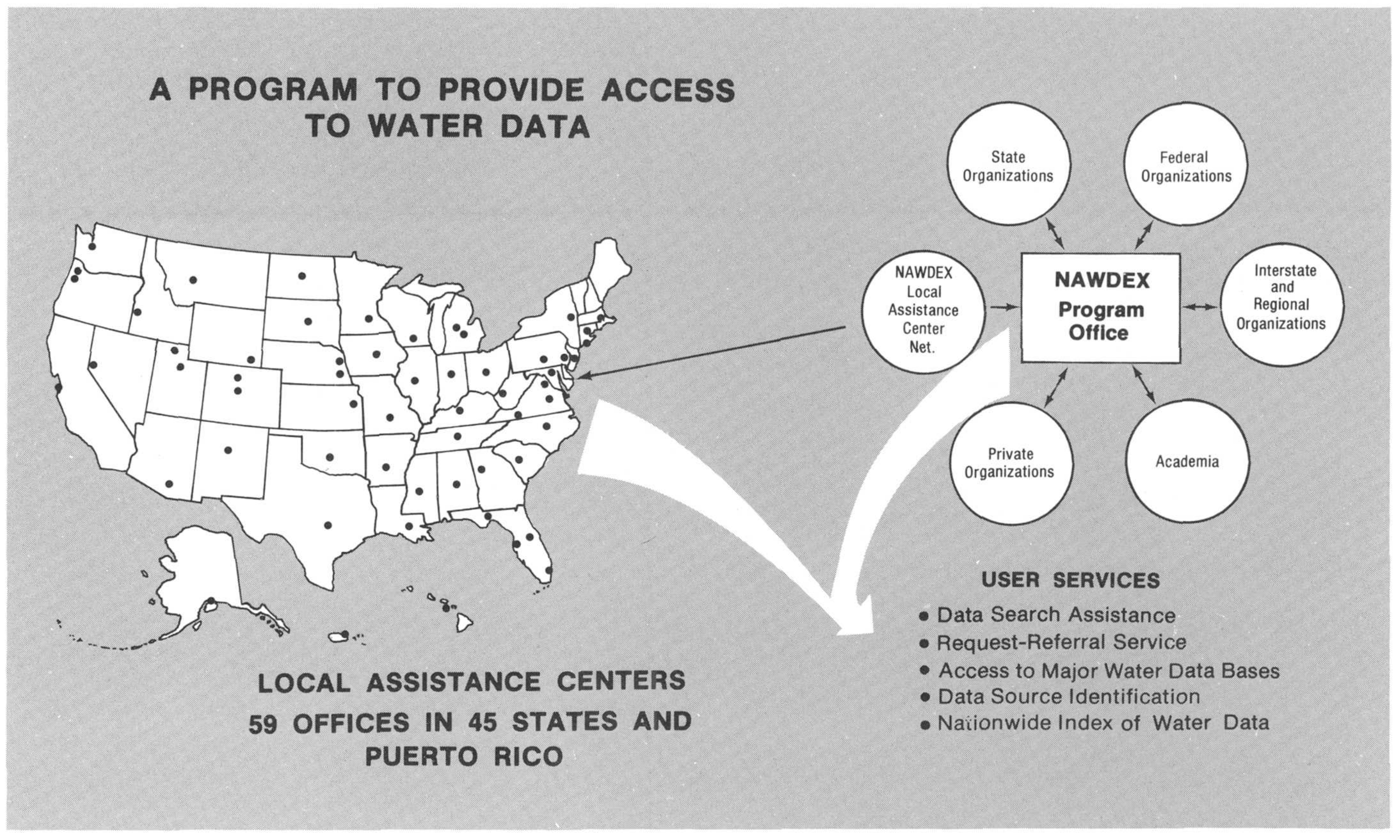


Figure 9.2-1 Access to water data

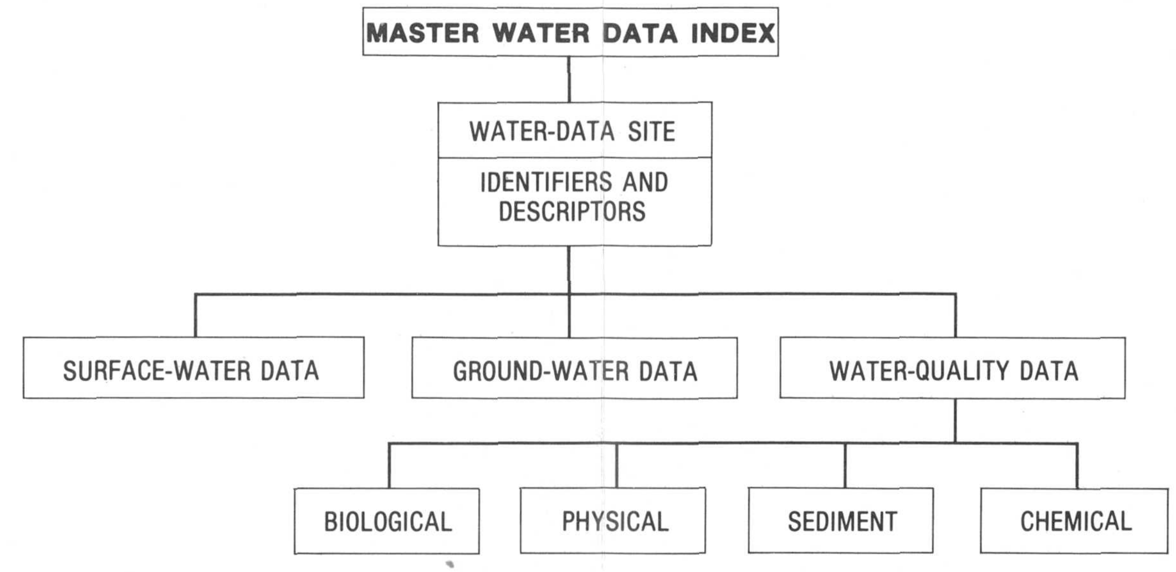


Figure 9.2-2 Master water-data index

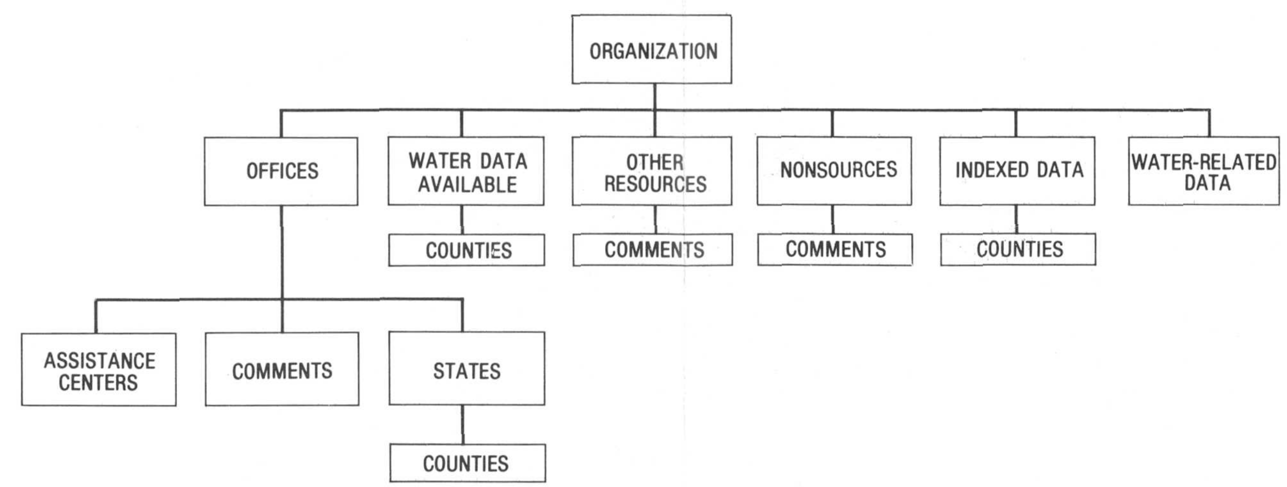


Figure 9.2-3 Water-data sources directory

WATSTØRE Automated Data System

The National Water Data Storage and Retrieval System (WATSTØRE) of the U.S. Geological Survey provides computerized procedures and techniques for processing water data and provides effective and efficient management of data-releasing activities.

The National Water Data Storage and Retrieval System (WATSTØRE) was established in November 1971 to computerize the U.S. Geological Survey's existing water-data system and to provide for more effective and efficient management of its data-releasing activities. The system is operated and maintained on the central computer facilities of the Survey at its National Center in Reston, Va. Data may be obtained from WATSTØRE through the Water Resources Division's 46 district offices. General inquiries about WATSTØRE may be directed to:

Chief Hydrologist
U. S. Geological Survey
437 National Center
Reston, VA 22092

or

U. S. Geological Survey
Water Resources Division
Room 202, Oil & Gas Board Building
P. O. Box V
University, AL 35486

The Geological Survey currently (1980) collects data at approximately 16,000 streamgaging stations, 1,000 lakes and reservoirs, 5,200 surface-water quality stations, 1,020 sediment stations, 30,000 water-level observation wells, and 12,500 ground-water quality wells. Each year many water-data collection sites are added and others are discontinued; thus, large amounts of diversified data, both current and historical, are amassed by the Survey's data-collection activities.

The WATSTØRE system consists of several files in which data are grouped and stored by common characteristics and data-collection frequencies. The system also is designed to allow for the inclusion of additional data files as needed. Currently, files are maintained for the storage of: (1) surface-water, quality-of-water, and ground-water data measured on a daily or continuous basis; (2) annual peak values for streamflow stations; (3) chemical analyses for surface- and ground-water sites; (4) water parameters measured more frequently than daily; and (5) geologic and inventory data for ground-water sites. In addition, an index file of sites for which data are stored in the system is also maintained (fig. 9.3-1). A brief description of each file is as follows:

Station Header File: All sites for which data are stored in the Daily Values, Peak Flow, Water-Quality, and Unit Values files of WATSTØRE are indexed in this file. It contains information pertinent to the identification, location, and physical description of nearly 220,000 sites.

Daily Values File: All water-data parameters measured or observed either on a daily or on a continuous basis and numerically reduced to daily values are stored in this file. Instantaneous measurements at fixed-time intervals, daily mean values, and statistics such as daily maximum and minimum values also may be stored. This file currently contains over 200 million daily values including data on streamflow, river stages, reservoir contents, water temperatures, specific-conductance, sediment concentrations, sediment discharges, and ground-water levels.

Peak Flow File: Annual maximum (peak) streamflow (discharge) and gage height (stage) values at surface-water sites comprise this file, which currently contains over 400,000 peak observations.

Water-Quality File: Results of over 1.4 million analyses of water samples that describe the chemical, physical, biological, and radiochemical characteristics of both surface and ground waters are contained in this file. These analyses contain data for 185 different constituents.

Unit Values File: Water parameters measured on a schedule more frequent than daily are stored in this file. Rainfall, stream discharge, and temperature data are examples of the types of data stored in the Unit Values File.

Ground-Water Site-Inventory File: This file is maintained within WATSTØRE independent of the files discussed above, but it is cross-referenced to the Water-Quality File and the Daily Values File. It contains inventory data about wells, springs, and other sources of ground water. The data included are site location and identification, geohydrologic characteristics, well-construction history, and one-time field measurements such as water temperature. The file is designed to accomodate 255 data elements and currently contains data for nearly 700,000 sites.

All data files of the WATSTØRE system are maintained and managed on the central computer facilities of the Geological Survey at its National Center. However, data may be entered into or retrieved from WATSTØRE at a number of locations that are part of a nationwide telecommunication network.

Remote Job Entry Sites: Almost all of the Water Resources Division's district offices are equipped with high-speed computer terminals for remote access to the WATSTØRE system. These terminals allow each site to put data into or retrieve data from the system within several minutes to overnight, depending upon the priority placed on the request. The number of remote job entry sites is increased as the need arises.

Digital Transmission Sites: Digital recorders are used at many field locations to record values for parameters such as river stages, conductivity, water temperature, turbidity, wind direction, and chlorides. Data are recorded on 16-channel paper tape, which is removed from the recorder and transmitted over telephone lines to the receiver at Reston, Va. The data are recorded on magnetic tape for use on the central computer. Extensive testing of satellite data collection platforms indicates their feasibility for collecting real-time hydrologic data on a national scale. Battery-operated radios are used as the communication link to the satellite. About 200 data relay stations are being operated currently (1980).

Central Laboratory System: The Water Resources Division's two water-quality laboratories, located in Denver, Colo., and Atlanta, Ga., analyze more than 150,000 water samples per year. These laboratories are equipped to automatically perform chemical analyses ranging from determinations of simple inorganic compounds, such as chlorides, to complex organic compounds, such as pesticides. As each analysis is completed, the results are verified by laboratory personnel and transmitted via a computer terminal to the central computer facilities to be stored in the Water-Quality File of WATSTØRE.

Water data are used in many ways by decision-makers for the management, development, and monitoring of our water resources. In addition to its data processing, storage, and retrieval capabilities, WATSTØRE can provide a variety of useful products ranging from simple data tables to complex statistical analyses. A minimal fee, plus the actual computer cost incurred in producing a desired product, is charged to the requester.

Computer-Printed Tables: Users most often request data from WATSTØRE in the form of tables printed by the computer. These tables may contain lists of actual data or condensed indexes that indicate the availability of data stored in the files. A variety of formats is available to display the many types of data.

Computer-Printed Graphs: Computer-printed graphs for the rapid analysis or display of data are another capability of WATSTØRE. Computer programs are available to produce bar graphs (histograms), line graphs, frequency distribution curves, X-Y point plots, site-location map plots, and other similar items by means of line printers.

Statistical Analyses: WATSTØRE interfaces with a proprietary statistical package (SAS) to provide extensive analyses of data such as regression analyses, the analysis of variance, transformations, and correlations.

Digital Plotting: WATSTØRE also makes use of software systems that prepare data for digital plotting on peripheral offline plotters available at the central computer site. Plots that can be obtained include hydrographs, frequency distribution curves, X-Y point plots, contour plots, and three-dimensional plots.

Data in Machine-Readable Form: Data stored in WATSTØRE can be obtained in machine-readable form for use on other computers or for use as input to user-written computer programs. These data are available in the standard storage format of the WATSTØRE system or in the form of punched cards or card images on magnetic tape.

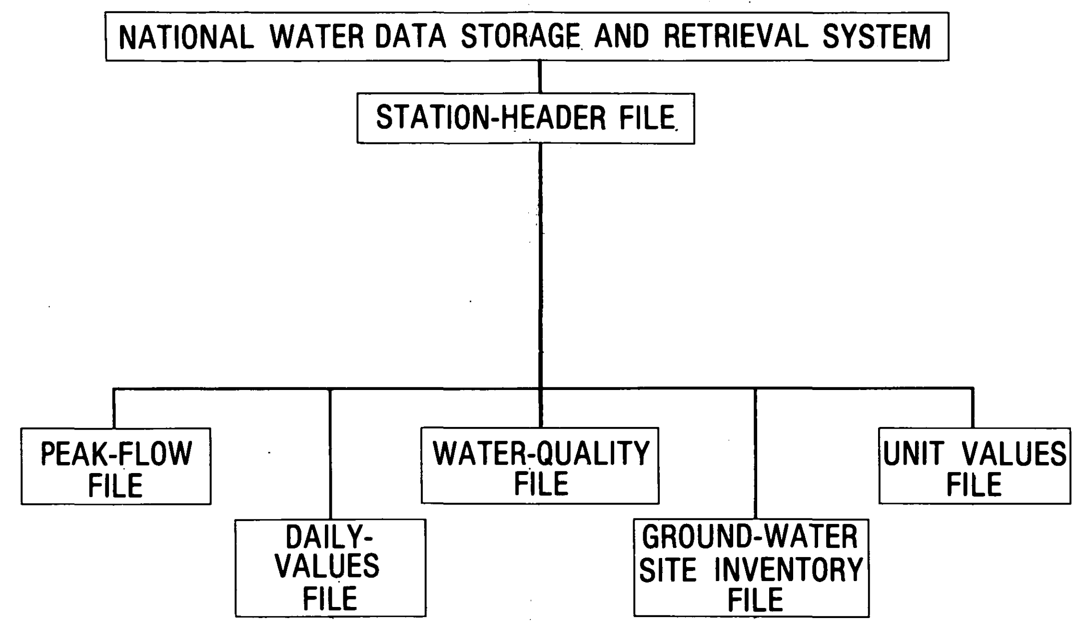


Figure 9.3-1 Index file stored data

Water Data Indexed for Coal Provinces

A special index, "Index to Water-Data Activities in Coal Provinces of the United States," has been published by the U.S. Geological Survey's Office of Water Data Coordination (OWDC).

The "Index to Water-Data Activities in Coal Provinces of the United States" was prepared to assist those involved in developing, managing, and regulating the Nation's coal resources by providing information on the availability of water-resources data in the major coal provinces of the United States. It is derived from the "Catalog of Information on Water Data," which is a computerized information file about water-data acquisition activities in the United States, and its territories and possessions, with some international activities included.

This special index consists of five volumes (fig. 9.4-1): volume I, Eastern Coal province; volume II, Interior Coal province; volume III, Northern Great Plains and Rocky Mountain Coal provinces; volume IV, Gulf Coast Coal province; and volume V, Pacific Coast and Alaska Coal provinces. The information presented will aid the user in obtaining data for evaluating the effects of coal mining on water resources and in developing plans for meeting additional water-data needs. The report does not contain the actual data; rather, it provides information that will enable the user to determine if needed data are available.

Each volume of this special index consists of four parts: Part A, Streamflow and Stage Stations; Part B, Quality of Surface-Water Stations; Part C, Quality of Ground-Water Stations; and Part D, Areal Investigations and Miscellaneous Activities. Information given for each activity in Parts A-C includes: (1) the identification and location of the station, (2) the major types of data collected, (3) the frequency of data collection, (4) the form in which the data are stored, and (5) the agency or organization reporting the activity. Part D summarizes areal hydrologic investigations and water-data activities not included in the other parts of the index. The agencies that submitted the information, agency codes, and the number of activities reported by type are shown in a table.

Those who need additional information from the Catalog file or who need assistance in obtaining water data should contact the National Water Data Exchange (NAWDEX) (See section 9.2).

Further information on the index volumes and their availability may be obtained from:

U. S. Geological Survey
Water Resources Division
Room 202, Oil & Gas Board Bldg.
P. O. Box V
University, AL 35486

Telephone: (205) 752-8104
FTS 229-2957

or

Office of Surface Mining
U. S. Department of the Interior
530 Gay St., Suite 500
Knoxville, TN 37902

Telephone: (615) 637-8060
FTS 852-0060

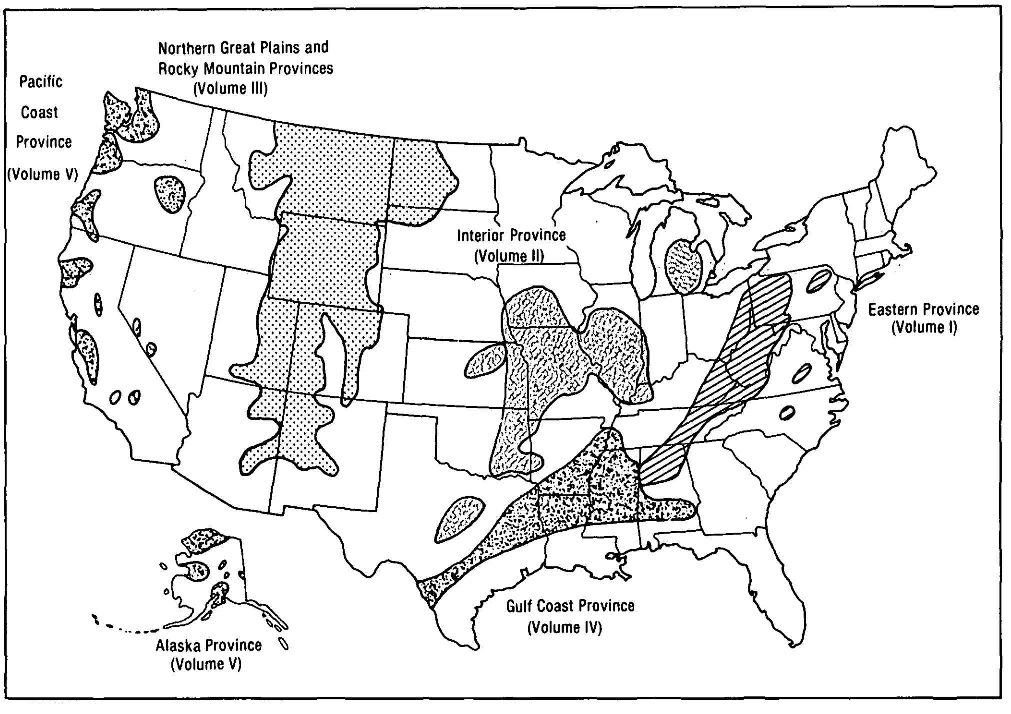


Figure 9.4-1 Index volumes and related provinces

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Appendix 1. Stream Classification Alabama Intrastate Waters

Use Classification of Streams
(in descending order of quality)

PWS	Public water supply	A&I	Agricultural and industrial water supply
S	Swimming and other whole-body water-contact sports	IO	Industrial operations
F&W	Fish and wildlife	N	Navigation

Stream	From	To	Classification(s)
		CAHABA RIVER BASIN	
Cahaba River........	Alabama River	Junction of Lower Little.. Cahaba River	S
Cahaba River........	Junction of Lower Little... Cahaba River	Dam near U.S. Highway 280.	F&W
Cahaba River........	Dam near U.S. Highway 280..	Grant's Mill Road.........	PWS
Cahaba River........	Grant's Mill Road..........	U.S. Highway 11...........	F&W
Cahaba River........	U.S. Highway 11............	Its source................	F&W
Schultz Creek.......	Cahaba River...............	Its source................	S
Little Cahaba River. (Bibb County)	Cahaba River...............	Its source (junction of... Mahan and Shoal Creeks)	F&W
Sixmile Creek.......	Little Cahaba River........	Its source	S
Mahan Creek.........	Little Cahaba River........	Its source................	F&W
Shoal Creek.........	Little Cahaba River........	Its source................	F&W
Caffee Creek........	Cahaba River...............	Its source................	F&W
Shades Creek........	Cahaba River...............	Jefferson County line.....	F&W
Shades Creek........	Jefferson County line......	Shades Creek Sewage....... Treatment Plant	A&I
Shades Creek........	Shades Creek Sewage........ Treatment Plant	Its source................	F&W
Buck Creek..........	Cahaba River...............	Cahaba Valley Creek.......	F&W
Buck Creek..........	Cahaba Valley Creek........	Its source................	A&I
Cahaba Valley Creek.	Buck Creek.................	Its source................	F&W
Peavine Creek.......	Buck Creek.................	Its source................	F&W
Oak Mountain State.. Park Lakes	....	....	PWS

Appendix 1. Stream Classification Alabama Intrastate Waters (continued)

Stream	From	To	Classification(s)
		CAHABA RIVER BASIN--Continued	
Patton Creek.......	Cahaba River................	Its source..............	A&I
Little Shades Creek.	Cahaba River................	Its source..............	F&W
Little Cahaba River. (Jefferson-Shelby Counties)	Cahaba River................	Head of Lake Purdy.......	PWS
Little Cahaba River. (Jefferson County)	Head of Lake Purdy..........	Its source..............	F&W
		WARRIOR RIVER BASIN	
Warrior River.......	Tombigbee River.............	Warrior Lock and Dam.....	S/F&W
Warrior River.......	Warrior Lock and Dam........	Oliver Lock and Dam......	F&W
Warrior River.......	Oliver Lock and Dam.........	Hurricane Creek..........	F&W
Warrior River.......	Hurricane Creek.............	Bankhead Lock and Dam....	S/F&W
Warrior River.......	Bankhead Lock and Dam.......	Junction of Locust and... Mulberry Forks	PWS/S/F&W
Locust Fork.........	Junction of Locust and...... Mulberry Forks	Jefferson County Highway (Maxine)	S/F&W
Wolf Creek..........	Lost Creek..................	Its source..............	F&W
Burnt Cane Creek....	Mulberry Fork...............	County Road 81...........	F&W
Burnt Cane Creek....	County Road 81..............	Its source..............	A&I
Cane Creek (Jasper).	Mulberry Fork...............	Its source..............	A&I
Town Creek..........	Cane Creek..................	Its source..............	A&I
Blackwater Creek....	Mulberry Fork...............	Its source..............	F&W
Locust Fork.........	Jefferson County Highway 61 (Maxine)	Sayre water supply intake	F&W
Locust Fork.........	Sayre water supply intake...	County road between Hayden and county line	PWS/F&W
Locust Fork.........	County road between Hayden.. and county line	Junction of Slab and Clear Creeks	F&W
Mulberry Fork.......	Junction of Locust and...... Mulberry Forks	Burnt Cane Creek (9 miles below Cordova)	PWS/S/F&W

Appendix 1. Stream Classification Alabama Intrastate Waters (continued)

Stream	From	To	Classification(s)
	WARRIOR RIVER BASIN--Continued		
Mulberry Fork........	Burnt Cane Creek (9 miles... below Cordova)	Frog Ague Creek.......... (Cordova)	F&W
Mulberry Fork........	Frog Ague Creek (Cordova)...	Junction of Mulberry and. Sipsey Forks	PWS/F&W
Mulberry Fork........	Junction of Mulberry and.... Sipsey Forks	Its source...............	F&W
North River.........	Warrior River...............	City of Tuscaloosa's water supply reservoir dam	F&W
North River.........	City of Tuscaloosa's water.. supply reservoir dam	Binnion Creek............	PWS/S
North River.........	Binnion Creek..............	Its source................	F&W
Binnion Creek.......	North River................	Its source................	F&W
Cedar Creek.........	North River.................	Its source	F&W
Hurricane Creek.....	Warrior River..............	Its source................	F&W
Yellow Creek........	Warrior River..............	City of Tuscaloosa's water supply reservoir dam	F&W
Yellow Creek........	City of Tuscaloosa's water.. supply reservoir dam	Its source................	PWS
Davis Creek.........	Warrior River..............	Its source................	F&W
Blue Creek..........	Warrior River..............	Its source................	F&W
Big Yellow Creek....	Warrior River..............	Its source................	S/F&W
Valley Creek........	Warrior River..............	Head of backwater above... Bankhead Lock and Dam	F&W
Valley Creek........	Head of backwater above..... Bankhead Lock and Dam	County road crossing 1½... miles northeast of Johns	A&I
Valley Creek........	County road crossing 1½..... miles northeast of Johns	Opossum Creek............	IO
Valley Creek........	Opossum Creek..............	Its source................	A&I
Opossum Creek.......	Valley Creek...............	Its source................	IO
Village Creek.......	Locust Fork................	Bayview Lake.............	A&I

Appendix 1. Stream Classification Alabama Intrastate Waters (continued)

Stream	From	To	Classification(s)
		WARRIOR RIVER BASIN--Continued	
Village Creek........	Bayview Lake................	Its source................	IO
Five Mile Creek......	Locust Fork.................	Coalburg	A&I
Five Mile Creek......	Coalburg....................	Ketona.....................	IO
Turkey Creek.........	Locust Fork.................	Its source................	F&W
Cunningham Branch....	Turkey Creek................	Its source................	F&W
Self Creek...........	Locust Fork.................	Town of Bradford's water.. supply intake	F&W
Self Creek...........	Town of Bradford's water.... supply intake	Its source................	PWS
Gurley Creek.........	Self Creek..................	Its source................	F&W
Lost Creek...........	Mulberry Fork...............	U.S. Highway 124..........	F&W
Lost Creek...........	U.S. Highway 124............	Its source................	A&I
Cane Creek (Oakman)..	Lost Creek..................	Its source................	A&I
Indian Creek.........	Lost Creek..................	Its source................	A&I
		UPPER TOMBIGBEE RIVER BASIN	
Buttahatchee River...	Alabama-MississippiState... line	Lake Buttahatchee Dam.....	F&W
Buttahatchee River...	Lake Buttahatchee Dam.......	Head of backwaters of..... Lake Buttahatchee	S
Buttahatchee River...	Head of backwaters of....... Lake Buttahatchee	Its source................	F&W
Sipsey River.........	Tombigbee River.............	U.S. Highway 43...........	F&W
Sipsey River.........	U.S. Highway 43.............	Alabama Highway 102.......	PWS/F&W
Sipsey River.........	Alabama Highway 102.........	Its source................	F&W
New River............	Sipsey River................	Its source................	F&W
Beaver Creek.........	Buttahatchee River..........	U.S. Highway 78...........	F&W
Beaver Creek.........	U.S. Highway 78............	Its source................	PWS/F&W
Purgatory Creek.....	Beaver Creek................	Its source................	F&W
Camp Creek..........	Buttahatchee River..........	Its source................	F&W
Town Creek..........	Beaver Creek................	Alabama Highway 107.......	F&W
Town Creek..........	Alabama Highway 107.........	Its source................	PWS/F&W
Unidentified........ tributary to Luxapallila Creek	Luxapallila Creek........... at Winfield	Its source................	PWS/F&W
Moore Creek.........	Buttahatchee River..........	Its source................	F&W

Appendix 2. Surface-water stations

Site number (fig. 4.1-1)	Station		Location		Drainage area (mi²)	Period and type of record			
	Number	Name	Latitude ° ' "	Longitude ° ' "		Discharge	Chemical quality	Sediment	Biological
1	02423130	Cahaba River at Trussville, Ala.	33 37 50	086 35 58	....	1964-68,1970	1960, 1967, 1979		
2	02423160	Cahaba River near Whites Chapel, Ala.	33 36 13	086 32 57	....	1975			
3	02423190	Big Black Creek near Leeds, Ala.	33 35 44	086 31 56	41.2		1967, 1979		
4	02423380	Cahaba River near Mountain Brook, Ala.	33 28 54	086 42 46	141				
5	02423390	Cahaba River at pump station near Birmingham, Ala.	33 27 05	086 42 58	137		1970-79		
6	02423398	Little Cahaba River near Leeds, Ala.	33 31 25	086 34 32	18.8	1943-49, 1952-54, 1964	1968, 1979		
7	02423413	Little Cahaba River near Cahaba Heights, Ala.	33 27 04	086 41 29	45.9				
8	02423415	Cahaba River near Homewood, Ala.	33 25 53	086 42 48	....	1967-68	1960, 1967-68		
9	02423425	Cahaba River near Cahaba Heights, Ala.	33 24 56	086 44 23	201	1975-79	1975-79		
10	02423500	Cahaba River near Acton, Ala.	33 21 45	086 48 48	230	1938-57	1949, 1952, 1960		
11	02423555	Cahaba River near Helena, Ala.	33 17 04	086 52 57	334	1965-77	1964-68		
12	02423571	Shades Creek at Elder Street near Springdale, Ala.	33 31 15	086 43 01	9.46	1968-71			
13	02423573	Shades Creek near Mountain Brook, Ala.	33 30 03	086 44 05	14.2	1968, 1971-72			
14	02423580	Shades Creek near Homewood, Ala.	33 27 56	086 46 54	20.8	1968, 1971-72	1967, 1979		
15	02423623	Unnamed tributary to Little Shades Creek near Bessemer, Ala.	33 22 17	086 56 14	....	1967-68	1967		
16	02423625	Shades Creek at Hopewell, Ala.	33 21 17	086 56 12	....	1953-56, 1964, 1967-72	1967		
17	02423630	Shades Creek near Greenwood, Ala.	33 19 34	086 56 59	72.3	1964-79	1965-79		
18	02423639	Mud Creek near Greely, Ala.	33 15 22	087 04 45	8.34		1971		
19	02423647	Cahaba River near West Blocton, Ala.	33 05 53	087 03 10	592	1976-78	1976-79		
20	02423730	Shoal Creek at Montevallo, Ala.	33 05 40	086 51 45	....	1967-68	1967-68		
21	02423785	Mahan Creek near Brierfield, Ala.	33 01 25	086 52 18	....		1968		
22	02423800	Little Cahaba River near Brierfield, Ala.	33 03 27	086 57 10	148	1957-70	1965-70		
23	02423870	Copperas Creek near Six Mile, Ala.	32 58 33	086 53 52	....	1968	1968		
24	02423875	Six Mile Creek near Six Mile, Ala.	32 59 56	086 59 49	....	1948-49, 1953-54, 1968	1960, 1968		
25	02423915	Schultz Creek near West Blocton, Ala.	33 02 03	087 11 41	....	1960, 1968	1968		
26	02423945	Hill Creek near West Blocton, Ala.	33 03 12	087 11 12	....	1968	1968		
27	02424000	Cahaba River at Centreville, Ala.	32 56 42	087 08 21	1,029	1901-08, 1929-32, 1935-78	1960, 1965-79		
28	02437784	Buttahatchee River (below lake) near Hamilton, Ala.	34 06 54	087 42 59	....		1964		
29	02437791	Buttahatchee River near Whitehouse, Ala.	34 06 46	087 43 53	....	1964-67	1964, 1967		
30	02437793	Unnamed tributary to Buttahatchee River near Haleyville, Ala.	34 06 41	087 43 50	....		1965		
31	02437795	West Branch Buttahatchee River at Whitehouse, Ala.	34 07 42	087 44 15	....		1979		
32	02437800	Barn Creek near Hackleburg, Ala.	34 10 00	087 47 00	12.9	1959-73	1965-68		
33	02437805	Barn Creek at U.S. Highway 278 near Hamilton, Ala.	34 08 09	087 48 00	....		1979		
34	02437815	Buttahatchee River near Pearces Mills, Ala.	34 08 10	087 52 10	....	1966-67	1967, 1979		
35	02437825	Camp Creek near Hamilton, Ala.	34 08 50	087 52 10	....	1966-67	1967, 1979		
36	02437850	Clifty Creek near Hamilton, Ala.	34 11 20	087 53 20	....	1966-67	1967		
37	02437868	Williams Creek above Hamilton, Ala.	34 10 13	087 58 50	....	1966-67	1979		
38	02437900	Woods Creek near Hamilton, Ala.	34 07 33	087 54 16	14.1	1959-72	1965-68, 1979		
39	02438000	Buttahatchee River below Hamilton, Ala.	34 06 22	087 58 38	284	1950-78	1956, 1960, 1965-70, 1976-77		
40	02438450	Buttahatchee River at Fulton Bridge, Ala.	34 05 25	088 00 43	....		1979		
41	02438500	Buttahatchee River near Hamilton, Ala.	34 05 12	088 00 52	316	1941-50	1965-67		
42	02438550	Buttahatchee River at Henson Springs, Ala.	34 01 07	088 03 12	....		1979		
43	02438700	Mill Creek near Detroit, Ala.	33 59 24	088 05 12	....		1971		
44	02438710	Spruiell Branch near Detroit, Ala.	33 58 26	088 05 47	....		1971		
45	02438852	Beaver Creek west of Guin, Ala.	33 58 03	087 56 27	....		1979		
46	02438900	Beaver Creek near Beaverton, Ala.	33 56 09	088 01 24	....	1967	1967		
47	02439000	Buttahatchee River near Sulligent, Ala.	33 55 47	088 06 07	472	1939-60, 1971-78	1966-69		
48	02445245	New River near Winfield, Ala.	33 55 47	087 40 47	55.6	1942, 1946-47, 1951-73	1965-68, 1978-79		
49	02445320	Sipsey River near Hubbertville, Ala.	33 50 45	087 43 26	....	1967-68	1967, 1979		
50	02445330	Boxes Creek near Howard, Ala.	33 49 28	087 37 25	7.48		1979		
51	02445400	Sipsey River above Fayette, Ala.	33 45 50	087 45 37	....	1967-68	1967		
52	02445500	Sipsey River at Fayette, Ala.	33 40 10	087 48 59	276	1939-59	1956, 1960,		
53	02446000	Sipsey River at Moores Bridge, Ala.	33 26 54	087 45 50	403	1939-51			
54	02446500	Sipsey River near Elrod, Ala.	33 15 25	087 45 46	518	1928-32, 1939-71, 1978	1956, 1960, 1965-71, 1979		
55	02452540	Mathis Creek near Sumiton, Ala.	33 47 31	087 06 08	2.94				
56	02452600	Blackwater Creek at Ashbank, Ala.	34 00 43	087 30 14	21.1	1966-67	1967		
57	02452660	Splunge Creek at Ashbank, Ala.	34 01 00	087 29 00	....	1966-67	1967, 1979		
58	02452680	Browns Creek at Stone Church, Ala.	34 04 59	087 30 19	6.40	1966-67	1967		
59	02452700	Browns Creek near Ashbank, Ala.	34 00 50	087 27 40	22.3	1967	1967		
60	02452701	Blackwater Creek near Nauvoo, Ala.	34 00 30	087 27 33	....	1966-67	1967, 1979		
61	02452900	Tributary to Spring Creek near Manchester, Ala.	33 56 35	087 18 37	....		1965, 1978		
62	02453000	Blackwater Creek near Manchester, Ala.	33 54 30	087 15 25	188	1938-71	1952, 1956, 1965-72, 1978-79		
63	02453020	Blackwater Creek near Jasper, Ala.	33 53 05	087 09 41	213	1949, 1967-68	1960, 1967, 1978-79		
64	02453050	Mulberry Fork near Argo, Ala.	33 48 25	087 08 25	1,842	1967-68	1967		
65	02453384	Cane Creek at Cameron, Ala.	33 47 54	087 16 35	....		1979		

Appendix 2. Surface-water stations (continued)

Site number (fig. 4.1-1)	Station Number	Station Name	Location Latitude ° ' "	Location Longitude ° ' "	Drainage area (mi²)	Period and type of record: Discharge	Chemical quality	Sediment	Biological
66	02453400	Flat Branch near Jasper, Ala.	33 47 23	087 13 50	2.47	1958-69	1966-69		
67	02453500	Mulberry Fork at Cordova, Ala.	33 45 27	087 10 13	1,914	1890-97, 1900-79	1951		
68	02453700	Mulberry Fork near Highlevel, Ala.	33 39 45	087 10 35	1,980	1967-68	1967		
69	02453828	West Fork Lost Creek near Townley, Ala.	33 50 28	087 27 23	....				
70	02453835	Trinity Creek near Carbon Hill, Ala.	33 54 05	087 33 14	....	1978-79	1978-79	1978-79	
71	02453839	Lost Creek east of Carbon Hill, Ala.	33 53 14	087 29 52	....		1979		
72	02453895	Lost Creek below Carbon Hill, Ala.	33 52 52	087 27 49	....		1979		
73	02453900	Cheatham Creek near Carbon Hill, Ala.	33 53 29	087 26 59	4.70	1967-70	1967-68, 1978-79		
74	02453950	Lost Creek near Jasper, Ala.	33 48 56	087 23 02	115	1942-45, 1949, 1951-70	1966-68, 1972, 1978-79		
75	02454000	Lost Creek near Oakman, Ala.	33 45 50	087 21 30	134	1951-70	1956, 1960, 1965-69, 1978-79		
76	02454065	Unnamed Creek near Oakman, Ala.	33 44 13	087 26 10	....		1965		
77	02454072	Black Branch near Oakman, Ala.	33 44 17	087 24 55	3.30		1975, 1978-79		
78	02454085	Unnamed tributary to Cane Creek near Parrish, Ala.	33 42 19	087 20 35	.51				
79	02454095	Cane Creek near Parrish, Ala.	33 41 15	087 18 50	23.4		1979		
80	02454155	Wolf Creek at Alabama Highway 102 near Townley, Ala.	33 47 21	087 31 20	9.93		1979		
81	02454175	Wolf Creek at Corona, Ala.	33 42 34	087 28 39	....		1979		
82	02454185	Blue Water Creek near Berry, Ala.	33 40 00	087 29 49	....		1979		
83	02454190	Unnamed tributary to Blue Water Creek near Oakman, Ala.	33 39 46	087 25 22	....		1979		
84	02454195	Unnamed tributary to Wolf Creek near Enoe, Ala.	33 40 38	087 23 43	83.9		1978		
85	02454200	Wolf Creek near Oakman, Ala.	33 40 20	087 23 15	85.0	1959-70	1960, 1965-69, 1978-79		
86	02454250	Lost Creek near Goodspring, Ala.	33 38 03	087 15 07	....	1967-68, 1973	1967		
87	02455500	Locust Fork at Trafford, Ala.	33 49 49	086 45 21	624	1930-69	1952, 1965-69, 1974, 1979		
88	02456000	Turkey Creek at Morris, Ala.	33 44 25	086 48 45	80.9	1944-79	1952, 1956, 1965-77, 1979		
89	02456041	Tributary to Turkey Creek west of Morris, Ala.	33 44 51	086 50 10	....				
90	02456045	Tributary to Turkey Creek downstream from Morris, Ala.	33 45 21	086 49 36	.50		1975-77	1976-77	
91	02456050	Turkey Creek upstream from Kimberly, Ala.	33 45 32	086 49 37	84.0		1975-76, 1979	1976-77	
92	02456055	Tributary to Turkey Creek near Kimberly, Ala.	33 45 34	086 49 56	.35		1975-77	1976-77	
93	02456310	Crooked Creek near Mt. Olive, Ala.	33 43 41	086 51 59	11.6		1975-77	1975-76	
94	02456320	Tributary to Crooked Creek near Mt. Olive, Ala. Mt. Olive, Ala.	33 43 43	086 51 54	2.41		1975-76	1975-76	
95	02456322	Crooked Creek downstream from Mt. Olive, Ala.	33 43 45	086 52 00	14.0		1975-76	1975-76	
96	02456327	Tributary to Crooked Creek near Morris, Ala.	33 43 57	086 52 19	1.72		1976-77		
97	02456330	Crooked Creek near Morris, Ala.	33 44 10	086 52 00	16.2	1975-79	1975-79	1975-77	
98	02456500	Locust Fork at Sayre, Ala.	33 42 35	086 59 00	885	1928-32, 1942-79	1965-79		
99	02456900	Fivemile Creek at Fivemile Road near Huffman, Ala.	33 36 29	086 42 00	9.70	1974			
100	02457000	Fivemile Creek at Ketona, Ala.	33 36 05	086 45 20	23.9	1953-79	1952, 1965-69, 1974-79		
101	02457650	Fivemile Creek at Cardiff, Ala.	33 38 37	086 56 00	....		1967, 1978		
102	02457700	Fivemile Creek at Linn Crossing, Ala.	33 40 04	086 57 35	96.2	1965-75	1965-70, 1972-73, 1979		
103	02458000	Locust Fork at Palos, Ala.	33 38 20	087 03 30	1,030	1901-06	1972-74		
104	02458200	Village Creek at Apalachee Street in Birmingham, Ala.	33 32 45	086 47 09	15.6	1971-77			
105	02458300	Village Creek at 24th Street in north Birmingham, Ala.	33 32 33	086 49 03	26.0	1974-77			
106	02458450	Village Creek at Avenue 'W' at Ensley, Ala.	33 31 03	086 52 45	33.5	1975-79	1975-78		
107	02458500	Village Creek at Avenue 'F' at Ensley, Ala.	33 31 15	086 53 21	35.7	1936, 1974-77	1952		
108	02460000	Village Creek near Mulga, Ala.	33 34 21	086 59 33	73.6	1909-10			
109	02460500	Village Creek near Adamsville, Ala.	33 36 20	087 00 25	83.5	1953-71, 1973-79	1965-69, 1972-73, 1975-79		1978
110	02460505	Village Creek at Porter, Ala.	33 37 38	087 03 13	96.6	1972-74	1972-74		
111	02460600	Locust Fork at Powhatan, Ala.	33 35 12	087 06 35	1,152	1967-68	1960, 1967		
112	02460700	Short Creek at Short Creek, Ala.	33 33 15	087 05 39	....		1965		
113	02461200	Valley Creek at Cleburne Avenue near Powderly, Ala.	33 28 08	086 53 16	20.1	1974			
114	02461450	Oppossum Creek near Rutledge Springs, Ala.	33 27 52	086 56 45	....		1975		
115	02461500	Valley Creek near Bessemer, Ala.	33 25 09	086 58 58	52.5	1946-48, 1974-79	1974-79		
116	02462000	Valley Creek near Oak Grove, Ala.	33 26 50	087 07 20	145	1954-79	1952, 1965-70, 1972-79		
117	02462025	Lost Creek near Pleasant Grove, Ala.	33 30 22	086 59 46	....		1969		
118	02462040	Rock Creek near Hopkins, Ala.	33 29 01	087 06 14	....	1967-68	1967, 1978-79		
119	02462050	Valley Creek at Toadvine Road near Oak Grove, Ala.	33 29 32	087 09 47	....		1979		
120	02462080	Mud Creek near Oak Grove, Ala.	33 27 38	087 11 52	....		1960, 1967, 1978-79		

Site number (fig. 4.1-1)	Station Number	Station Name	Location Latitude ° ' "	Location Longitude ° ' "	Drainage area (mi²)	Period and type of record: Discharge	Chemical quality	Sediment	Biological
121	02462255	Unnamed tributary to Walker County Shoal Creek, Ala.	33 34 21	087 17 49	....		1978-79		
122	02462257	Tributary to unnamed tributary to Walker County Shoal Creek, Ala.	33 34 24	087 17 52	....		1978-79		
123	02462480	Big Yellow Creek near Whitson, Ala.	33 34 18	087 24 10	14.4	1973-74	1960, 1967, 1979		
124	02462490	Little Yellow Creek near Whitson, Ala.	33 34 01	087 24 37	15.0	1973-74	1976-77, 1979		
125	02462500	Black Warrior River at Bankhead Lock and Dam near Bessemer, Ala.	33 27 30	087 21 15	3,979	1928-36, 1973, 1976-78	1976, 1979		
126	02462501	Black Warrior River below Bankhead Lock and Dam near Bessemer, Ala.	33 27 24	087 21 20	39.7	1911-78	1979		
127	02462600	Blue Creek near Oakman, Ala.	33 31 17	087 29 07	5.32	1959-73 1976-79,	1960, 1966-67, 1976-79	1977-79	1977-79
128	02462625	Blue Creek near Windham Springs, Ala.	33 29 02	087 28 18	....		1976-77, 1979		
129	02462650	Blue Creek near Spencer Hill, Ala.	33 27 01	087 24 51	37.4	1973-74	1975-77, 1979		
130	02462685	Davis Creek at Abernant, Ala.	33 17 13	087 11 50	17.2	1956-59	1975, 1979		
131	02462800	Davis Creek below Abernant, Ala.	33 18 30	087 13 10	45.2	1956-73	1956-57, 1965-71, 1979		
132	02462805	Hannah Mill Creek near Brookwood, Ala.	33 17 18	087 16 59	....		1965		
133	02462812	Hannah Mill Creek near Burchfield, Ala.	33 19 32	087 15 23	....		1978-79		
134	02462830	Cane Creek near Burchfield, Ala.	33 21 17	087 17 37	....		1978		
135	02462840	Davis Creek near Antioch Church near Searles, Ala.	33 23 20	087 18 30	....	1973-74	1979		
136	02462941	Tributary to Rocky Branch near Peterson, Ala.	33 15 48	087 23 58	.11		1977	1977	
137	02462952	Black Warrior River below Holt Lock and Dam near Holt, Ala.	33 15 16	087 26 21	....	1966-78	1979		
138	02462970	Yellow Creek near Windham Springs, Ala.	33 25 23	087 27 49	....		1976-77, 1979		
139	02462973	Tributary to Yellow Creek near Windham Springs, Ala.	33 25 07	087 27 21	....		1976-77, 1979		
140	02462980	Yellow Creek above Northport, Ala.	33 23 26	087 28 30	3.64	1977-79	1976-79	1977-79	1977-79
141	02462985	Tributary to Yellow Creek near Northport, Ala.	33 23 18	087 27 51	2.49	1977-79	1976-79	1977-79	1977-79
142	02462990	Yellow Creek near Northport, Ala.	33 22 23	087 28 26	8.23	1976-79	1976-79	1977-79	1977-79
143	02462991	Tributary to Yellow Creek above Watermelon Road near Tuscaloosa, Ala.	33 21 38	087 27 39	....	1977-79	1977-79	1977-79	1977-79
144	02462992	Yellow Creek at Watermelon Road near Tuscaloosa, Ala.	33 21 36	087 27 40	....		1977		
145	02463090	Cypress Creek near Holt, Ala.	33 15 38	087 27 58	....		1977, 1979		
146	02463200	Hurricane Creek near Cedar Cove, Ala.	33 13 15	087 19 00	29.0	1957-60	1957, 1975, 1978-79		
147	02463500	Hurricane Creek near Holt, Ala.	33 13 45	087 26 55	108	1942-45, 1949, 1952-69	1956, 1960, 1965-69, 1975, 1978-79		
148	02463540	North River near Philadelphia, Ala.	33 46 06	087 36 05	13.1		1967		
149	02463545	North River below Lowery Branch above Berry, Ala.	33 45 36	087 36 36	....		1979		
150	02463575	Cane Creek near Pea Ridge, Ala.	33 42 13	087 33 32	1.80				
151	02463580	Unnamed tributary to Cane Creek near Pea Ridge, Ala.	33 42 45	087 34 03	....		1978-79		
152	02463585	Cane Creek near Berry, Ala.	33 42 00	087 35 19	....		1979		
153	02463605	Ellis Creek near Cleveland, Ala.	33 42 09	087 38 18	....		1978-79		
154	02463607	Unnamed tributary to Ellis Creek near Cleveland, Ala.	33 42 06	087 38 45	.09		1978		
155	02463610	Ellis Creek near Berry, Ala.	33 41 25	087 37 27	....		1978		
156	02463670	Clear Creek near Bankston, Ala.	33 40 41	087 39 36	....		1967		
157	02463700	North River near Berry, Ala.	33 37 50	087 38 47	....		1960, 1967		
158	02463835	Unnamed tributary to North River near New Lexington, Ala.	33 33 55	087 38 42	....		1978-79		
159	02463840	Little Tyro Creek near Sandtown, Ala.	33 36 02	087 30 25	.26		1976-77, 1979		
160	02463850	Tyro Creek near New Lexington, Ala.	33 33 58	087 34 34	23.0		1967, 1976-77; 1979		
161	02463880	Tributary to Bear Creek near Samantha, Ala.	33 33 49	087 32 12	3.02		1976, 1979		
162	02463890	Dry Branch near Samantha, Ala.	33 32 33	087 32 22	.72	1977-79	1976-79	1977-79	1977-79
163	02463900	Bear Creek near Samantha, Ala.	33 32 33	087 33 43	15.0	1976-79	1976-79	1977-79	1977-79
164	02464000	North River near Samantha, Ala.	33 28 45	087 35 50	219	1938-57, 1968-79	1966-79		
165	02464020	Johnson Branch near Utley, Ala.	33 30 32	087 32 24	2.71		1976-77, 1979		
166	02464025	Cripple Creek near Samantha, Ala.	33 29 34	087 33 46	....		1976-77, 1979		
167	02464035	Cripple Creek east of Samantha, Ala.	33 28 25	087 34 06	....	1977-79	1977-79	1977-79	1977-79
168	02464143	Tributary to Turkey Creek near Tuscaloosa, Ala.	33 23 55	087 29 11	....		1976-77, 1979		
169	02464145	Turkey Creek near Tuscaloosa, Ala.	33 24 32	087 30 45	6.13	1977-79	1960, 1976-79	1977-79	1977-79
170	02464150	Turkey Creek near Samantha, Ala.	33 23 45	087 33 45	....		1967		
171	02464313	Barbee Creek near New Lexington, Ala.	33 31 47	087 39 30	....		1977, 1979		
172	02464317	Barbee Creek near Samantha, Ala.	33 30 27	087 38 48	....		1977, 1979		
173	02464360	Binion Creek below Gin Creek near Samantha, Ala.	33 25 59	087 38 33	....		1979		
174	02464380	Binion Creek near Samantha, Ala.	33 24 33	087 36 48	....		1960, 1967, 1970		
175	02464500	North River near Tuscaloosa, Ala.	33 21 10	087 33 25	386	1952-69	1956, 1960, 1965-68		
176	02464640	Carroll Creek near Brownville, Ala.	33 20 23	087 39 26	....		1979		
177	02464800	Lake Tuscaloosa reservoir near Tuscaloosa, Ala.	33 16 54	087 31 06	....		1979		
178	02465000	Black Warrior River at Northport, Ala.	33 12 50	087 34 25	4,828	1889-1905, 1928-79	1908, 1952, 1960, 1965-79		
179	02465004	Black Warrior River at Oliver Lock near Tuscaloosa, Ala.	33 12 50	087 34 25	....	1944			
180	02465005	Black Warrior River below Oliver Lock and Dam near Tuscaloosa, Ala.	33 13 00	087 34 00	4,828	1939-78			

Appendix 3. Ground-water stations

Site number (fig. 4.2-1)	Site identification number	Local number	Formation tapped	Period of record and frequency of measurement[1]	
1	333351086313401	Z-4	Ordovician Limestone	1961-80	P
2	333758086354201	L-5	Ft. Payne Chert	1968-80	P
3	333137086430801	W-14	Bangor Limestone	1975-80	P
4	332108086431001	J-15	Ft. Payne Chert	1968-80	P
5	334914086443201	B-1	Pottsville	1968-80	P
6	332605086523001	Jef-1	Bangor Limestone	1954-80	R
7	332000086561901	LL-9	Ft. Payne Chert	1968-80	P
8	325117086575001	T-6	Coker	1967-80	P
9	325622087075501	Bib-1	Cambrian and Ordovician Dolomite	1948-80	R
10	335403087160801	I-2	Pottsville	1968-76	P
11	334127087215701	TW-23	Pottsville	1979-80	P
12	334346087265101	TW-22	Pottsville	1979-80	P
13	333226087275301	TW-3	Pottsville	1978-80	P
14	332251087280001	Barger 109	Coker	1978-80	R
15	332424087261401	TW-11	Pottsville	1978-80	P
16	332549087261401	TW-14	Pottsville	1978-80	R
17	332155087270201	TW-10	Pottsville	1979-80	R
18	332413087270701	TW-2	Coker	1978-80	P
19	333500087303601	TW-13	Pottsville	1978-80	P
20	333344087291001	TW-4	Pottsville	1978-80	R
21	333220087293901	Zennah No. 50	Pottsville	1977-80	R
22	333157087294501	TW-28	Pottsville	1978-80	P
23	332859087330701	TW-30	Pottsville	1978-80	P
24	332603087275001	TW-15	Coker	1978-80	R
25	332441087271301	TW-17	Pottsville	1978-80	R
26	332248087283901	TW-25	Pottsville	1978-80	P
27	332224087282701	TW-26	Pottsville	1978-80	R
28	333206087302801	TW-12	Pottsville	1979-80	P
29	332604087290201	TW-27	Pottsville	1978-80	P
30	332534087295901	TW-9	Pottsville and Coker	1979-80	P
31	332425087284501	TW-18	Pottsville	1978-80	P
32	332411087275101	TW-16	Coker	1978-80	R
33	332504087285601	TW-24	Coker	1979-80	R
34	332215087291301	TW-1	Coker	1978-80	P
35	334645087324201	TW-31	Pottsville	1979	P
36	334315087320001	TW-21	Pottsville	1979-80	P
37	334131087344201	TW-20	Pottsville	1979-80	P
38	333451087331501	TW-8	Pottsville	1978-80	R
39	333322087335701	TW-7	Pottsville	1978-80	R
40	333204087324601	TW-5	Pottsville	1978-80	R
41	333144087330401	TW-6	Pottsville	1978-80	P
42	332917087284101	TW-29	Pottsville	1978-80	P
43	334151087362001	TW-19	Pottsville	1979-80	P
44	331239087323601	Tus-1	Coker	1952-80	R
45	335948087355101	TW-34	Pottsville	1979	P
46	335754087385101	TW-33	Pottsville	1979	P
47	335220087413001	TW-32	Pottsville	1979	P
48	332646087474301	E-20	Coker	1957-80	P
49	335803087551301	MAR-1	Pottsville	1952-80	R

1/ R - recorded
P - periodic

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