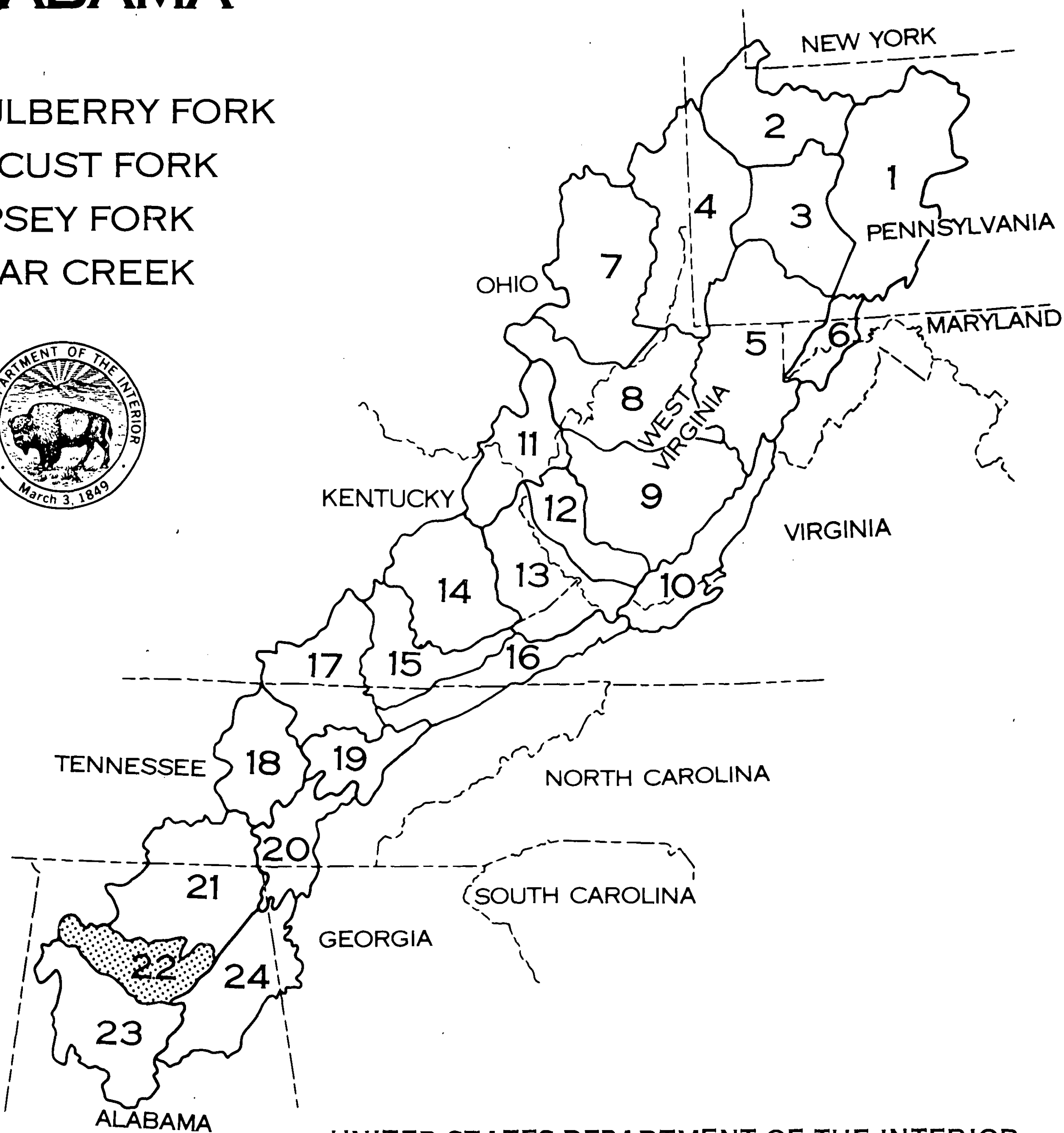
HYDROLOGY OF AREA 22, EASTERN COAL PROVINCE, ALABAMA

- MULBERRY FORK
- LOCUST FORK
- SIPSEY FORK
- BEAR CREEK



UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

WATER-RESOURCES INVESTIGATIONS
OPEN-FILE REPORT 81-135

HYDROLOGY OF AREA 22, EASTERN COAL PROVINCE, ALABAMA

BY
JOE R. HARKINS AND OTHERS

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TUSCALOOSA, ALABAMA
MARCH 1981

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 International System of Units (SI), the data may be converted by using the following factors:

Multiply the inch-pound units	By	To obtain the 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)
acre	0.4047	square hectometers (hm^2)
acre feet	1233	cubic meters (m^3)
gallons per minute (gal/min)	0.06309	liters per second (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 [$(ton/mi^2)/yr$]	0.03753	metric tons per square kilometer per year [$(t/km^2)/yr$]

HYDROLOGY OF AREA 22, EASTERN COAL PROVINCE, ALABAMA

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ABSTRACT

The Eastern Coal Province is divided into 24 hydrologic reporting areas. Area 22 is located near the southern end of the Eastern Coal Province, in the Mobile and Tennessee River basins. It includes part of the Plateau and the northern edge of the Warrior coal fields in Alabama, and covers an area of 2,495 square miles.

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

The area is underlain by the Cretaceous Tuscaloosa Group (Gordo and Coker Formations), Pennsylvanian Pottsville Formation, and pre-Pennsylvanian rocks. The Pottsville Formation, containing the coal beds, underlies about 85 percent of the Area, including all of the central part. Pre-Pennsylvanian rocks are exposed in two valleys along the eastern side of the Area and the Tuscaloosa Group overlies the Pottsville Formation and the pre-Pennsylvanian rocks along the western side.

The Area lies in four stream basins, the Mulberry and Locust Forks of the Black Warrior River and Bear Creek, which is a tributary to the Tennessee River. Sipsey Fork, the largest basin, is a tributary to Mulberry Fork. Mulberry Fork basin is underlain almost entirely by the coal-bearing rocks of the Pottsville Formation. Sipsey Fork, principal tributary to Mulberry Fork, and most of it's tributaries flow into Lewis Smith Lake. The outflow of the lake is regulated by hydropower generating turbines. Locust Fork drains the eastern side of the Area. It's basin contains part of two valleys of pre-Pennsylvanian rocks. Bear Creek and it's tributaries drain the western edge of the Area where the Tuscaloosa Group overlies the Pottsville Formation or the pre-Pennsylvanian rocks.

The Area has a moist temperate climate with an annual rainfall that ranges from 56 inches in the southern part to 52 inches along the western edge. The majority of the Area is covered by forest and the soils have a high erosion potential when 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 largest uses of water are for hydroelectric power generation, and industrial and municipal supplies for use outside the Area (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 74 surface-water stations, 13 observation wells, and 4 springs. 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) as well as in published reports.

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 per square mile per year from areas not affected by mining to 300,000 tons per square mile per year 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 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 although 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 22 Report Submitted in Support of Public Law 95-87

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

This report provides broad hydrologic information, using a brief text on an accompanying map, chart, graph, or other illustrations for each of a series of water-resources related topics. The summation of the topical discussions 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 in the preparation of permits and regulatory authorities in appraising the adequacy of permit applications.

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, August 3, 1977. The Act established a new Federal agency, Office of Surface Mining Reclamation and Enforcement (OSM), within the U.S. Department of the Interior, 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 authorities to administer and enforce State laws 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 " and (3) that measures be taken by mining permittees to control adverse effects of mining on the "hydrologic balance" and reclamation of the land.

This report broadly characterizes the hydrology of Area 22 in Alabama as delineated in figure 1.1-1. The hydrologic information presented or available through sources identified in this report, may be used in describing the hydrology of the "general area" of any proposed mine. Furthermore, it is expected that this hydrologic information will be supplemented by the lease applicant's specific site data as well as data from other sources to provide a more detailed picture of the hydrology of the area in the vicinity of the mine and the anticipated hydrologic consequences of the mining operation.

Figure 1.1-1 Location Map

1.0 INTRODUCTION

1.1 OBJECTIVE

Area 22 is Located in Southern Part of Eastern Coal Province

Area 22 includes 2495 square miles of which 2194 square miles are in the Black Warrior River basin and 301 square miles are in the Bear Creek basin.

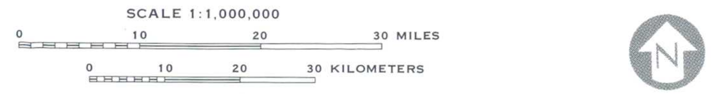
The Eastern Coal province is divided into 24 hydrologic reporting areas. The division is based on hydrologic factors, location, size, and mining activity. Hydrologic units (drainage basins) or parts of units are combined to form each area (see front cover for areas in the Eastern Coal province). The drainage basins in Area 22 are shown in figure 1.2-1.

Area 22 is near the southern end of the Eastern Coal province in Alabama. The area, which includes parts of Etowah, Blount, Marshall, Cullman, Walker, Winston, Lawrence, Franklin, and Marion Counties, lies within the Mobile River basin except for the area in Franklin County, a small area in the western edges of Lawrence and Winston Counties, and the northern edge of Marion County which drain to the Tennessee River by way of Bear Creek.

Area 22 includes 2495 mi^2 and encompasses the upper part of the Black Warrior River basin and the headwater area for Bear Creek. It includes the basins of Locust and Mulberry Forks of the Black Warrior River from Trafford to the headwaters of Locust Fork and from Empire to the headwaters of Mulberry Fork. The basin of Sipsey Fork, a tributary to Mulberry Fork, is the largest single basin in Area 22 and contains Lewis Smith Lake with a surface area of 33.1 mi^2 (21,200 acres). The mouth of the Sipsey Fork is also in Area 22. The headwater area of Bear Creek basin is drained by Bear Creek and two tributaries, Cedar and Little Bear Creeks.

Area 22 covers most of the southern end of the Plateau Coal Field and a small part of the Warrior Coal Field along the southern edge of the Area (fig. 1.2-2). The Area also includes the southern end of the Sequatchie Valley and almost all of Murphrees Valley. These valleys extend across the Area in a northeast-southwest direction across the eastern side and are not a part of the coal fields.

The Cumberland Plateau section of the Appalachian Plateaus province comprises most of Area 22 (fig. 1.2-3). The eastern half of Franklin County lies in three physiographic regions; the Highland Rim section of the Interior Low Plateaus province, the Cumberland Plateau section of the Appalachian Plateaus province, and East Gulf Coastal Plain of the Coastal Plain province.



EXPLANATION

—●●——●●— Basin boundary

—●●——●●— Subbasin boundary

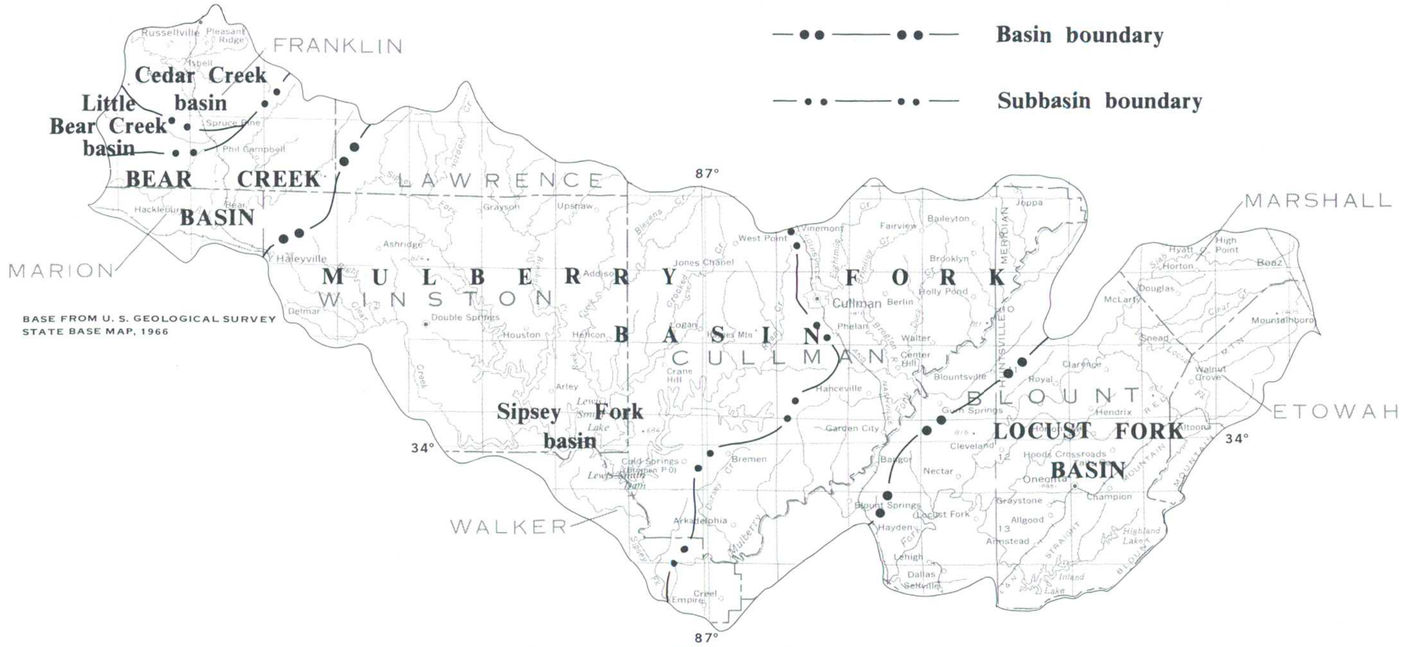


Figure 1.2-1 Drainage basins.

EXPLANATION

Coal Fields

Plateau Field

Warrior Field

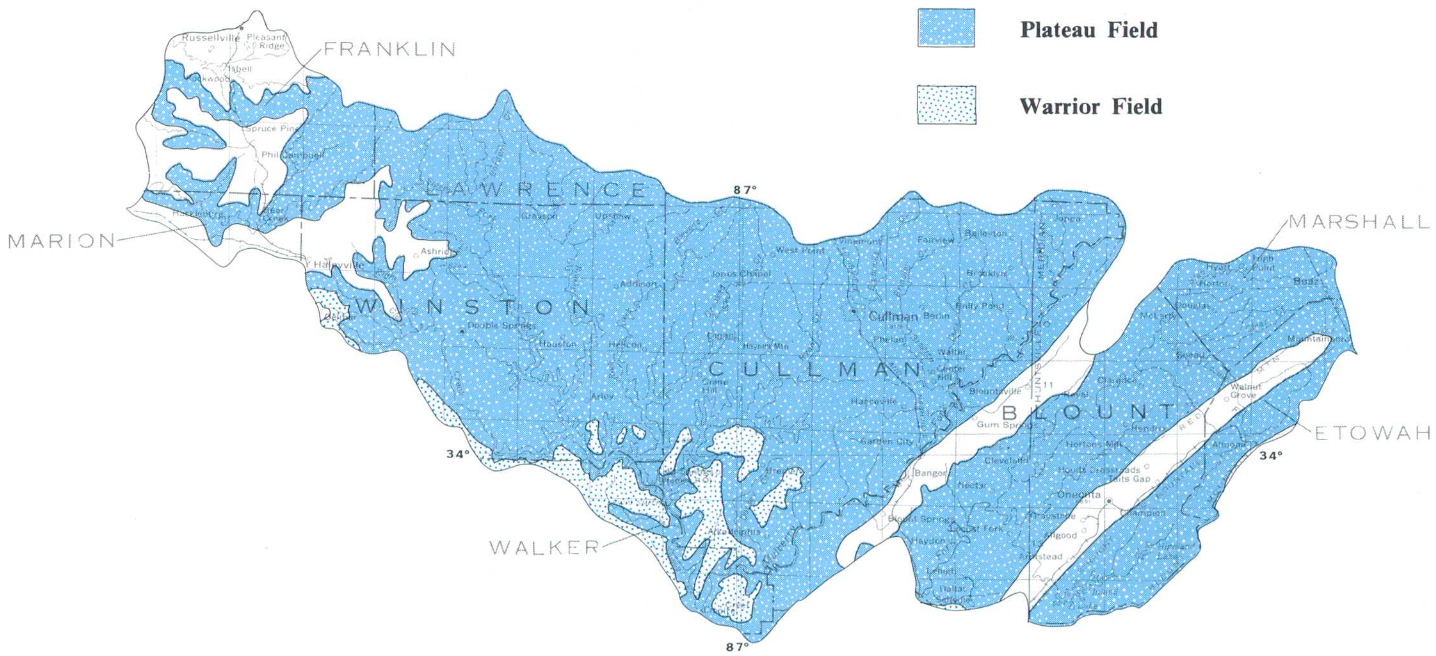


Figure 1.2-2 Coal fields.

EXPLANATION

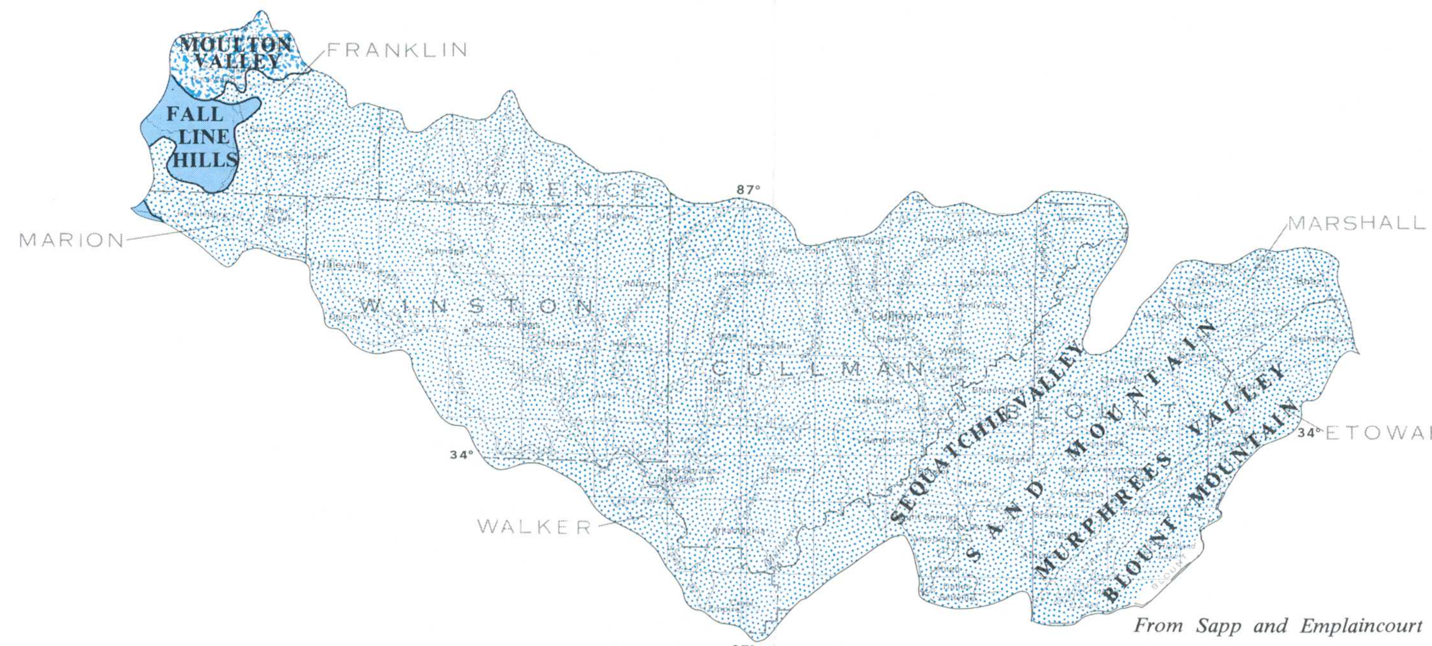
Physiographic Divisions

Highland Rim section
(Interior Low Plateaus province)

Cumberland Plateau section
(Appalachian Plateaus province)

East Gulf Coastal Plain section
(Coastal Plain province)

Location of Area 22 in Alabama



From Sapp and Emplaincourt (1975)

Figure 1.2-3 Physiographic divisions.

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, diversion of drainage, and degradation of water quality are typical problems associated with surface coal mining.

Surface mining drastically alters 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 increases the potential for erosion and sedimentation (fig. 1.3-1). Average annual sediment yields for streams draining relatively undisturbed basins in Area 22 generally range from 20 to 800 (tons/mi^2)/yr. 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 include excessive sediment deposition in streams and reservoirs which in turn increases the cost of maintaining navigation channels and treating industrial and domestic water. Examples of extreme erosion and sediment deposition that have occurred in adjacent Area 23 are shown in figure 1.3-1. Sediment deposition in Locust Fork of the Black Warrior River near Sayre has resulted in an alteration of the aquatic habitat, increased flooding due to filling of the stream channel by sediment, and reduction of aesthetic value in recreation areas (fig. 1.3-1). Sediment deposition at Lake Harris, a municipal water-supply source for the city of Tuscaloosa, has reduced reservoir storage capacity (fig. 1.3-2).

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. A hypothetical diagram illustrating water-level declines resulting from surface mining is shown in figure 1.3-3. The water level declines could be temporary or permanent depending on depth of excavation and subsequent reclamation.

The alteration of natural topography by surface mining commonly diverts drainage. Such diversion alters the streamflow characteristics (Knight and Newton, 1977). Diversion of drainage is illustrated by the hypothetical diagrams shown in fig. 1.3-4.

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 quantities of soluble mineral salts. Water draining such a mined area generally has low pH values (2.5-5.0 units), high sulfate, and high dissolved-solids concentrations. The acidic water reacts with other minerals and commonly increases trace-element concentrations including aluminum, 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.

Figure 1.3-1 Spoil banks along Locust Fork of Black Warrior River near Sayre, Jefferson County.

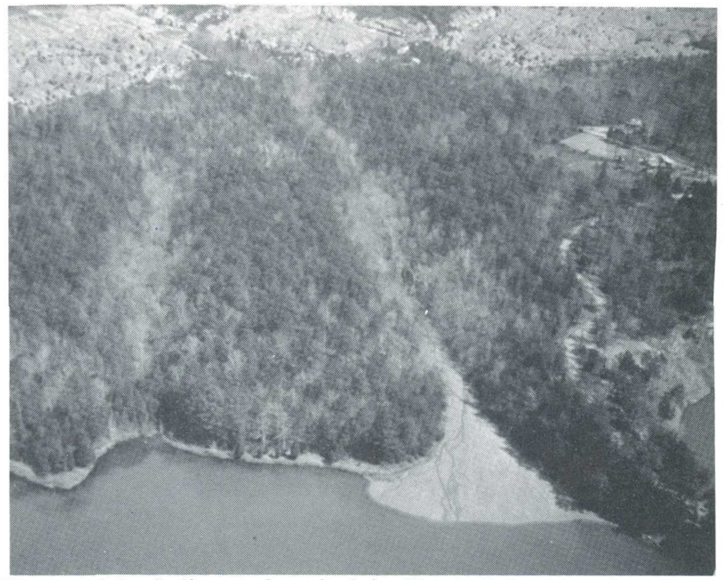


Figure 1.3-2 Sediment deposited in Harris Lake, Tuscaloosa County.

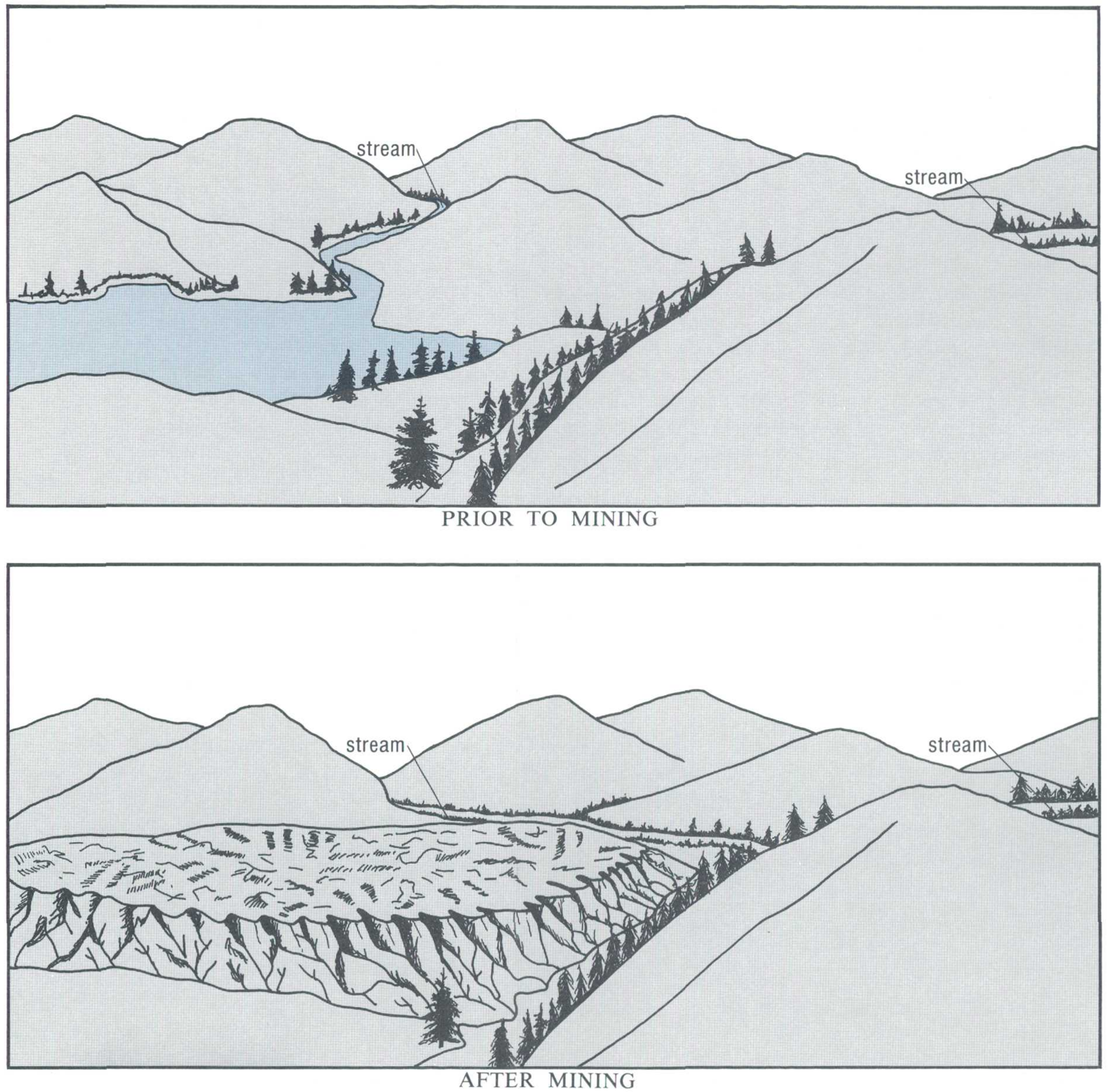


Figure 1.3-4 Possible disruption of drainage patterns resulting from mining operations.

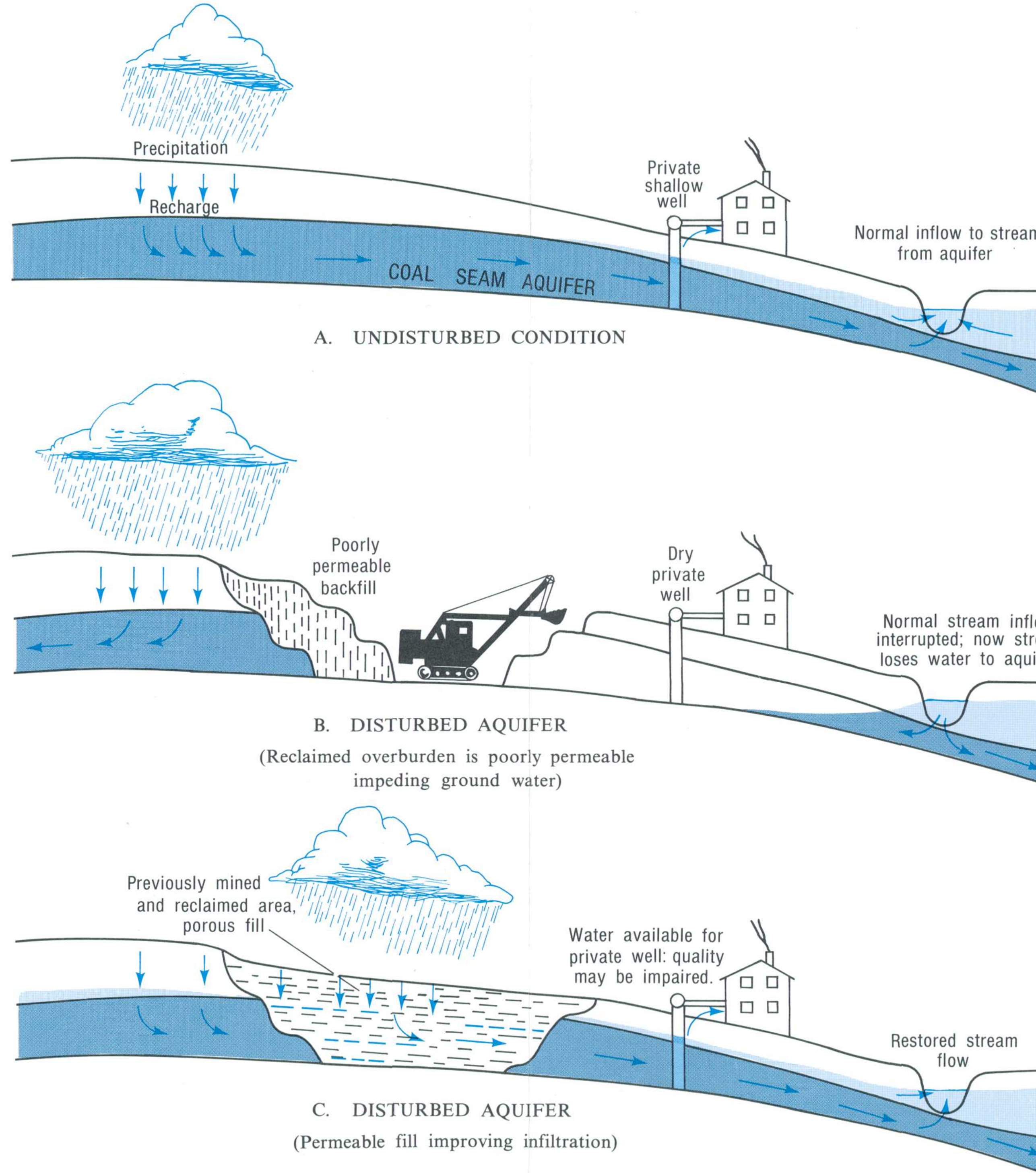


Figure 1.3-3 Possible impacts of mining aquifers

Three Geologic Units Underlie the Area

Area 22 is underlain by three principal geologic units: the Pottsville Formation, which contains the coal beds; the undifferentiated pre-Pennsylvanian rocks; and the Tuscaloosa Group.

The Pottsville Formation of Pennsylvanian age underlies about 85 percent of Area 22, including all of the central part of the Area. Undifferentiated pre-Pennsylvanian rocks occupy two valleys in the eastern part of the Area and also crop out in the west. The Coker and Gordo Formations of the Tuscaloosa Group of Late Cretaceous age cap the hills in the western part (fig. 2.1.1). The outcrop area of the Pottsville Formation includes parts of two coal fields, the Plateau and the Warrior.

The geologic structure in Area 22 is most complex in the east, where the strata are folded and faulted to form northeast-southwest trending anticlines and synclines. The anticlines have eroded to form the topographic lows of Sequatchie Valley and Murphrees Valley. The synclinal troughs form Sand Mountain and Blount Mountain capped by the erosion-resistant sandstones of the Pottsville Formation. Elsewhere in the Area the strata dip southwestward 30 to 200 ft/mi.

The Pottsville Formation consists chiefly of alternating beds of gray sandstone, conglomerate, siltstone, and shale with beds of coal and underclay. The formation generally becomes thicker to the south because (1) the regional dip to the southwest is greater than the southward slope of the land surface preserving younger beds to the southwest, and (2) the beds of the formation thicken and increase in number to the south and southeast. Thickness of the Pottsville Formation within Area 22 ranges from 210 feet at the northern boundary (Faust and Jefferson, 1980) to 1,400 feet on Blount Mountain in the southeast (Culbertson, 1964). Blount Mountain is located on the downthrown side of a thrust fault which contributes in part to the greater thickness there (see eastern geologic structure section, fig. 2.1-1). In northern Walker County on the southern boundary of the Area, the Pottsville is 1,100 feet thick (McGlamery, 1955). The thickest and most productive coal beds are found in the upper part of the Pottsville above the base of the Black Creek coal bed (Adams, 1926). The outcrop of the Black Creek coal bed generally is considered the boundary between the Plateau Coal Field to the north and the Warrior Coal Field to the south (Mining Information Series, 1978). Lithology is difficult to correlate regionally. Generalized vertical sections showing coal beds are shown in figure 2.1-2.

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 Sequatchie Valley and Murphrees Valley in the eastern part of the area and in smaller stream valleys in the western part.

The Coker and Gordo Formations of the Tuscaloosa Group unconformably overlie the pre-Pennsylvanian rocks and the Pottsville Formation in the western part of the Area. The Coker is the older of the two formations and usually is present below the Gordo. However, in most of the Tuscaloosa Group outcrop in Area 22, the Gordo overlaps the Coker and rests on the Pottsville Formation. The base of the Coker dips toward the southwest about 30 ft/mi; the base of the Gordo dips southwestward about 25 ft/mi (Causey, 1972). Both formations consist of unconsolidated sand, gravel, and clay with the major gravel beds near the base of each formation. Thickness of the Tuscaloosa Group in Area 22 varies from zero feet at the Pottsville contact to about 50 feet at the western boundary of the area.

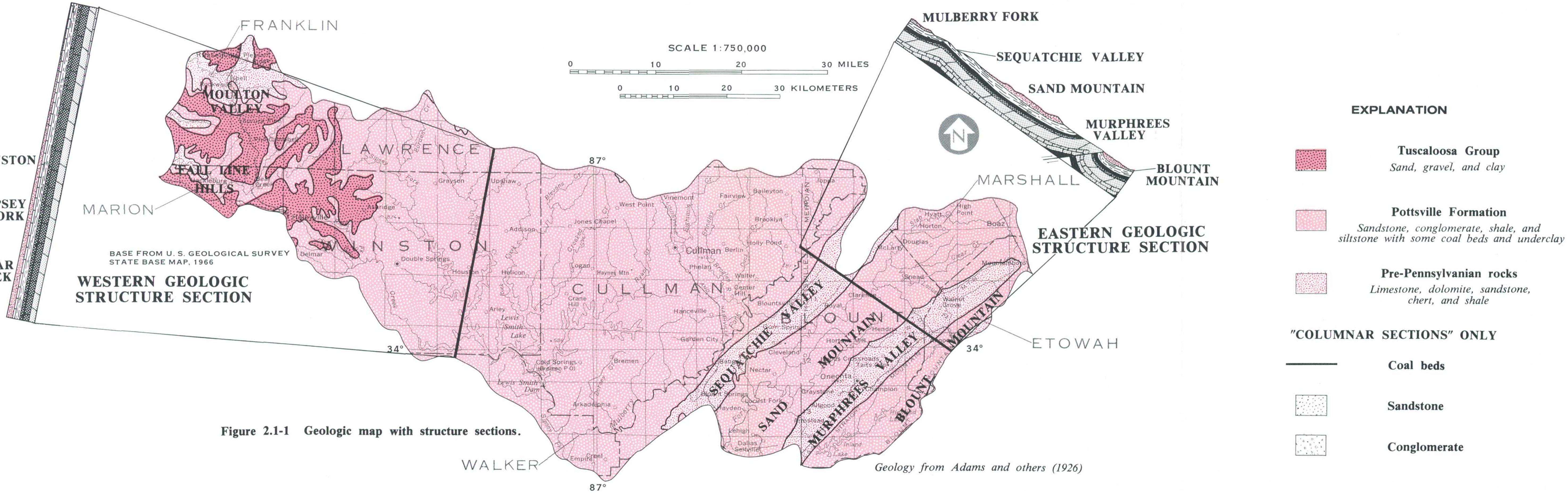
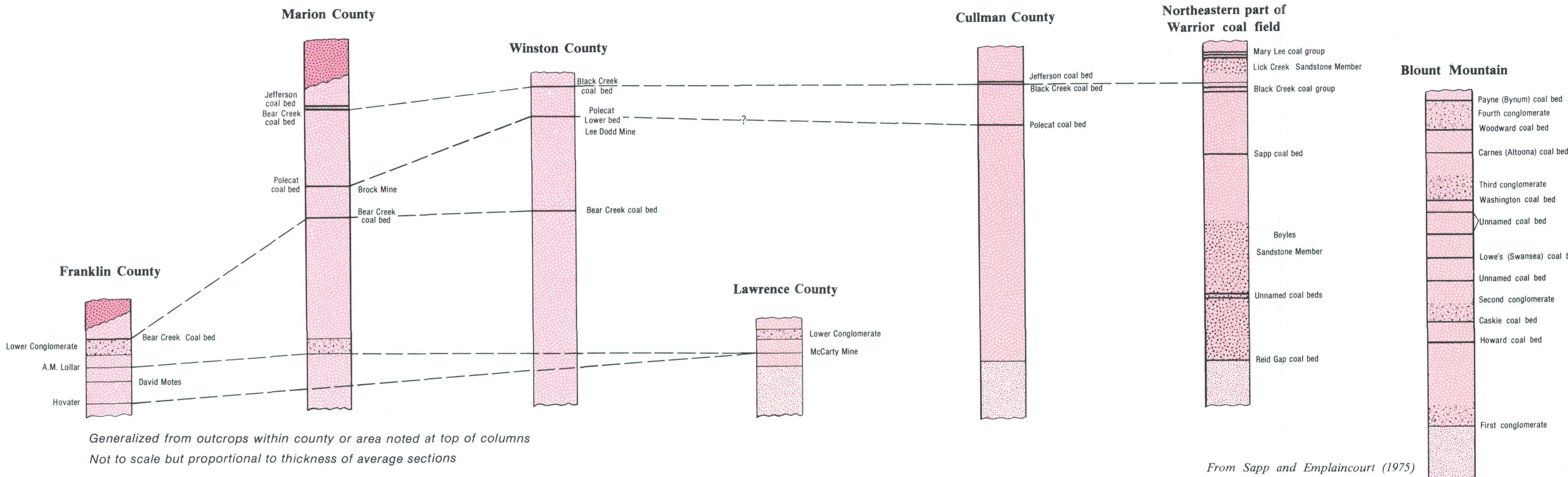


Figure 2.1-1 Geologic map with structure sections.



Generalized from outcrops within county or area noted at top of columns
Not to scale but proportional to thickness of average sections

From Sapp and Emplaincourt (1975)
Generalized from outcrops within county or area noted.

Figure 2.1-2 Generalized columnar sections showing possible relationships of coal beds.

Area 22 Within Three Physiographic Provinces

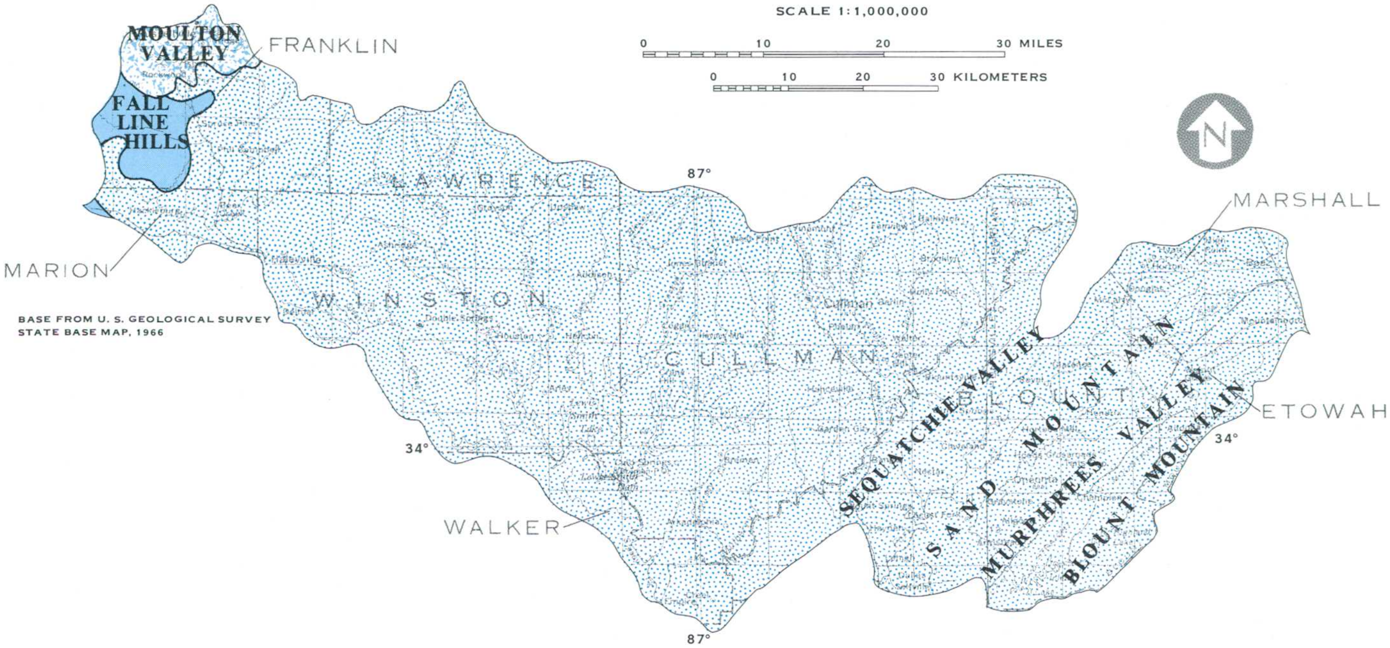
Area 22 lies within three physiographic provinces: Appalachian Plateaus, Interior Low Plateaus, and Coastal Plain.

Most of Area 22 lies within the Cumberland Plateau section of the Appalachian Plateaus physiographic province. Two other provinces are represented in the area: the Highland Rim section of the Interior Low Plateaus province and the East Gulf Coastal Plain section of the Coastal Plain province (fig. 2.2-1).

The surface of the Cumberland Plateau section is generally higher than that of adjacent provinces. Most of the Plateau is underlain by the Pottsville Formation which contains massive sandstone beds. These beds resist erosion and form escarpments along the edges of the Plateau. In Area 22, a north-facing escarpment delineates the northern boundary of the province (Johnston, 1932). The Plateau surface is dissected by the well-developed drainage patterns of Mulberry Fork of the Black Warrior River and its tributary, Sipsey Fork. Two large northeast-southwest trending valleys lie within the Plateau province in the eastern part of the area. These are Sequatchie Valley and Murphrees Valley, both underlain by pre-Pennsylvanian limestones and dolomites. Each valley is about 3 miles wide and contains two minor stream valleys and an intervening ridge within the major valley. Sand Mountain is a synclinal plateau separating Murphrees Valley from Sequatchie Valley. Blount Mountain is a similar plateau on the east side of Murphrees Valley. Both mountains are extensions of the Plateau upland. Blount Mountain, Murphrees Valley, and Sand Mountain are drained by the Locust Fork of the Black Warrior River.

North of the Cumberland Plateau in Franklin County lies Moulton Valley, a district of the Highland Rim section of the Interior Low Plateaus province. The valley floor is a rolling lowland underlain by pre-Pennsylvanian limestones and drained by streams flowing northwest to the Tennessee River.

Unconsolidated deposits of the Tuscaloosa Group cap the hills and ridges of the western Cumberland Plateau and cover the western part of Moulton Valley. The physiographic region underlain by these deposits is the Fall Line Hills district of the East Gulf Coastal Plain section. The inland margin of the East Gulf Coastal Plain is referred to as the Fall Line, but no topographic expression of the boundary exists in Area 22 (Fenneman, 1938).



From Sapp and Emplaincourt (1975)

EXPLANATION

Highland Rim section
(Interior Low Plateaus province)

Cumberland Plateau section
(Appalachian Plateaus province)

East Gulf Coastal Plain section
(Coastal Plain province)

Figure 2.2-1 Physiographic divisions

Four Major Streams Drain Area

Most of area is drained by Mulberry Fork of the Black Warrior River. Other major streams draining Area 22 are Locust Fork of the Black Warrior River, Sipsey Fork (tributary to Mulberry Fork), and Bear Creek.

Mulberry and Locust Forks form the Black Warrior River downstream in Area 23. The drainage eventually reaches the Mobile River that flows to the Gulf of Mexico. Bear Creek basin is drained by Cedar, Little Bear, and Bear Creeks in Area 22. Bear Creek and its tributaries, Cedar and Little Bear Creeks, drain the western edge of the Plateau Coal Field. Cedar and Little Bear Creeks flow into Bear Creek which flows into the Tennessee River in Pickwick Lake. The flow from the Tennessee River eventually reaches the Mississippi River which also flows into the Gulf of Mexico (fig. 2.3-1).

Locust Fork drains the eastern side of the Plateau Coal Field and part of two valleys of pre-Pennsylvanian rocks. The area drained by Mulberry Fork is underlain almost entirely by coal-bearing rocks of the Plateau Coal Field. The principal tributary to Mulberry Fork is Sipsey Fork. Drainage from 944 mi^2 of a total drainage area of 999 mi^2 of Sipsey Fork flows into Lewis Smith Lake. Lewis Smith Dam was closed in 1961 and has a storage capacity of 1,670,700 acre-feet at spillway crest. Since closure there has been no flow over the spillway. All flow released has been through turbines for hydro-power generation.

Area 22 has a surface area of 2,495 mi^2 and borders along the Tennessee-Mobile basin divide. Major streams having their headwaters within Area 22 and their drainage areas are as follows:

Basin	Area (square miles)
Mobile River basin	
Locust Fork	624
Mulberry Fork	571
Sipsey Fork (tributary to Mulberry Fork)	999

Total	2,194
Tennessee River basin	
Bear Creek	182
Cedar Creek	85
Little Bear Creek	34

Total	301

Drainage areas for selected locations on streams in Area 22 may be found in Geological Survey of Alabama Atlas Series 12 (1978), "Drainage Areas for the Upper Black Warrior River Basin, Alabama," and U.S. Army Engineers District, Mobile Corps of Engineers report titled, "Stream Mileage Tables with Drainage Areas" (1972). Drainage areas in the Bear Creek basin may be obtained from the Tennessee Valley Authority, Data Services Branch, Room 329 Evans Building, 524 Union Ave., Knoxville, TN 37902.

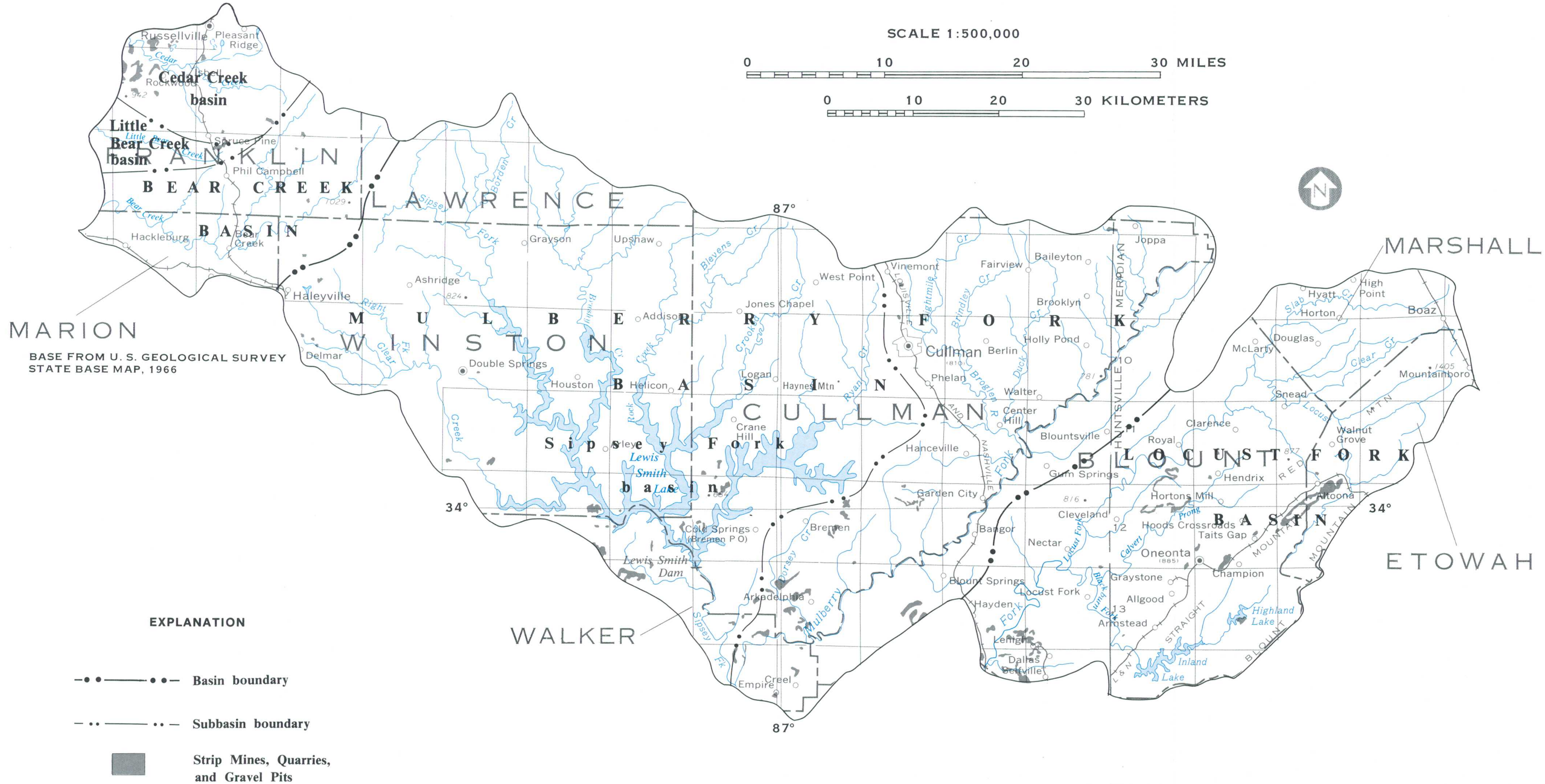


Figure 2.3-1 Drainage basins

Forest and Agricultural Land Cover Most of Area 22

Forest land covers majority of Area 22, followed closely by agricultural land. Remaining land use is approximately evenly divided between urban land, barren land, and water.

Area 22 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.

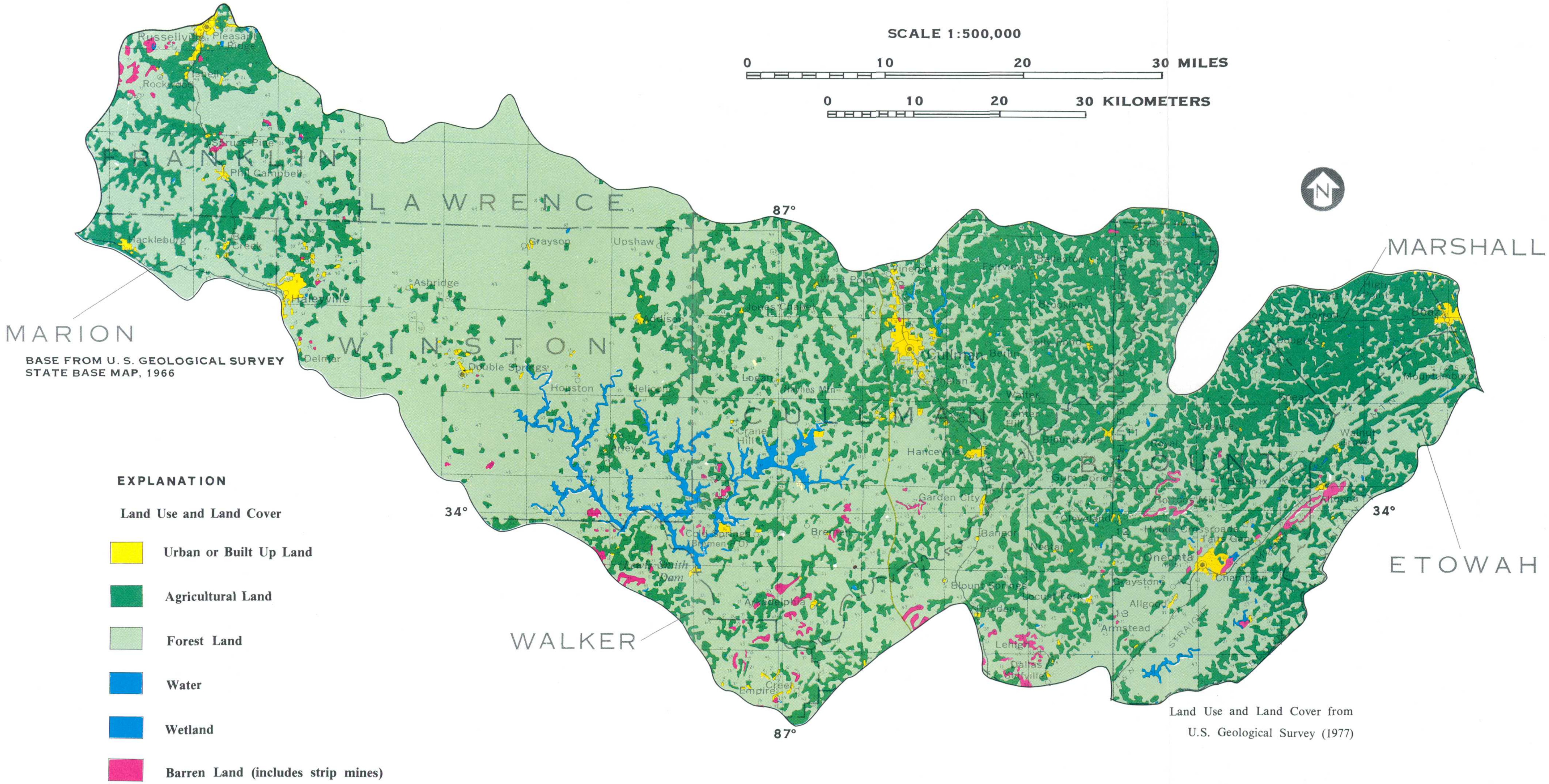


Figure 2.4-1 Land use and land cover

Soils Are Acidic and Generally Have High Erosion Potential

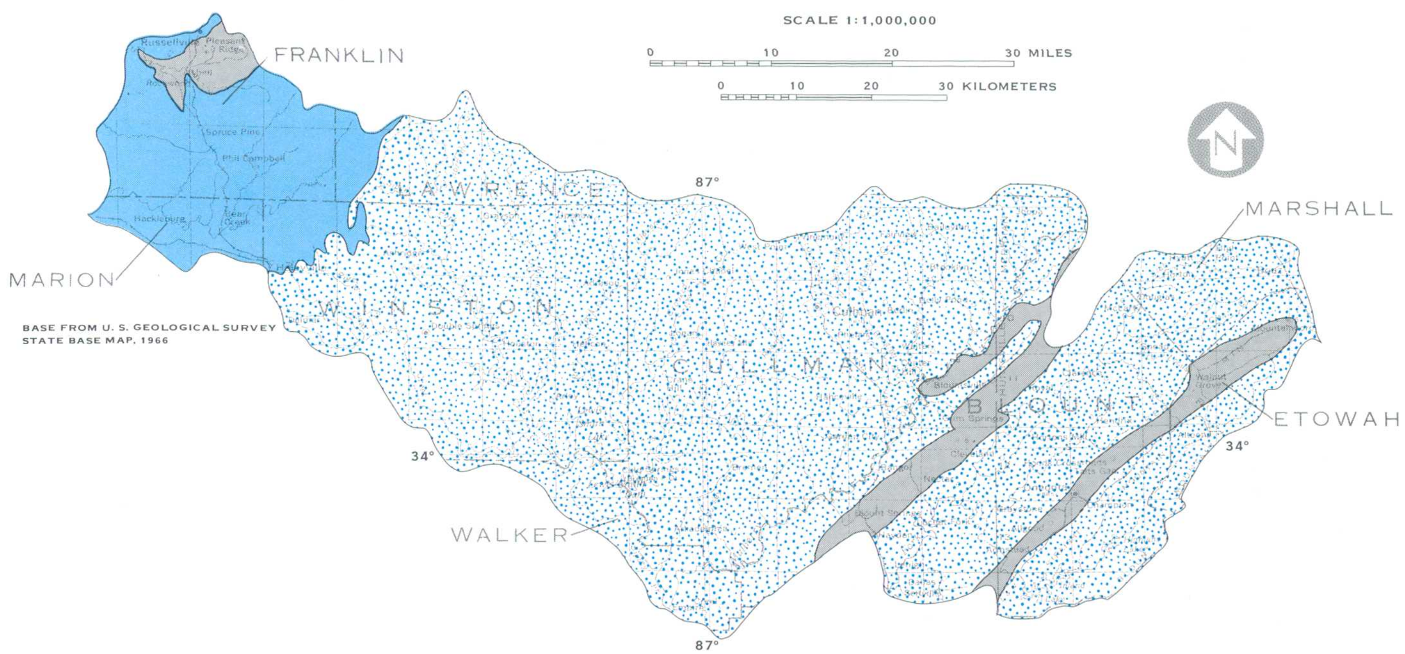
Soils in the area are acidic, with pH ranging from 3.6 to 6.0 units, and are easily eroded when vegetative cover is removed.

Soils in Area 22 generally have high acidity, high erosion potential, low organic content, low natural fertility, and moderate permeability rates (Buckman, 1969). Factors affecting erosion potential include: infiltration and permeability rates, soil texture and stability, soil depth, slope gradient, and vegetative cover. Removal of vegetative cover drastically alters natural erosion patterns. Erosion increases as the slope increases.

The generalized soil map for Area 22 shows three predominant soil associations (fig. 2.5-1). 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 soil suitability for plant growth media on disturbed lands are listed in table 2.5-2. The Minvale-Fullerton and Savannah-Ruston-Stough associations are fairly suitable for use as plant growth media in drastically disturbed land reclamation. The Montevallo-Enders-Townley association is fairly poor for plant growth purposes due to its acidity and low available water capacity.

The soils map and soil association descriptions 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 (1974)

EXPLANATION

SOIL ASSOCIATIONS

Minvale-Fullerton
Deep soils over limestone

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

Savannah-Ruston-Stough
Deep, moderately poor to 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 units	Permeability (inches/hour)	Available water capacity (inches/inch)	Slope (percent)
Minvale-Fullerton	Cherty silt loam underlain by limestone	>80	76	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
Savannah-Ruston-Stough	Loamy soils and subsoils with a fragipan*	>60	>5	4.0-5.5	0.2-6.0	0.05-0.12	0-8

*Fragipan - Dense and brittle pan or layer in soils that owes its hardness mainly to extreme density or compactness rather than high clay content or cementation - water moves through it very slowly (Buckman, 1969, 610 p.)

Table 2.5-2 Suitability rating of soil (to a depth of 3.28 feet) for use as a plant growth medium in drastically distributed land reclamation.

Factors affecting use	Degree of suitability		
	Good	Fair	Poor (essentially unsuitable)
Electrical conductivity EC (micromhos per centimeter at 25 C°)	< 8	8-16	> 16
Sodium absorption ratio SAR	< 2	2-12	> 12
Exchangeable-sodium-percentage ESP*	< 2	2-15	> 15
pH units	5.0-8.5	3.5-5.0	< 3.5; > 8.5
Coarse fragments over 3-inches 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.

Source: U.S. Department of the Interior, 1977

Area 22 Characterized By Moist Temperate Climate

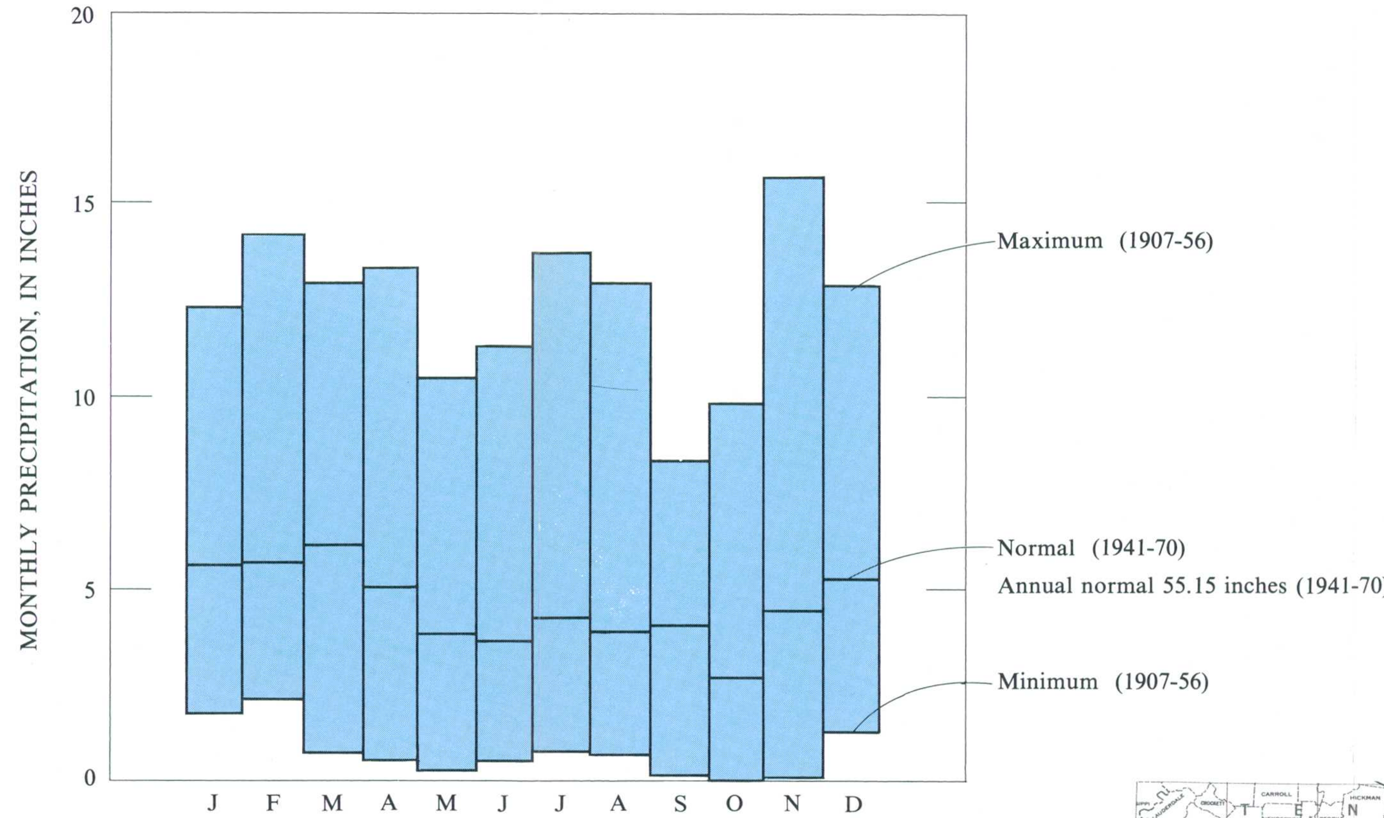
Area 22 has a moist temperate climate with the heaviest rainfall occurring in March and the least rainfall occurring in October.

The location of Area 22 gives it a moist temperate climate, with a mean annual rainfall that ranges from 52 inches along the western edge to 56 inches in the southern part of the area. 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 shown in figure 2.6-1 for the period 1931-55. Distribution of rainfall by months for St. Bernard, NOAA Weather station, located at Cullman is shown in figure 2.6-2. Normal precipitation is for the 30-year base period of 1941-70. The extremes for the base period are not readily available; however, the extremes for 1907-56 are available and these values are used to show variations above and below normal.

Daily observations of precipitation data may be used to develop various relationships and correlations and for other statistical analyses. For example, 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."



Based on record for 1941-70, and monthly extremes for 1907-56
Climatological data furnished by NOAA, Birmingham, Alabama.

Extremes of record 1907-56, in inches

Maximum annual precipitation	79.30	(1929)
Minimum annual precipitation	35.02	(1943)

Figure 2.6-2 Precipitation for St. Bernard, Cullman, Cullman County.

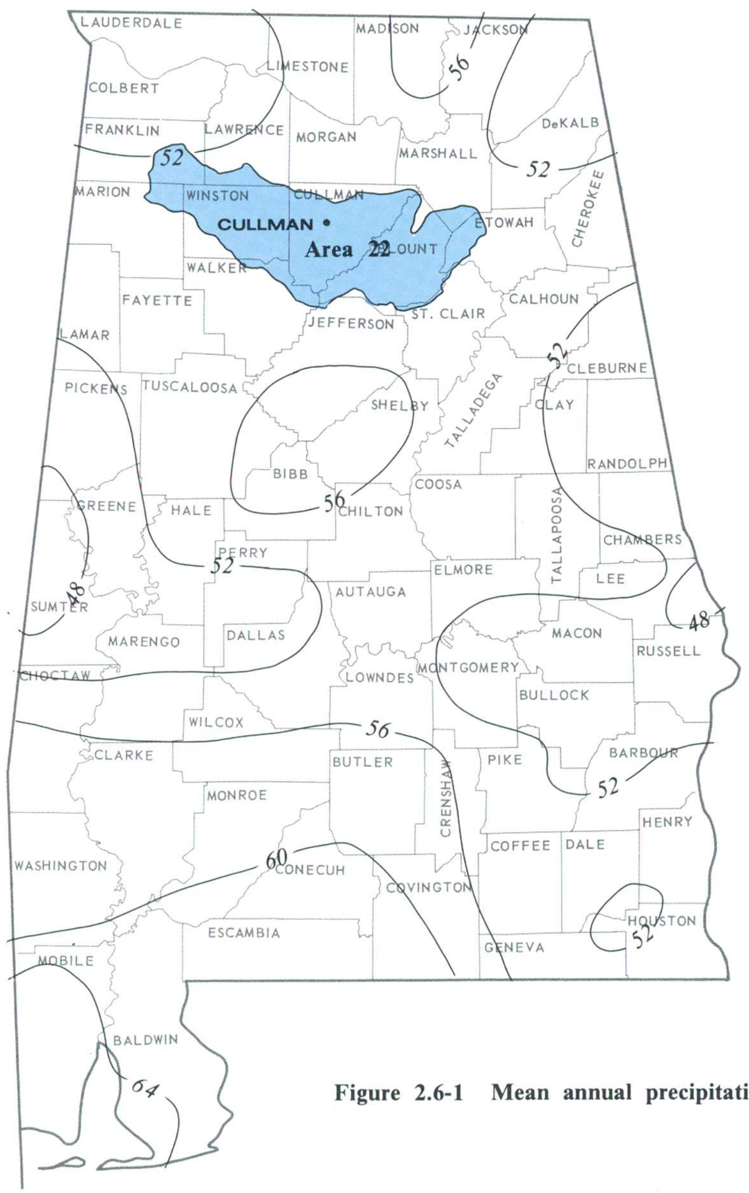
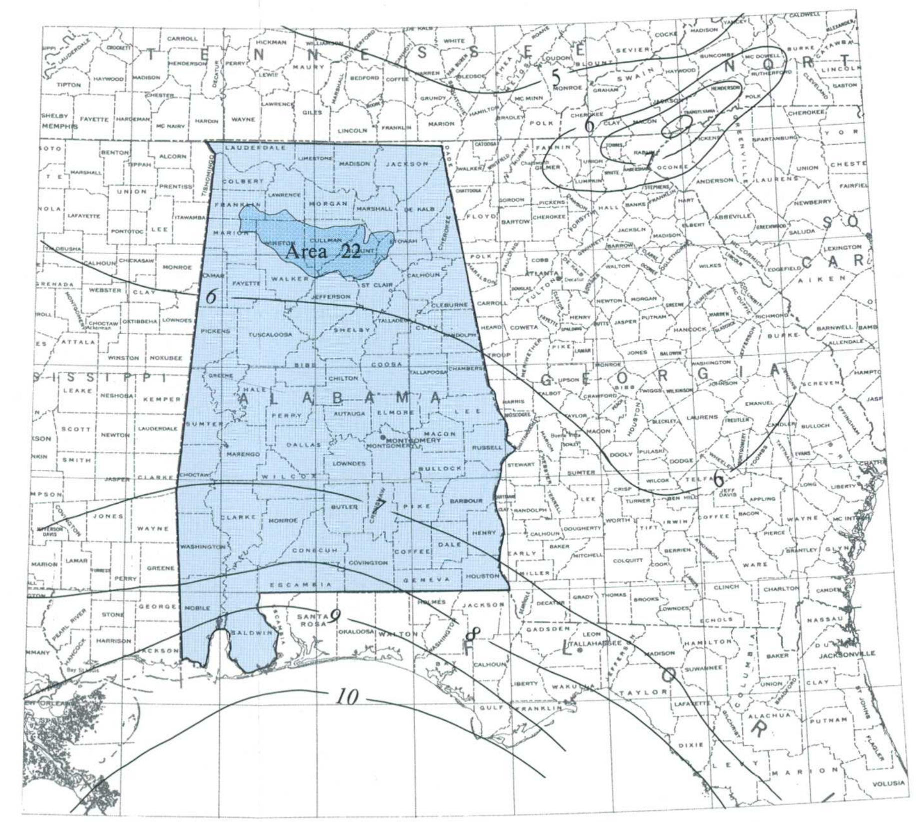


Figure 2.6-1 Mean annual precipitation, in inches.



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

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

Principal Water Uses in Area 22 are for Hydroelectric Power Generation, Public, and Industrial Supplies

About 900 Mgal/d in 1975 was from Lewis Smith Lake for hydroelectric power generation. Public and industrial water supplies account for approximately 35 Mgal/d--about 85 percent was water from streams and lakes and 15 percent was ground water from wells and springs.

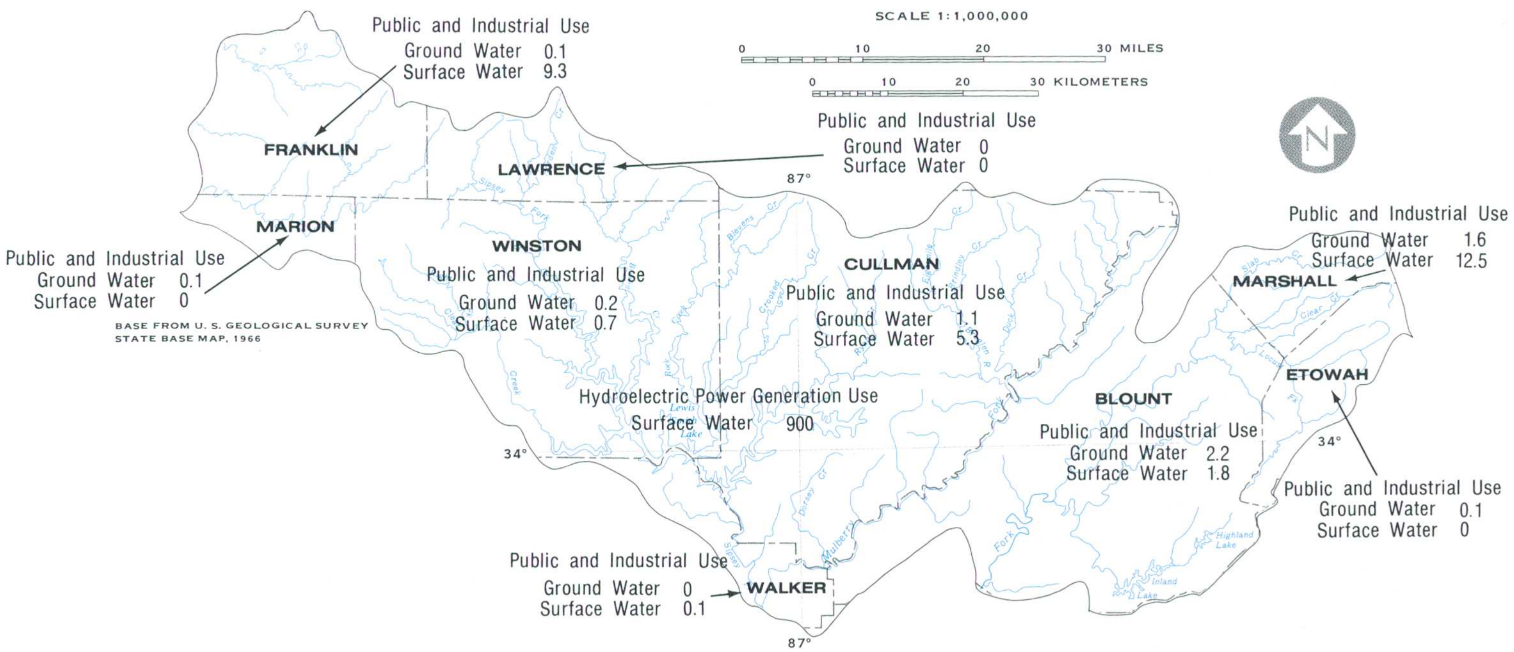
Water use for 1975, for hydroelectric power generation, was approximately 900 Mgal/d (95 percent) of the total water use in Area 22. Major sources of surface-water supply are Sipsey Fork immediately downstream from Lewis Smith Lake, Calvert Prong, Inland Lake on Blackburn Fork, Brindley Creek, Eightmile Creek, Pope Creek, and Clear Creek. Sipsey Fork and Inland Lake also serve as major water supplies for municipalities in Area 23 (fig. 3.1-1). Surface-water withdrawals accounted for 74 percent (32.3 Mgal/d) of the total water withdrawn from the area in 1975.

Water withdrawal by rural residents was less than 1 percent. Rural use was for domestic purposes (3.5 Mgal/d), livestock watering (3.2 Mgal/d), irrigation (0.6 Mgal/d), and catfish farming (0.7 Mgal/d). Approximately 74 percent of the rural water supply is from ground-water sources.

Nonconsumptive water use was more than 95 percent of the total water use in Area 22 for 1975. Hydroelectric power generation at the Lewis Smith Dam by Alabama Power Company was 900 Mgal/d. Water use for hydroelectric power generation, public and industrial supply, and rural supply are shown in figure 3.1-2.

The preceding data were taken from the report entitled, "Use of Water in Alabama, 1975, With Projections to 2020" (Mettee, 1978). Additional information on water use is contained in "Estimated Use of Water in the United States in 1975" (Murray, 1977).

Water-use data for 1980 are being collected and compiled by states and will be available through the National Water Data Exchange (NAWDEX). For details about NAWDEX see section 9 of this report.



Water use values by county prorated for Area 22.

Figure 3.1-1 Water use by county, in million gallons per day.

Total water use - 943.1 million gallons per day

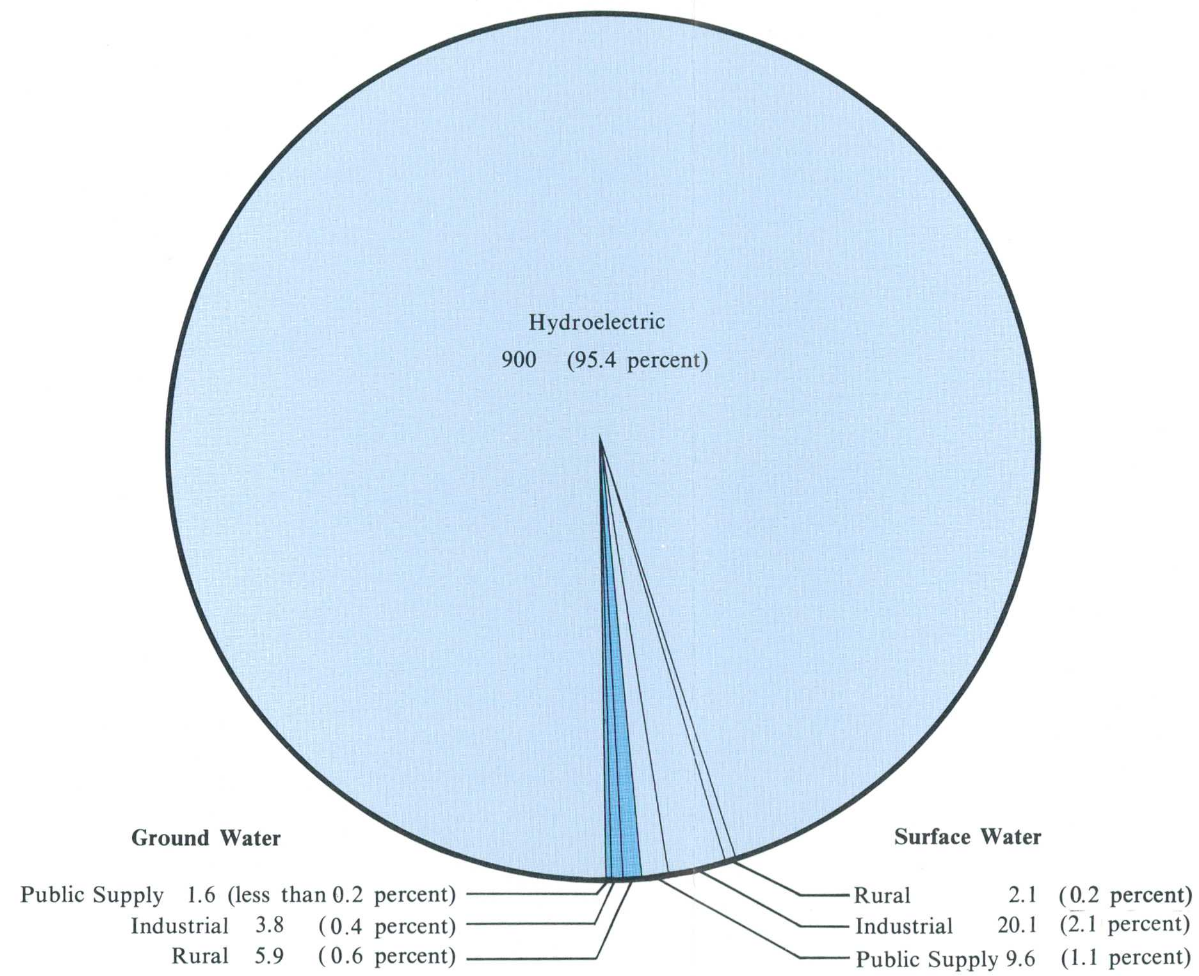


Figure 3.1-2 Water use, in million gallons per day.

Most Streams in Area 22 Have Fish And Wildlife or Better-Use Classification

The Alabama Water Improvement Commission has classified most streams in Area 22 as Fish and Wildlife or better use.

Use classification of stream reaches is shown in figure 3.2-1. The reaches as classified in March 1979 for Area 22 by the Alabama Water Improvement Commission, also given in Appendix 1, show most streams are classified as "Fish and Wildlife" or better (E. John Williford, written comm.).

All major streams and stream segments that to the Commission's knowledge are currently recipients of point-source discharges are included in the classification. In every instance where a segment is not included by name, the Commission has no information to assign a particular classification. However, the assumption was made by the Commission that these unnamed segments are classified as "Fish and Wildlife" and will remain so unless it is demonstrated that they are improperly classified.

Although not explicitly stated in the classifications, that with the exception of those segments in the "Public Water Supply" classification, every stream 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.

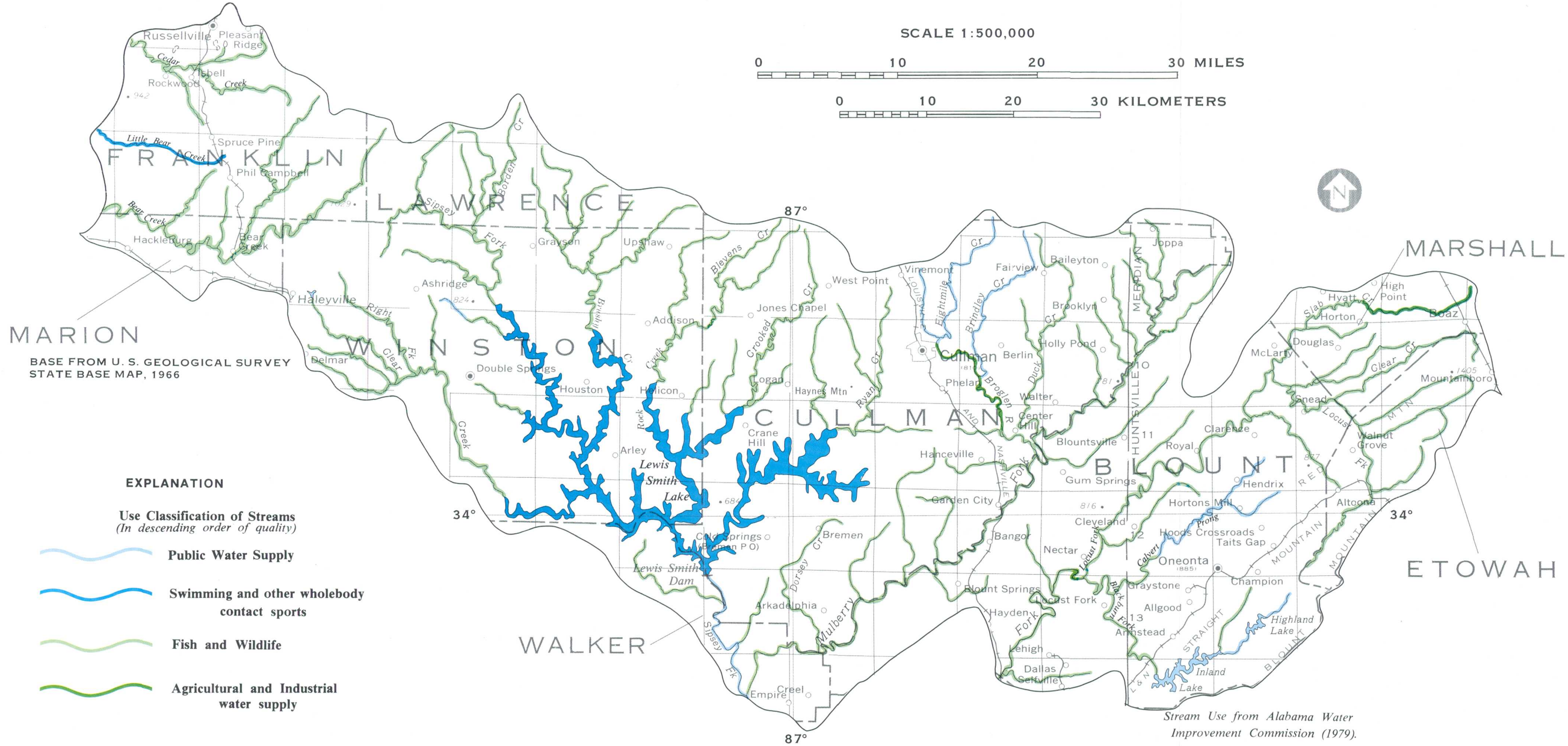


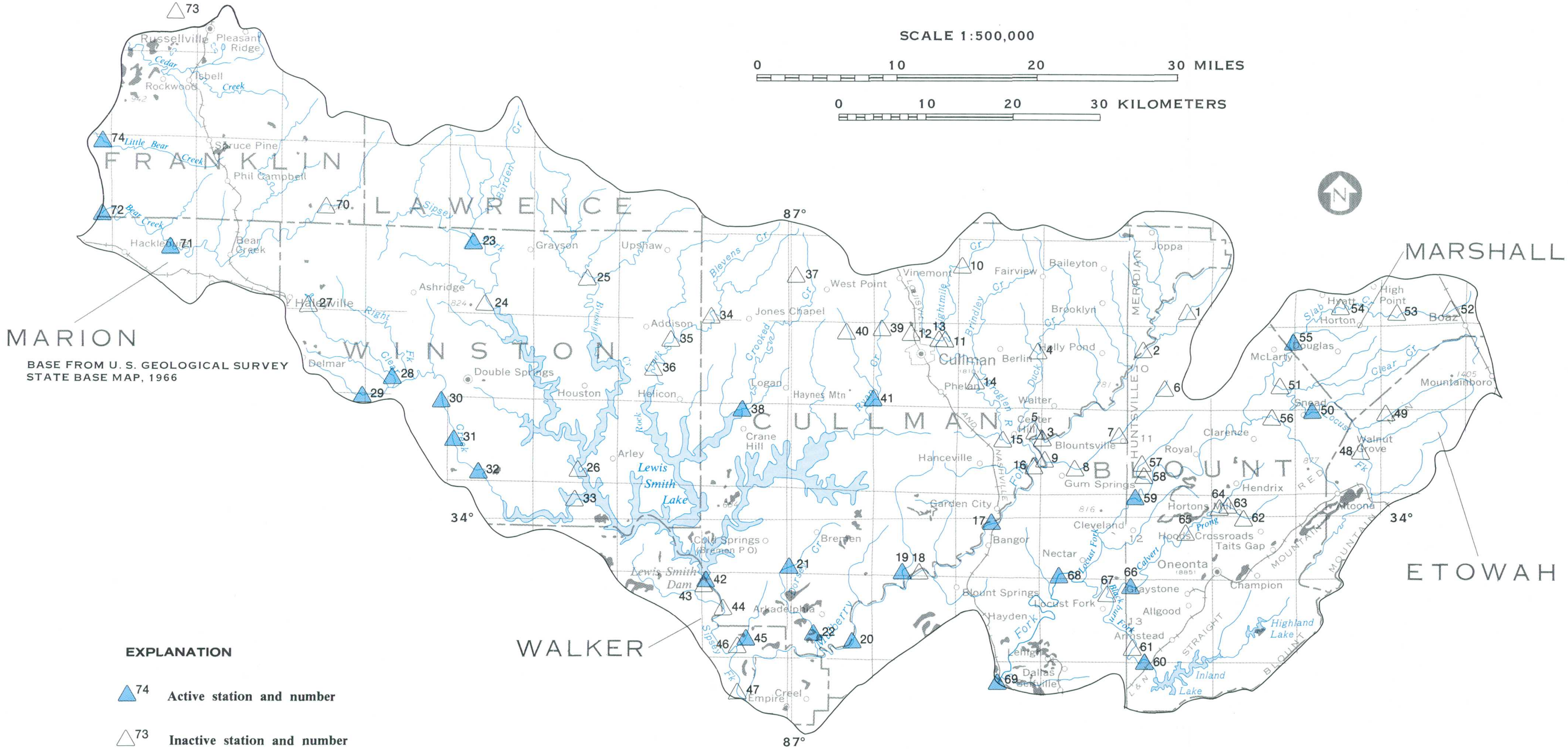
Figure 3.2-1 Use classification of Streams.

Information on Surface Water is Available for 74 Locations

The U.S. Geological Survey surface-water data-collection network for Area 22 was extended 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 74 locations.

Streamflow and water-quality information is available for 74 sites in Area 22; 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 six active stations. The active network has been increased to 25 sites 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."



EXPLANATION

74 Active station and number

73 Inactive station and number

Strip Mines, Quarries, and Gravel Pits

See Appendix 2 for detailed station description.

Figure 4.1-1 Surface-water network

Information on Ground-Water Levels and Spring Discharge is Available for 17 Locations

The U.S. Geological Survey ground-water network includes 13 monitoring wells and 4 springs in Area 22.

The ground-water network in Area 22 provides water-level and spring-discharge data, which combined with water-quality data, will aid applicants for coal-mining permits, mine owners and operators, consulting engineers, and regulatory agencies in determining the impact of coal mining on the ground-water resources of the permit area.

Water-level data for 13 wells and discharge data for 4 springs are available, including continuous records for 3 wells and 2 springs. The remaining wells and springs have been measured periodically. Locations of the network stations are shown on figure 4.2-1. Information including identification numbers, county, aquifer, and period of record for each station is given in Appendix 3. Additional information about the type of data, including the actual data, is available from (1) the National Water Data Exchange (NAWDEX), (2) the National Water Data Storage and Retrieval System (WATSTORE), (3) published annual U.S. Geological Survey reports, "Water Resorces Data for Alabama", and (4) reports on water availability for individual counties published by the Geological Survey of Alabama.

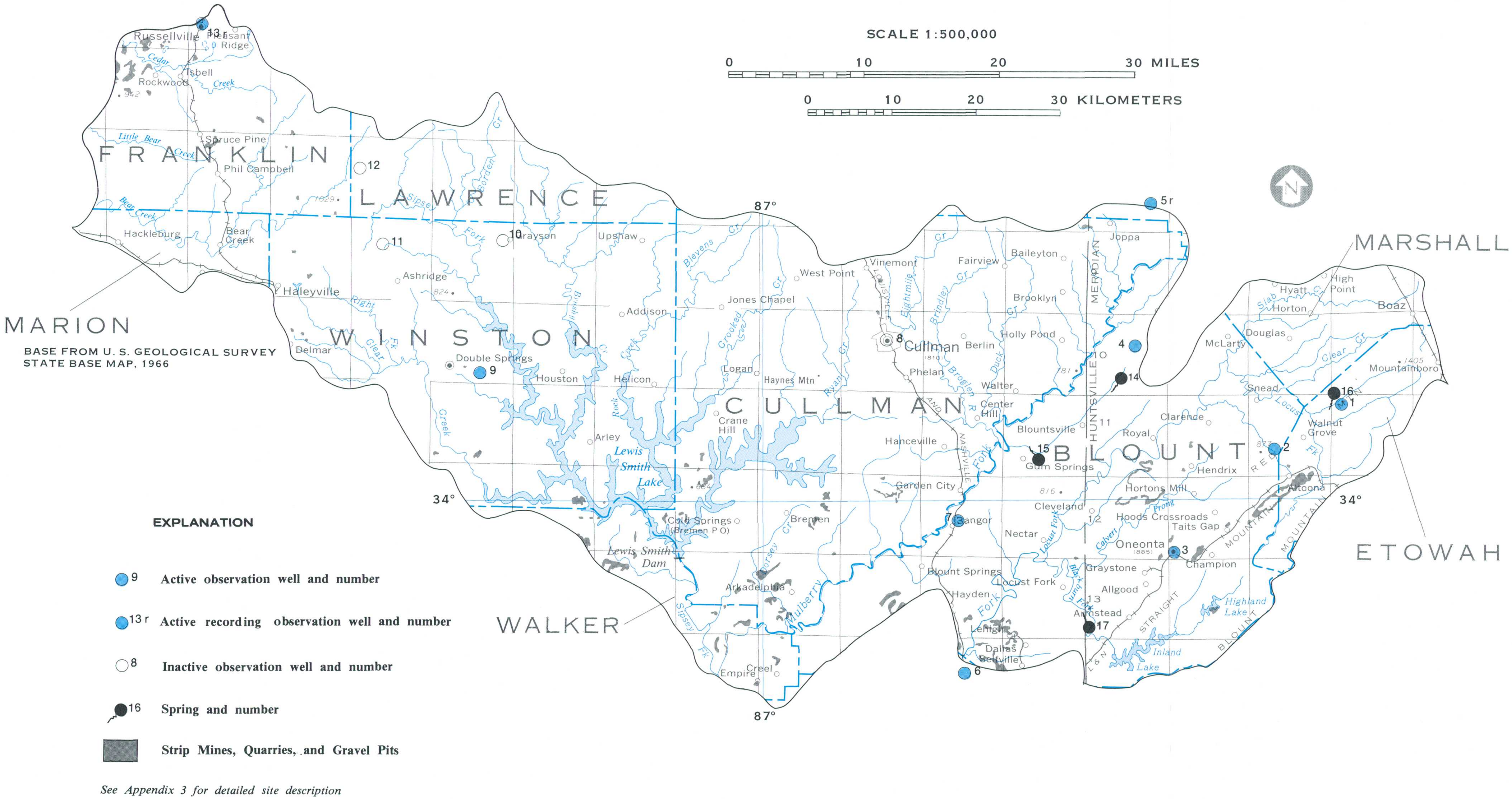


Figure 4.2-1 Ground-water network

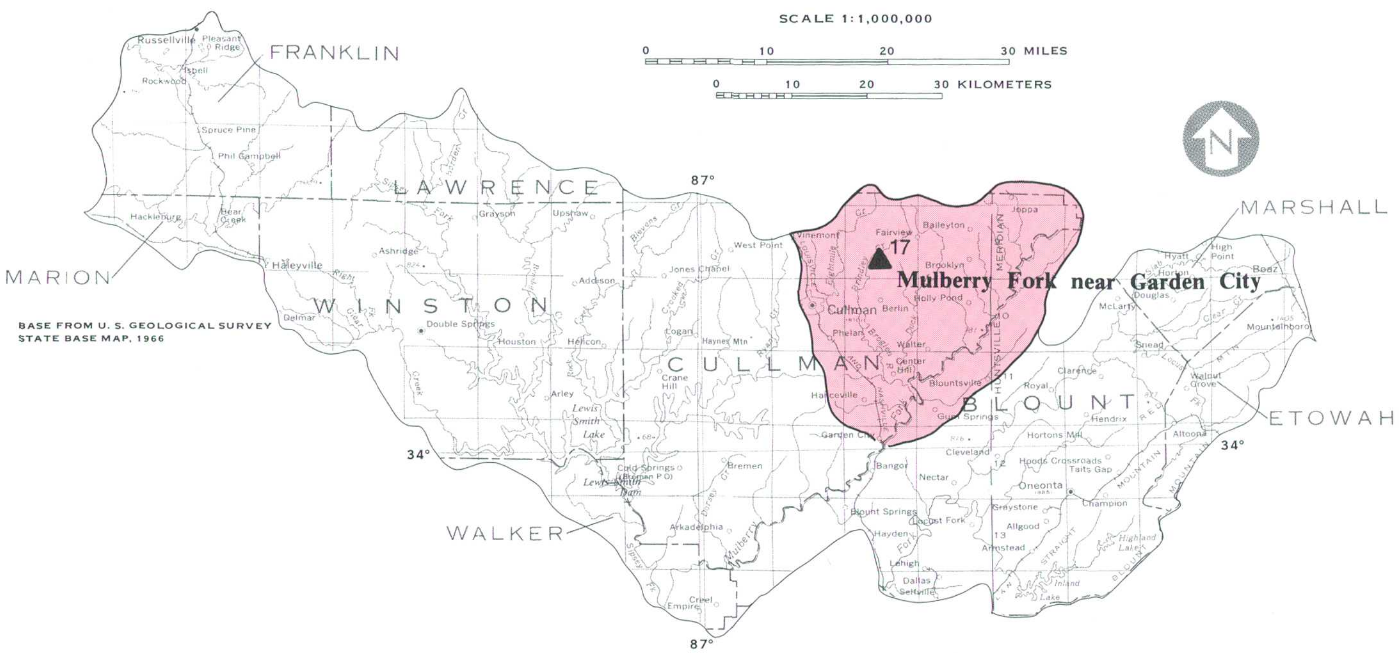
Streamflow Varies Seasonally With Rainfall and Evapotranspiration

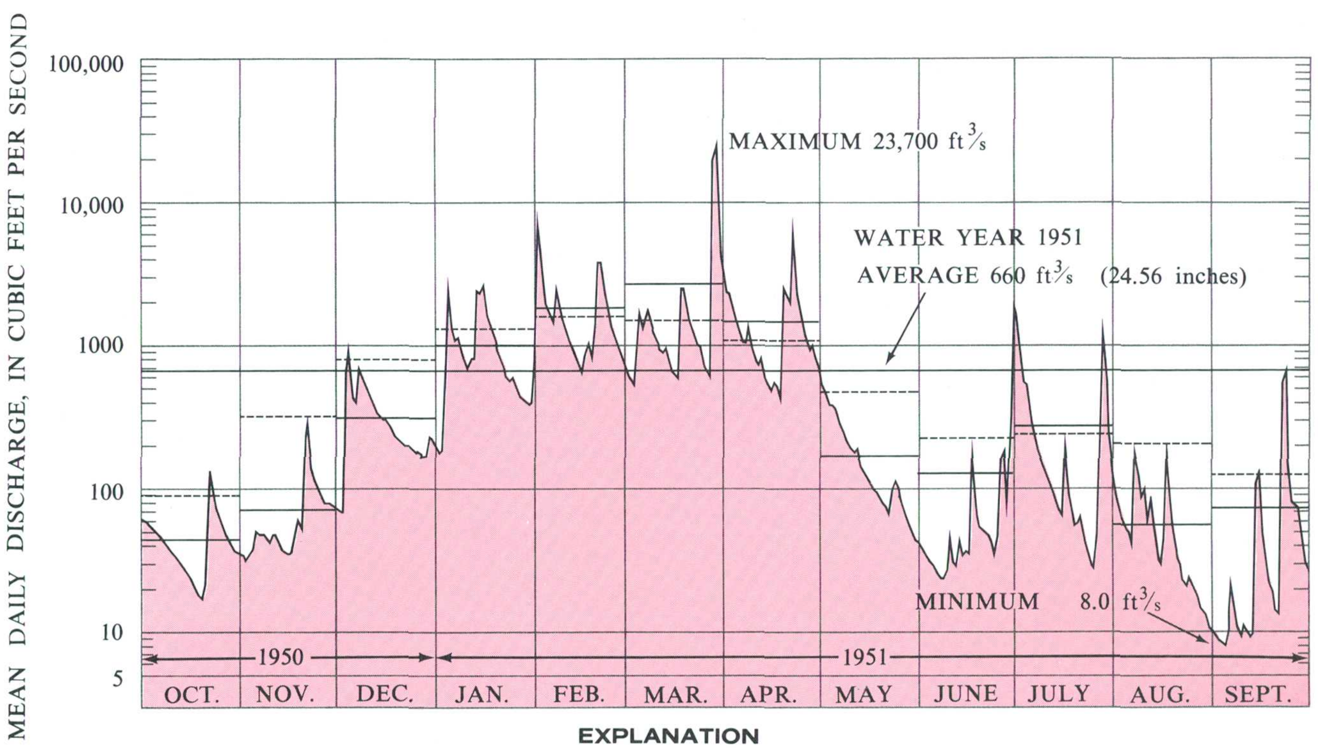
Variations in streamflow are related to the duration and intensity of rainfall and the seasonal changes in evapotranspiration.

The seasonal pattern of streamflow in Area 22 is shown by a sample 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 during October, the month of lowest average rainfall; increasing flow in November and December as evapotranspiration decreases and the winter rains begin; and high flows from January to April when heavy general rains fall on wet or saturated soil. Flows recede in May and June as rainfall diminishes and evapotranspiration increases; surface runoff from thunderstorm activity in July and early August; and, finally, recession of flow in August and September as rains become less frequent and ground-water outflow becomes the primary source of streamflow.

A streamflow characteristic illustrated by the hydrograph is its wide variability above and below the annual average flow (fig. 5.1-1). The variability of monthly mean streamflow is shown on figure 5.1-2.

A comparison of monthly mean rainfall and runoff is illustrated by figure 5.1-3 for the 30-year base period 1941-70. Evaporation from a free water surface, by months for 1978 is also shown. Limited data are available for evaporation and transpiration from the National Weather Service, Birmingham (see section 2.6).



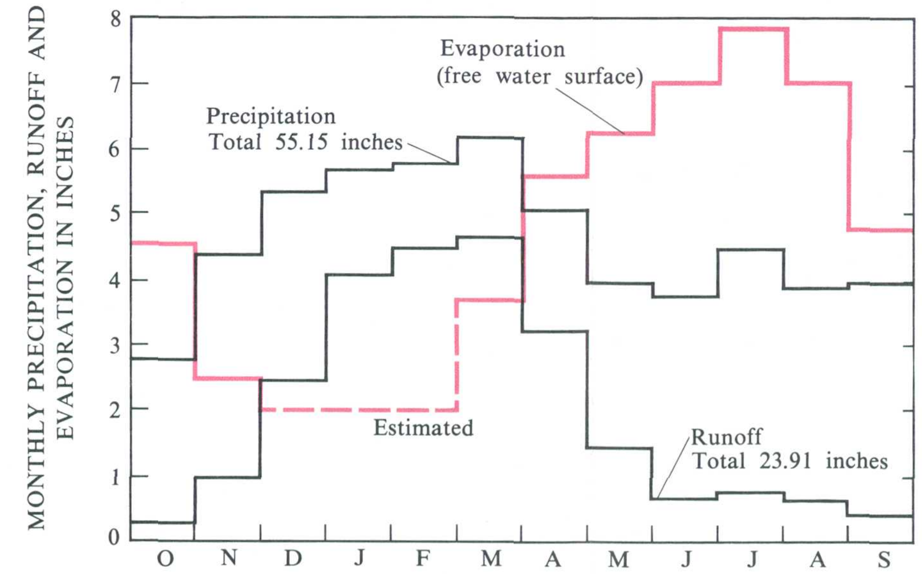


EXPLANATION

——— Mean monthly flow (1951)

----------- Mean monthly flow (1941-70)

Figure 5.1-1 Daily discharge for Mulberry Fork near Garden City.



EXPLANATION

Evaporaton data for Winfield 1978

Precipitation data for Cullman 1941-70

Runoff data for Mulberry Fork near Garden City 1941-70

Figure 5.1-3 Monthly mean rainfall and runoff, in inches, for Mulberry Fork near Garden City, 1941-70 (site 17) and evaporation, in inches, at Winfield, 1978.

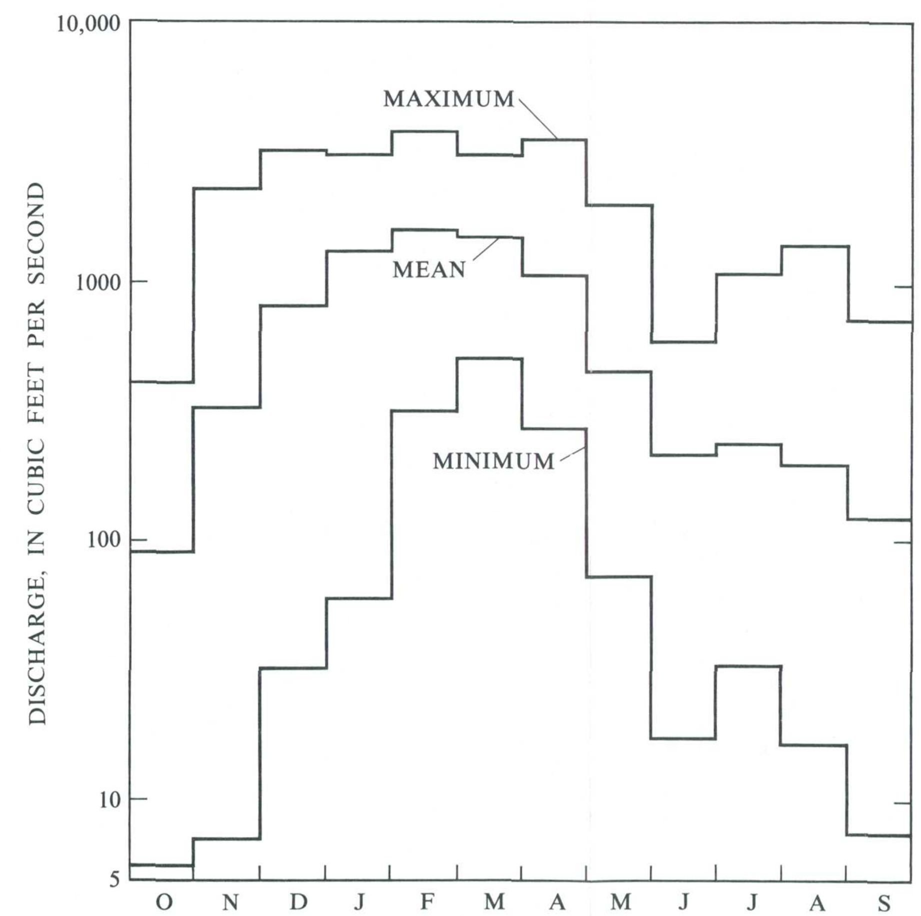


Figure 5.1-2 Maximum, mean and minimum monthly flows, in cubic feet per second, for Mulberry Fork near Garden City, 1941-70 (site 17).

Aquifers in Area 22 Vary Widely in Their Ability to Store and Release Water to Streams

Aquifers in Area 22 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 Tuscaloosa Group contain large quantities of water where areally extensive and thick. Streams draining small areas entirely in the Tuscaloosa Group have relatively high rates of flow during dry periods. The pre-Pennsylvanian rocks in Area 22 generally contain enough water to maintain 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 indices of low flow commonly used in Alabama are the 7-day Q_2 and 7-day Q_{10}. The 7-day low flow is the lowest average rate of flow for 7 consecutive days in each year. It will be less than the 7-day Q_2 at intervals averaging 2 years in length and less than the 7-day Q_{10} at intervals averaging 10 years in length. The 7-day Q_2 and 7-day Q_{10} can be estimated from figure 5.2-2 for drainage basins exceeding 5 mi^2. 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 lines of the bars in 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 lines of the bars are used for areas with 52 inches of annual precipitation. Discharge for drainage basins with intermediate values of annual precipitation can be determined by interpolating between the lines. In the example illustrated for a drainage basin with a low-flow index number of 140, a drainage area of 23 mi^2, 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 beyond the ranges shown nor should they be used for streams where man's activities have substantially affected the flow.

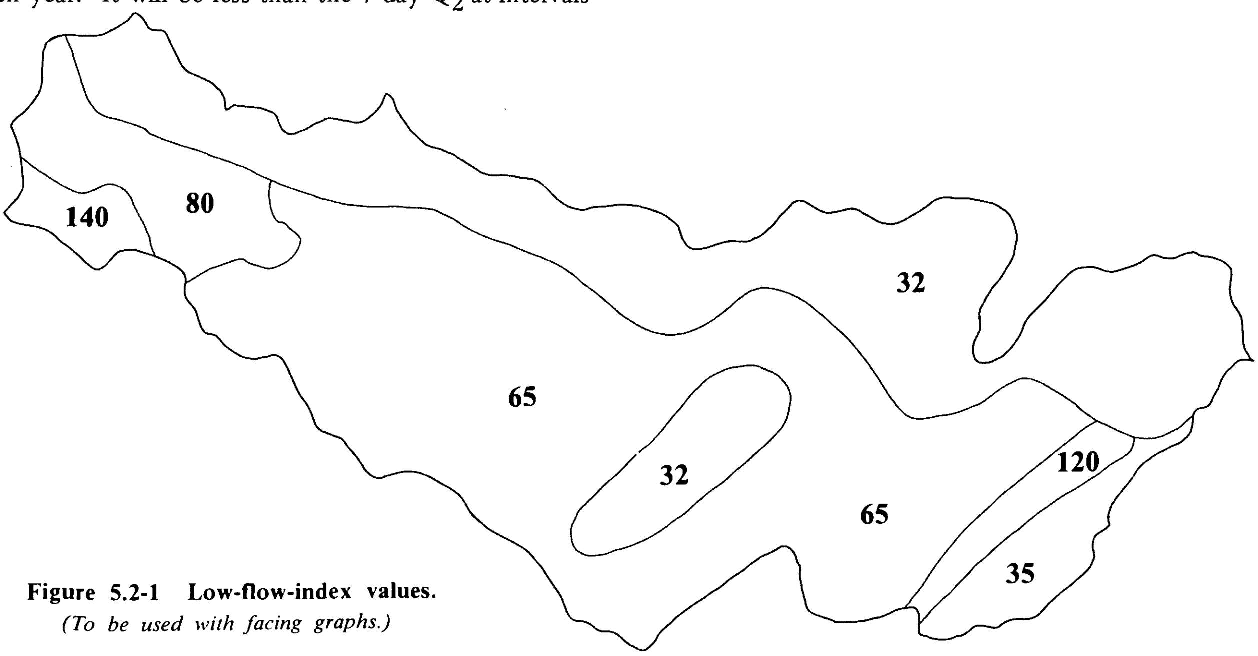


Figure 5.2-1 Low-flow-index values.
(To be used with facing graphs.)

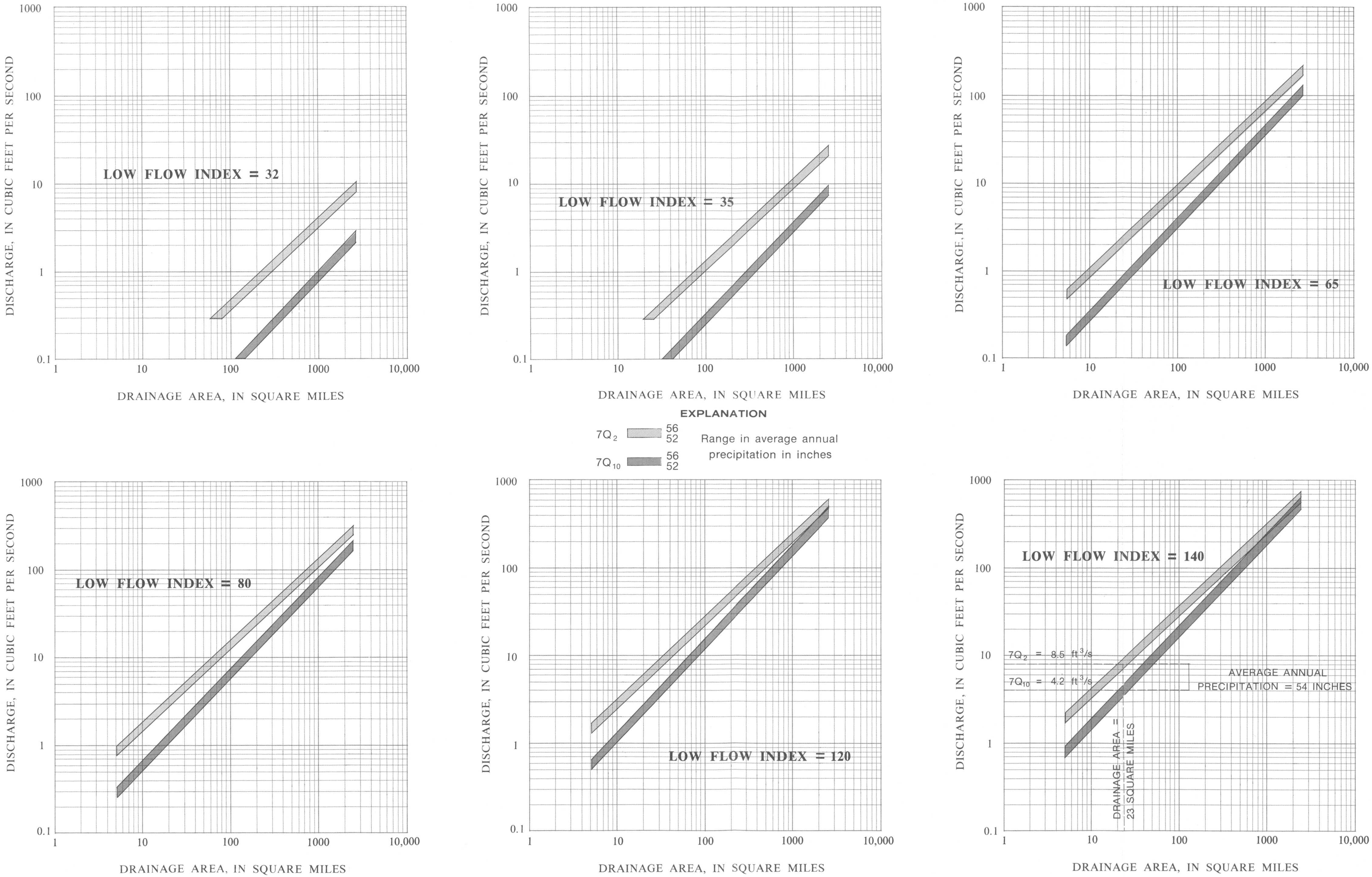


Figure 5.2-2 Relationships between low flow and drainage area.

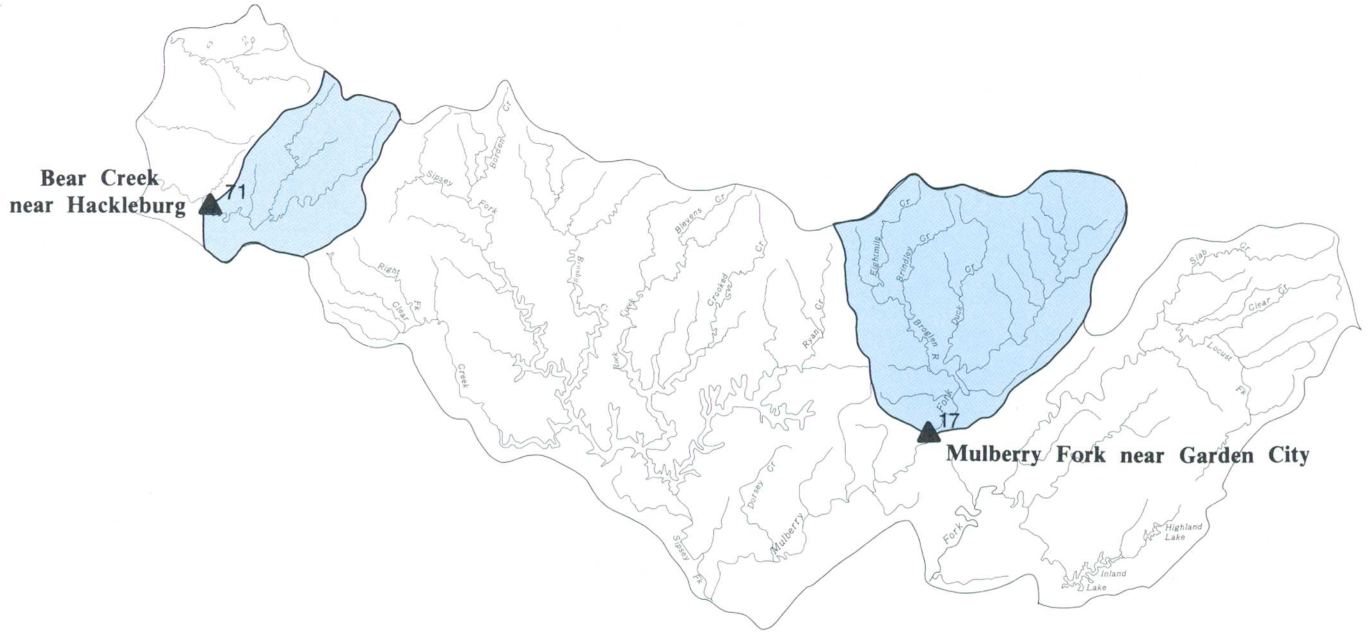
Flooding Chronic in Area 22

Natural conditions and cultural activities contribute to chronic flooding in Area 22.

Chronic flooding as the result of intensive rainfall is a natural characteristic of streams and rivers in Area 22. Floods are influenced by two factors: those relating to land and those relating to climate. Land factors include elevation, slope, soil composition, drainage pattern, and cultural influences. Narrow flood plains and steep slopes are characteristic of the Area. These factors contribute to the rapid accumulation of storm runoff. Climatic factors include seasonal distribution and intensity of storms. Examples of flood flows in response to a storm of unusual rainfall intensity which occurred during April 1979, are shown in figure 5.3-1.

Frequency and seasonal distribution of floods are generally related to climatic factors. Analyses of these characteristics for which data are applicable to Area 22 are contained in reports by Peirce (1954), Gamble (1965), Hains (1973), and Olin and Bingham (1977). Equations for estimating flood frequency of ungaged sites on unregulated streams draining from 1 to 15 mi^2 are contained in "Flood Frequency of Small Streams in Alabama" HPR No. 83 (Olin and Bingham, 1977).

Most of the flood damage in Area 22 is to farmlands, roads, and bridges in rural valleys with narrow flood plains and steep slopes. Damage also occurs near cities and towns where encroachment on the flood plains by industrial, commercial, and residential development is most prevalent. Topographic maps in Area 22 for which flood-prone areas have been estimated are on figure 5.3-2. These maps are available from either the U.S. Geological Survey, P. O. Box V, University, Ala. 35486 or the Alabama Office of State Planning and Federal Programs, Alabama State Planning Division, State Capitol, Montgomery, Ala. 36130.



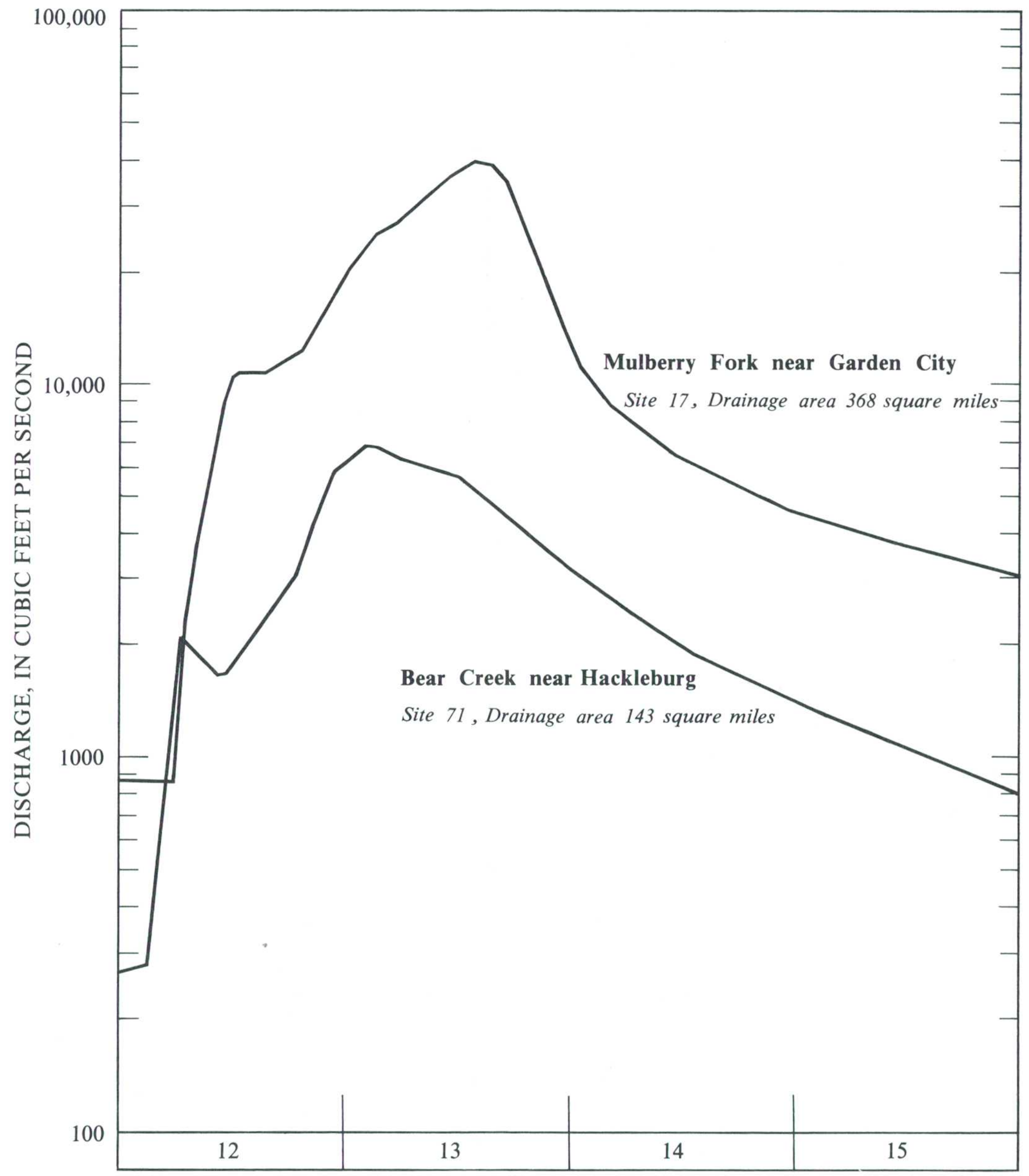
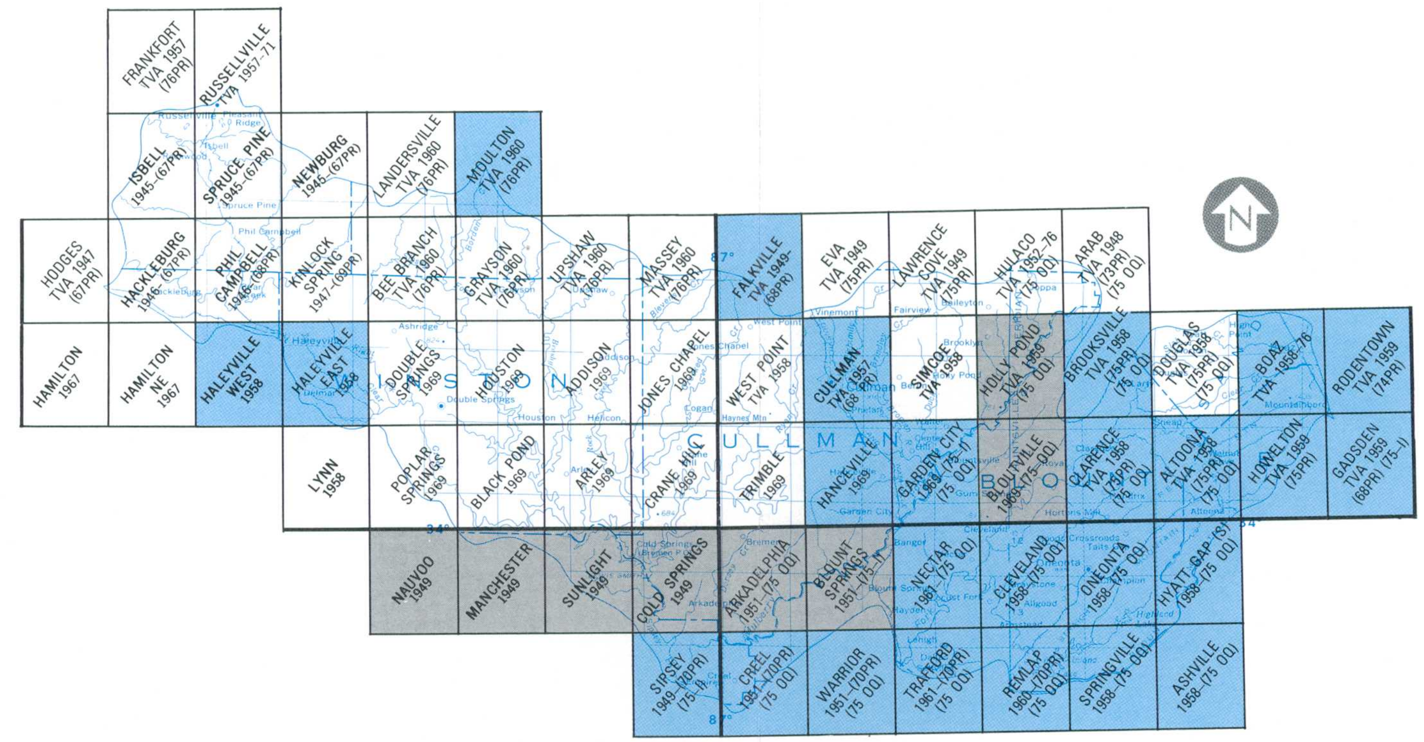


Figure 5.3-1 Flood Hydrographs, April 12 to 15, 1979.



EXPLANATION

Available from U.S. Geological Survey

Alabama Office of State Planning and Federal Programs

Figure 5.3-2 Maps of flood-prone areas.

5.0 SURFACE WATER (Continued)

5.3 FLOOD FLOW

Most Streams Poorly Sustained

Streams draining outcrop areas of the Pottsville Formation and pre-Pennsylvanian rock in Area 22 are poorly sustained in comparison with those draining areas of outcrop of the Tuscaloosa Group.

Differences in streamflow for three gaging stations in Area 22 are illustrated by flow-duration curves (fig. 5.4-2). These curves are based on streamflow for the period 1958-79 for each station and plotted in unit runoff (cubic feet per second per square mile) for a more direct comparison. The probability scale is used for the time axis and shows the percentage of time that a specific discharge can be expected to be equaled or exceeded.

Because basin characteristics are so clearly portrayed by the flow-duration curves, the curves for three streams draining areas of varying sizes and types of geologic outcrops are used to illustrate the effects of geology on streamflow (fig. 5.4-2). Their locations are shown on figure 5.4-1.

Three major geologic units cropping out in the area Tuscaloosa Group, Pottsville Formation, and pre-Pennsylvanian rocks (fig. 5.4-1). The Pottsville Formation consists of relatively impermeable shale, siltstone, and sandstone. In contrast, the Tuscaloosa Group contains permeable beds of sand and gravel and the pre-Pennsylvanian rocks consist of permeable limestone and dolomite.

The flow-duration curves reflect the effects of permeable or impermeable land surface and the ability of the ground-water reservoirs to release water to streamflow. In the Bear Creek basin the curve depicts the characteristics of the Tuscaloosa Group to absorb rainfall (recharge) and release water during rainless periods (low flow). The curve for Mulberry Fork depicts the impermeable effect of the Pottsville Formation. The curve for Locust Fork depicts the effect of the Pottsville Formation and the effect of the pre-Pennsylvanian rocks which readily accepts recharge and the water moves downdip (southwest) along the aquifers to areas outside the basin.

As a hydrologic tool, the flow-duration curve provides a convenient means of appraising the discharge characteristics of a stream. The slope of the flow-duration curve is a measure of the variability of flow--the steeper the slope, the greater the variability. A flat slope usually indicates the presence of storage, which tends to minimize the range of flow. This storage may be either on the surface in lakes, ponds, swamps, or in the ground as ground-water storage.

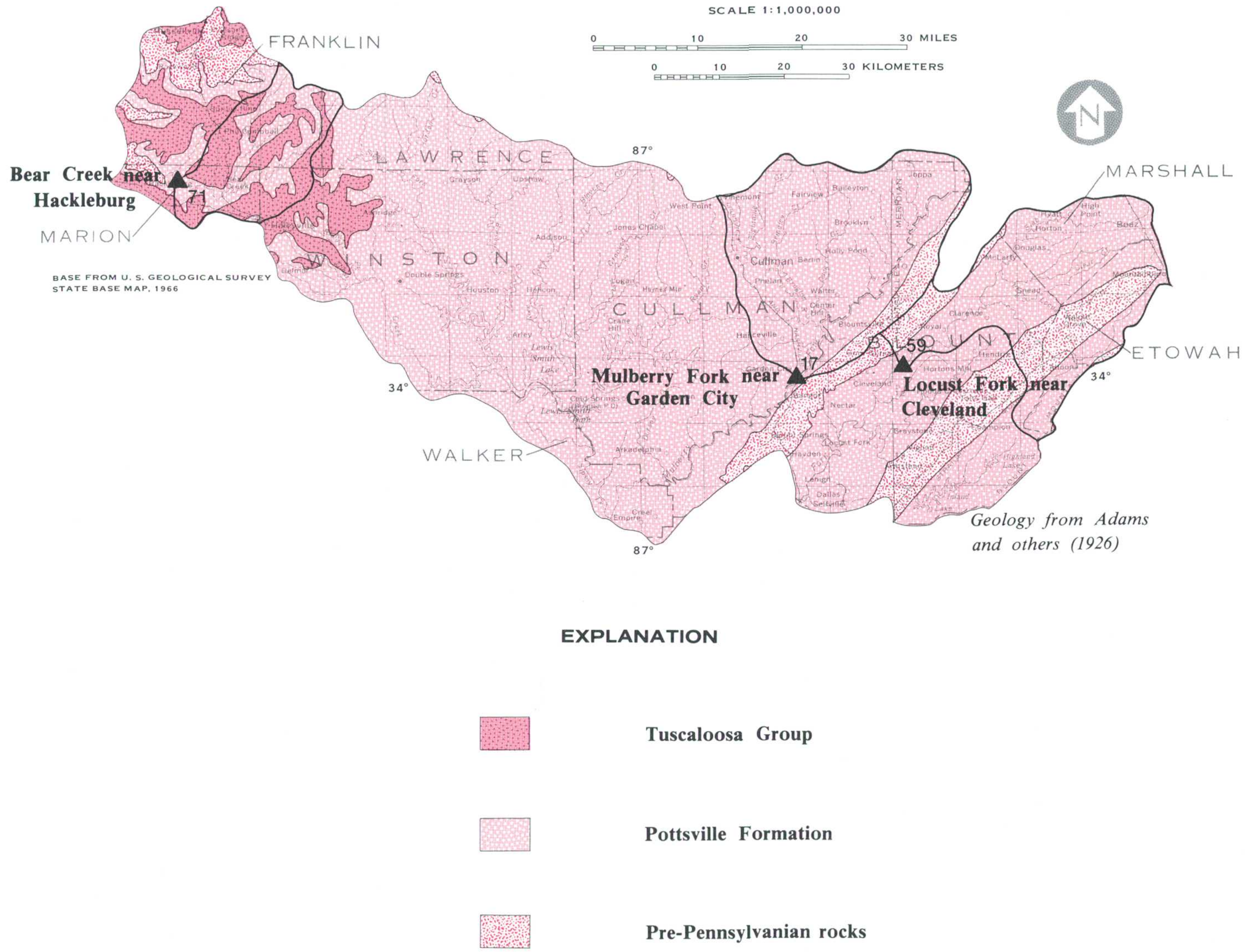


Figure 5.4-1 Geologic map showing drainage areas for selected gaging stations.

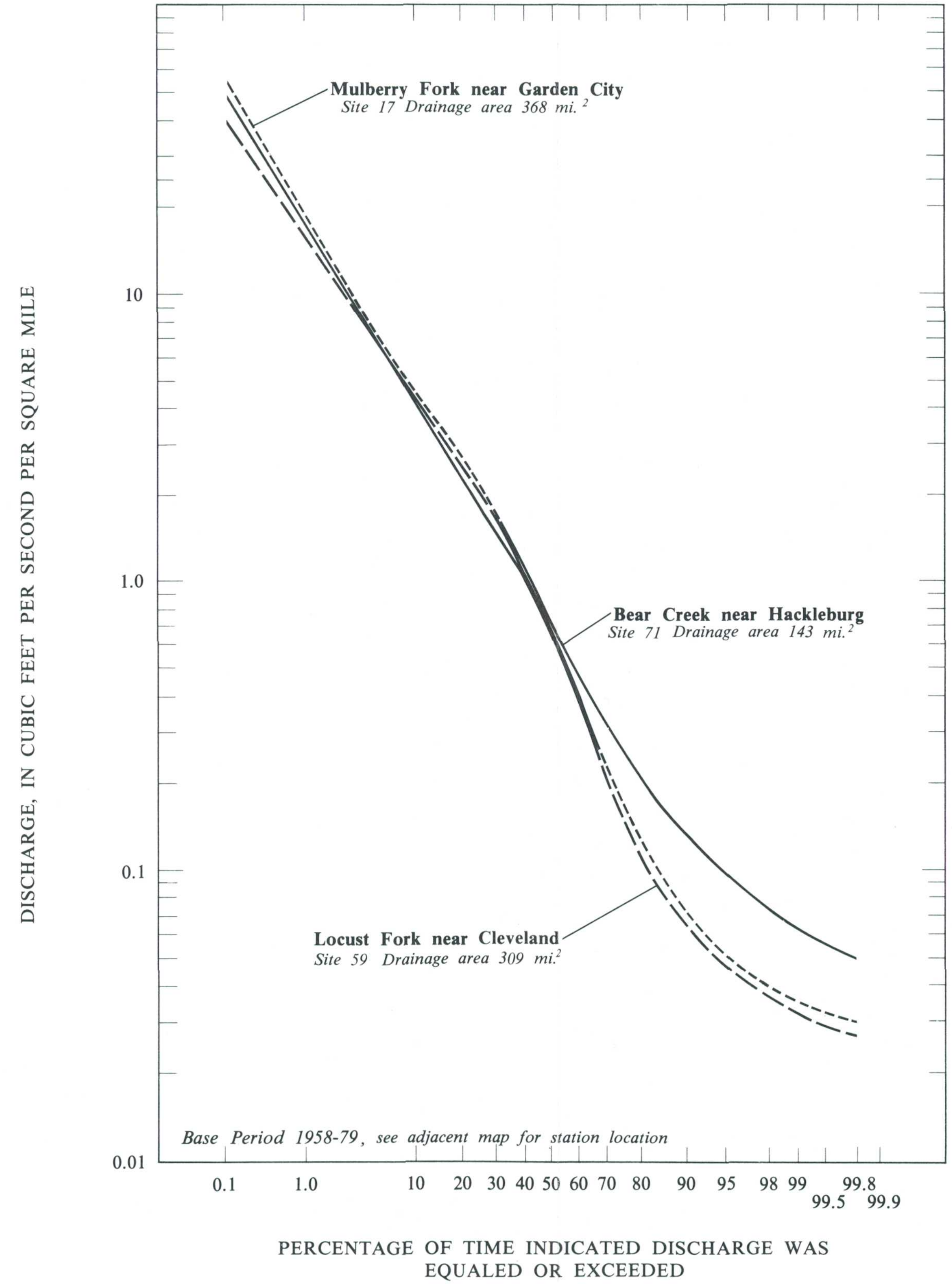


Figure 5.4-2 Representative flow-duration curves.

Specific Conductance and Dissolved-Solids of Water are Low Except in Coal-Mine and Industrial Areas

Mineralization of surface water resulting from coal-mining and industrial activity is reflected by an increase in specific conductance and dissolved solids.

Specific conductance of water is a measure of the ability of water to conduct an electric current. 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.

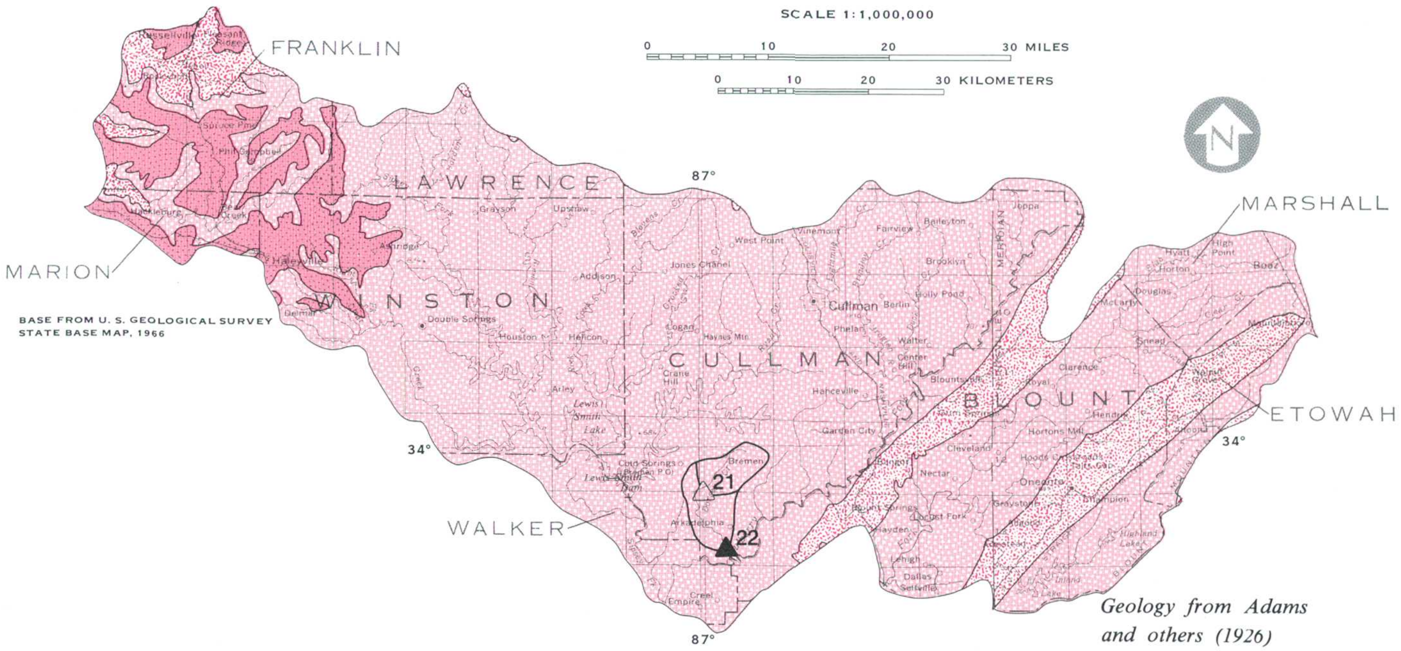
Specific conductance of surface water in Area 22 usually is low (fig. 6.1-1), except locally in areas of industrialization and coal mining. Streams in and near the city of Cullman and surrounding communities typically have higher specific conductances that reflect industrial-waste discharges. In other areas, higher specific conductance generally indicates coal-mine drainage.

Dissolved-solids content of water in streams usually is derived from soluble minerals in soil and geologic strata underlying the basin. The range of specific conductance generally observed in streams draining relatively undisturbed basins in the area are shown in figure 6.1-1. Factors are also shown that, when multiplied by specific conductance, provide an estimate of the dissolved-solids concentration (Cherry, 1963). Water in streams draining the Tuscaloosa Group and the Pottsville Formation (fig. 6.1-1) are very low in mineral content, reflecting the relatively insoluble strata (unconsolidated sand and gravel and indurated sandstone and shale) of the formations. Greater mineral content of water in streams draining the pre-Pennsylvanian rocks is due to the higher solubility of the carbonate strata (limestone and dolomite).

Relations between specific conductance and stream discharge draining undisturbed basins in each of the three geologic units in the area are illustrated in figure 6.1-2. Knowing the stream discharge this graph may be used to estimate specific conductance in streams draining unmined basins in Area 22. Specific conductance is generally higher during low-flow periods because of prolonged contact of water with soluble minerals in soils and rocks and less water available for dilution. During high-flow periods specific conductance is generally lower because of dilution by surface runoff.

Accelerated weathering of pyritic and other minerals present in coal-mine spoils results in the dissolution of large quantities of minerals and the production of sulfuric acid. These are contributed to streamflow draining mined areas. The acidic water reacts with other minerals increasing the dissolved-solids concentrations as well as specific conductance. Increases in specific conductance in streams draining mined areas are shown in figure 6.1-3. The specific conductance of water in Dorsey Creek at a discharge of 1.0 ft^3/s at site 22 (downstream from mined areas), is approximately six times greater than at site 21 (upstream from mined areas).

Specific conductance observed in streams draining mined areas in Area 22 generally ranges from 30 to 800 umhos/cm. In and immediately downstream from mined areas, the specific conductance of mine drainage can be as high as 3,000 umhos/cm. In general, specific conductance of water draining mined areas is highly variable and depends on such factors as: (1) the presence of pyritic and other 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. Highly mineralized water draining mined areas is usually local and generally decreases in downstream areas because of dilution.



EXPLANATION

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

▲22 Mined site and number

△21 Unmined site and number

Figure 6.1-1 Specific conductance in streams draining undisturbed areas.

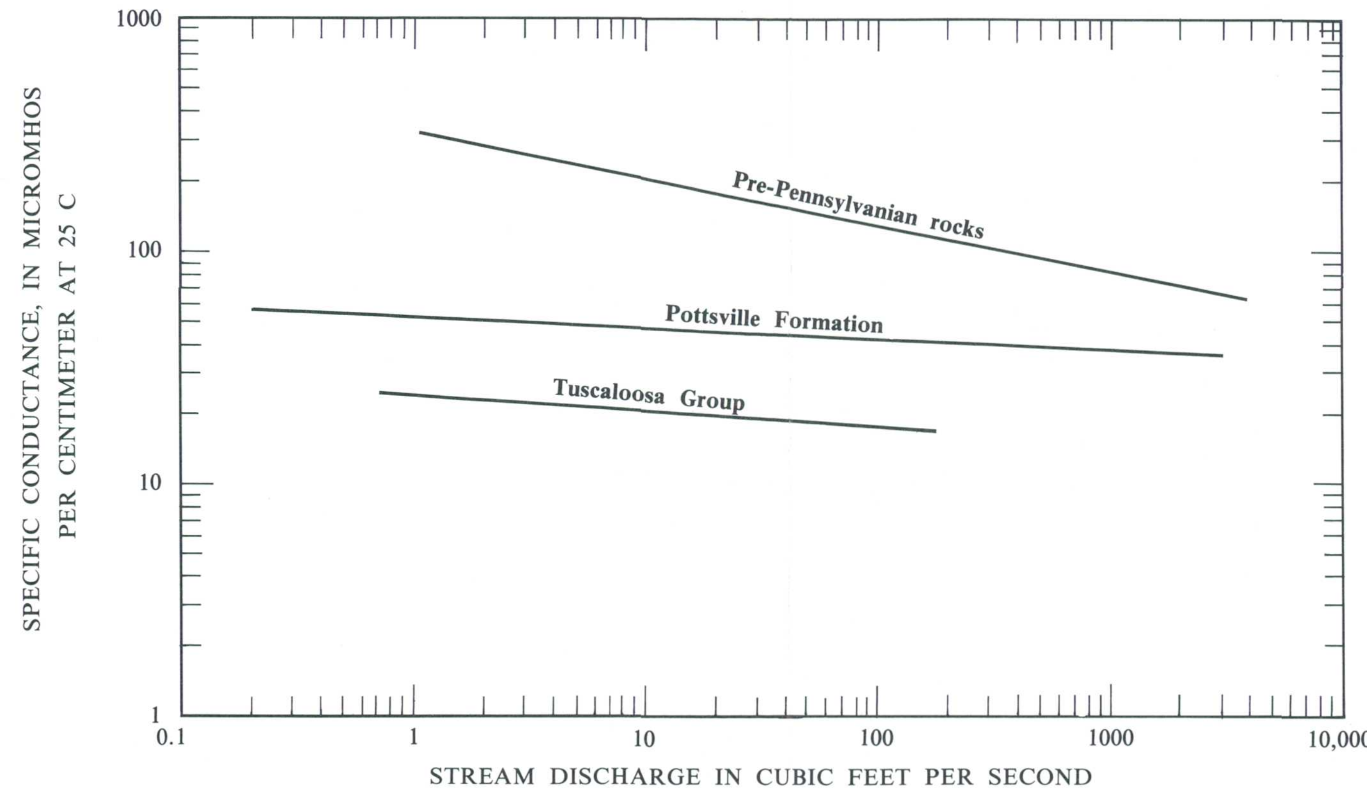


Figure 6.1-2 Relationship between stream discharge and specific conductance in undisturbed basins.

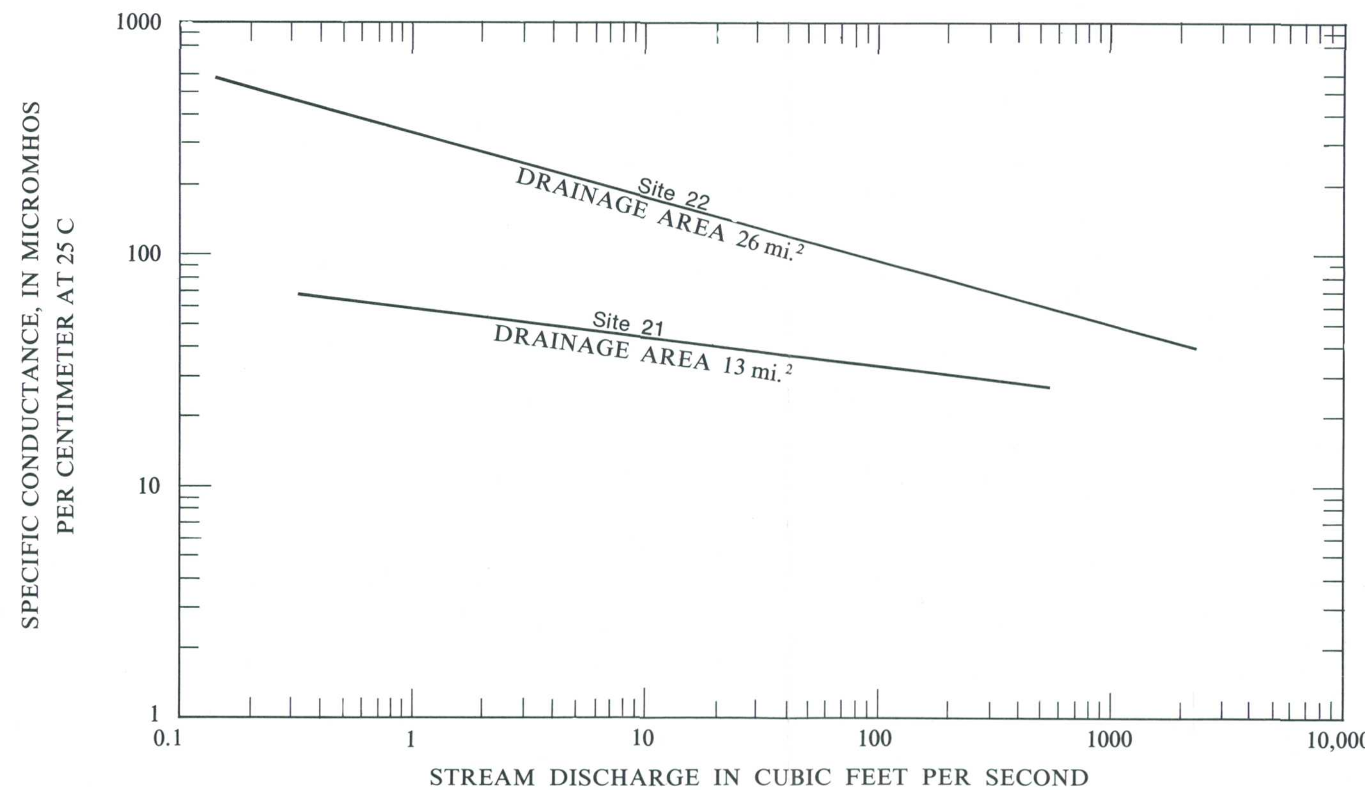


Figure 6.1-3 Relationship between stream discharge and specific conductance in Dorsey Creek.

pH of Streamflow Usually Fluctuates in Near Neutral Range

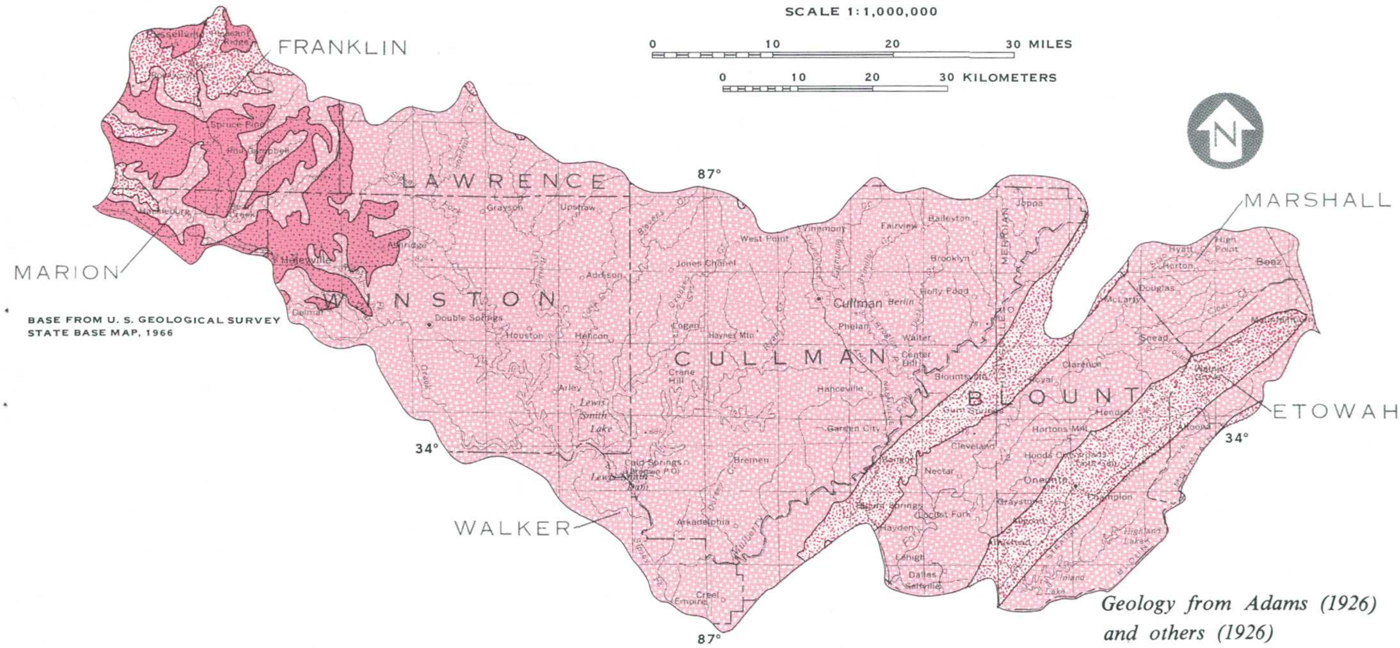
The pH of water in streams usually fluctuates in the near neutral range (6.0-8.0 units) and generally is not lowered by mine drainage.

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. The pH of water exerts a strong influence on the suitability of water for industrial, municipal, and recreation purposes. Prolonged extreme pH levels (pH less than 5.5 and greater than 9.0) can significantly affect aquatic productivity, corrosivity, and the toxicity, mobility, and solubility of many chemical compounds.

In unmined areas, the pH of water is primarily controlled by the presence of dissolved carbon dioxide and/or the hydrolysis of salts of weak acids and strong bases. Sources of these substances generally include rainfall, weathered geologic strata, and decomposition of organic matter in soils. The range of pH values generally observed in streams draining undisturbed basins is shown on figure 6.2-1. The pH of water in streams varies widely, but usually is in the near neutral range (6.0-8.0 units). Fluctuation of pH is generally related to one or more environmental factors such as geology, streamflow, and land use (Kaufman, 1970). The influence of geology on the pH of water in streams draining the area is shown in figure 6.2-1. The highest pH values generally occur in streams primarily underlain by carbonate strata such as limestone and dolomite of the pre-Pennsylvanian rocks; water in these streams is alkaline with a high neutralization capacity. The lowest pH values generally occur in streams underlain by unconsolidated sand and gravel of the Tuscaloosa Group; water in these streams usually is acidic with low neutralization capacity. Near neutral pH values generally occur in streams in the Pottsville Formation, an area primarily underlain by sandstone and shale.

pH values generally decrease with increased streamflow. During low flow the pH values in streams approach that of water in aquifers underlying the basin, while during high flow the pH values approach those of overland runoff. Overland runoff, in Area 22, is generally acidic because of acidic precipitation and a carbon dioxide and organic-rich soil environment.

In coal mine areas the pH of mine effluent is determined by the chemical character of spoil. In some areas, weathering of pyrite and other sulfate-bearing minerals results in the production of sulfuric acid. Acid-mine drainage may have pH values that range from 2.0 to 5.0 units. In many areas, calcareous minerals such as siderite, calcite, and ankarite commonly occur in large quantities in spoil. In these areas, acidic mine drainage is rapidly neutralized.



EXPLANATION

General pH range

(Tuscaloosa Group pattern)	**5.5-7.5**	**Tuscaloosa Group**
(Pottsville Formation pattern)	**6.0-8.0**	**Pottsville Formation**
(Pre-Pennsylvanian rocks pattern)	**6.5-8.5**	**Pre-Pennsylvanian rocks**

Figure 6.2-1 pH in streams draining undisturbed basins.

Surface Mining Drastically Alters Natural Sediment Yield

Sediment yields from undisturbed basins generally range from 20 to 800 (tons/mi^2)/yr while those from mined basins can be as high as 300,000 (tons/mi^2)/yr.

Annual sediment yields of streams draining relatively undisturbed basins in Area 22 are usually low and may range from 20 to 800 (tons/mi^2)/ yr. 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. In heavily mined but unreclaimed areas, sediment yields can be as high as 300,000 (tons/mi^2)/yr (Hubbard, 1976). Although sediment yields associated with surface mining can be high, they can be reduced by effective reclamation.

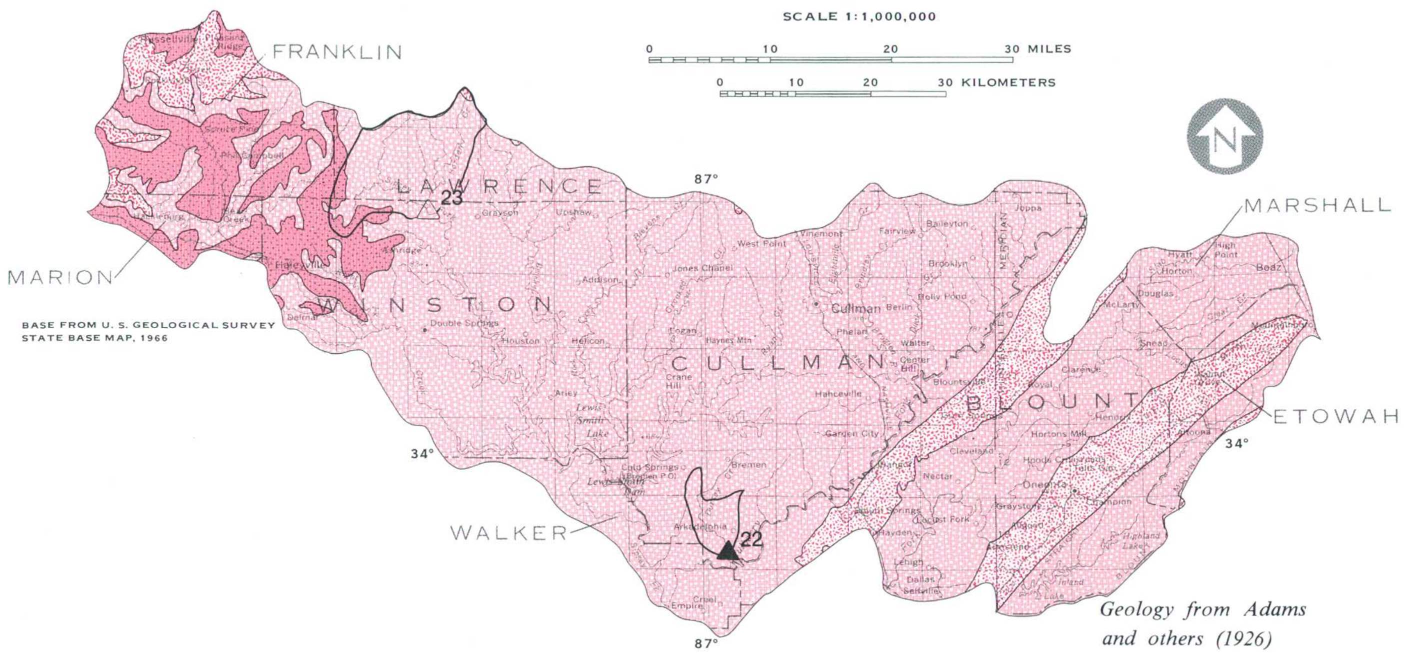
Basins in most of Area 22 are underlain by geologic formations (Pottsville and Tuscaloosa Group) characterized by hilly terrains with moderate to steep slopes and easily erodible soils. These characteristics tend to produce rapid runoff with high erosion potential. Most of the area, however, has a dense forest cover which lowers runoff velocities and decreases the influence of topography on erosion and sediment yields.

Suspended-sediment concentration ranges, estimated annual sediment yields, and drainage areas for sites 22 and 23 are shown in figure 6.3-1. The sites are located in an area of similar climate and topography and are underlain by the Pottsville Formation, but drain areas of different land use. Site 23 drains a relatively undisturbed basin; site 22 drains a basin with considerable active surface mining and areas under cultivation. The difference in land use in the basins is reflected by the relative positions of their respective sediment yield curves (fig. 6.3-2). During 1979 the annual sediment yield at site 22 was about seven times greater than at site 23. Most of the sediment loads were transported during high flow periods. In general, the highest suspended-sediment concentrations occur during high flow and the lowest during low flow.

Particle-size distribution of suspended sediment transported during high flows occurring on April 11-13, 1979 at site 22 was about 40 percent clay and silt (finer than 0.062 mm) and 60 percent sand (0.06-2.0 mm). This particle-size distribution reflects the lithologic character (fine-grained sandstone) of the Pottsville Formation in the basin.

Bed-material size composition at site 22 averaged 0 percent for clay and silt, 90 percent for sand, and 10 percent for gravel (2.0-6.4 mm).

Bedload, the sediment transported along and immediately adjacent to the streambed, is unmeasured at sites 22 and 23 and is not included in reported sediment yields.



EXPLANATION

	Tuscaloosa Group
	Pottsville Formation
	Pre-Pennsylvanian rocks

Gaging station location and number	▲22	△23
Period of record	1979	1979
Suspended sediment concentration range, in milligrams per liter	1-5,000	1-2,240
Estimated annual sediment yield, in tons per square mile per year	1,030	140
Drainage area, in square miles	26.0	91.3
Percent of basin mined	6	0

Figure 6.3-1 Suspended sediment at selected sites.

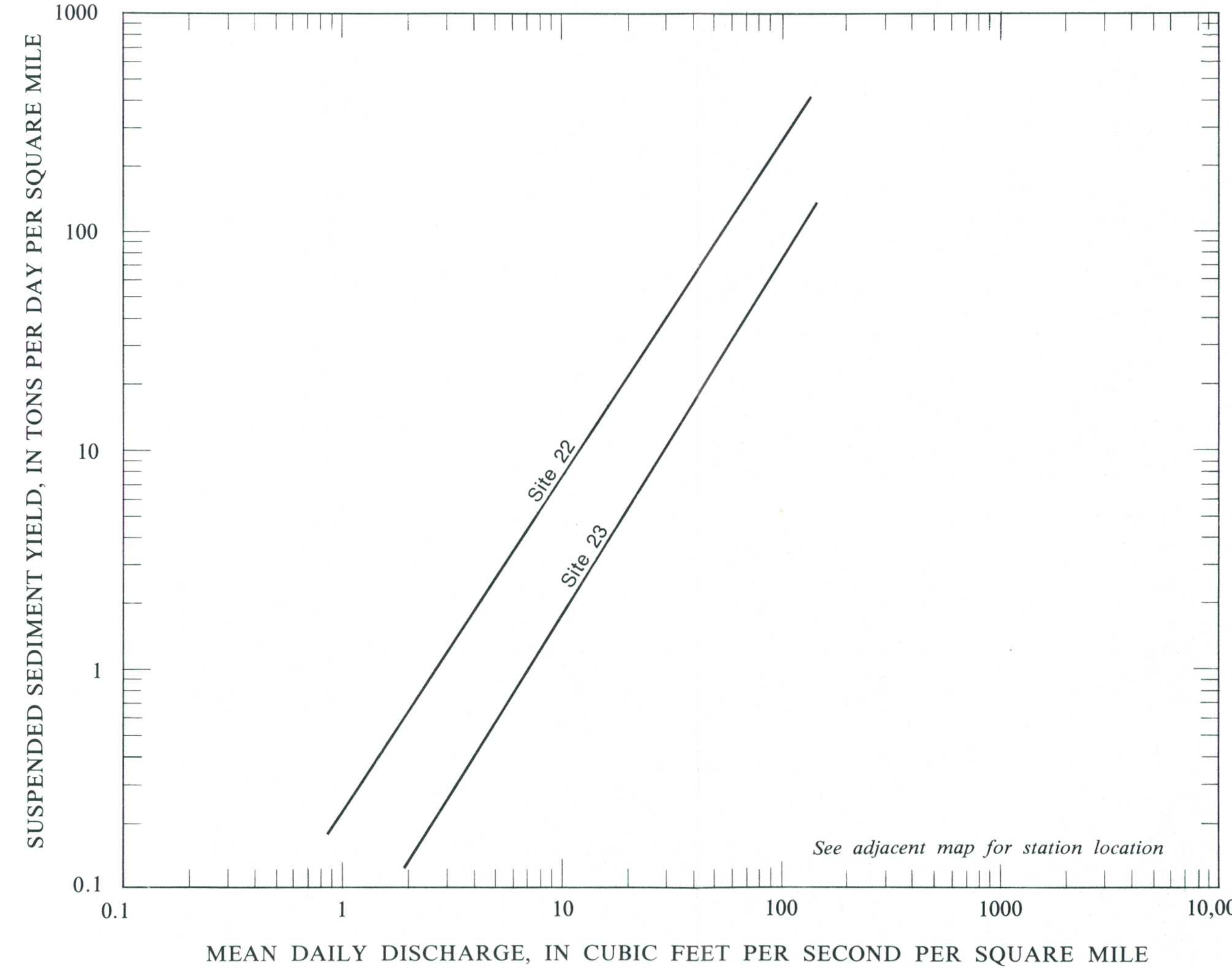


Figure 6.3-2 Relationship between stream discharge and suspended sediment.

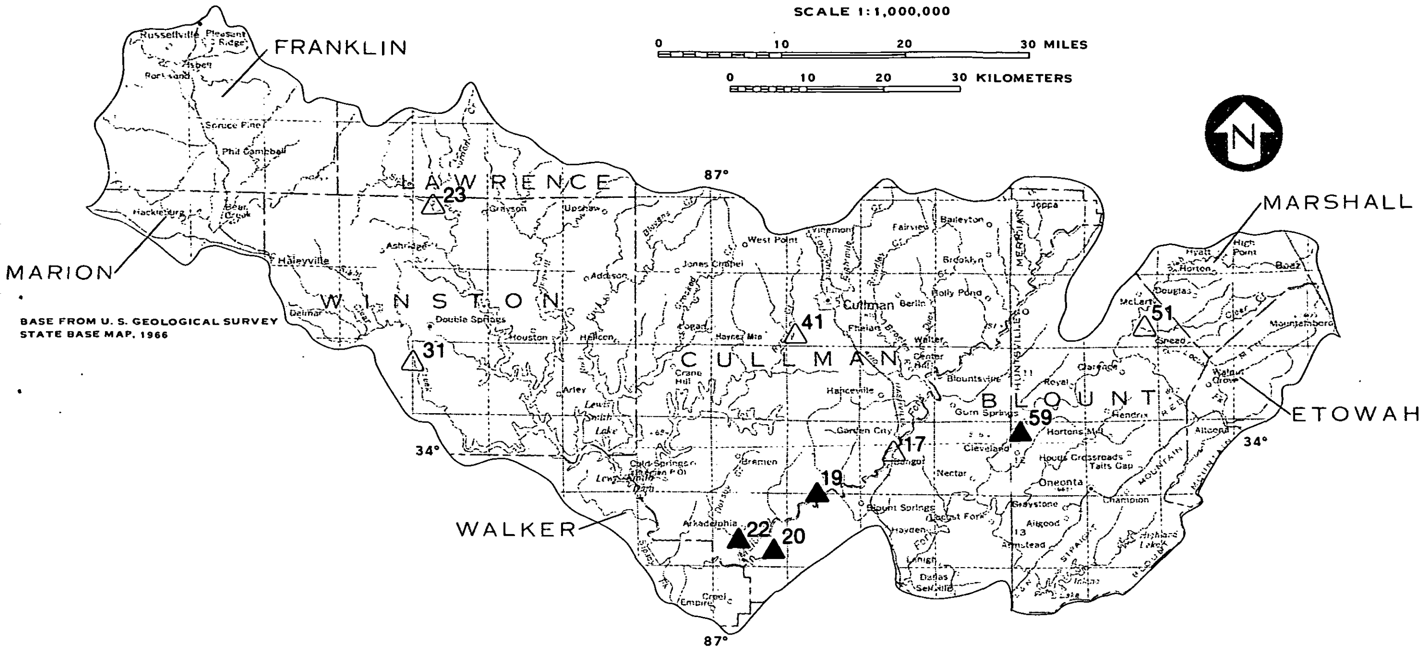
Dissolved Iron Concentrations of Streams Draining Mined and Unmined Basins are Similar, but Total Recoverable Iron Concentrations are Markedly Different

The similarity of dissolved iron in streams draining mined and unmined basins is due to aeration of the otherwise high dissolved iron content of mine effluent forming an insoluble precipitate that results in a reduction in dissolved iron but does not change the total recoverable iron concentration.

Dissolved-iron concentrations in streams draining mined areas are generally similar to those in streams draining unmined areas in Area 22. Ranges and mean values of observed dissolved-iron concentrations in streams draining mined and unmined basins are shown in figures 6.4-1 and 6.4-2. Dissolved-iron concentrations in streams draining relatively undisturbed basins in Area 22 are generally less than 300 μg/L (micro-grams per liter). Dissolved-iron concentrations exceeding 300 μg/L impart an objectionable 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. Large quantities of soluble iron salts can be contributed to streamflow from coal-mine spoils as a result of accelerated weathering of iron-bearing minerals such as pyrite and marcasite.

Although dissolved-iron concentrations are generally high in mine effluent, aeration and dilution rapidly decrease the high dissolved iron. Hence, in nearby downstream areas, dissolved-iron concentrations are generally similar to or even less than those in streams draining unmined areas. In contrast, total recoverable-iron concentrations are higher in streams draining mined areas and increase with increases in suspended-sediment concentrations.

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 in figure 6.4-3. These relations may be used for estimating iron loads from mined and unmined basins in the area. 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

△31 Unmined site and number

▲19 Mined site and number

Figure 6.4-1 Location of selected sites for iron concentrations.

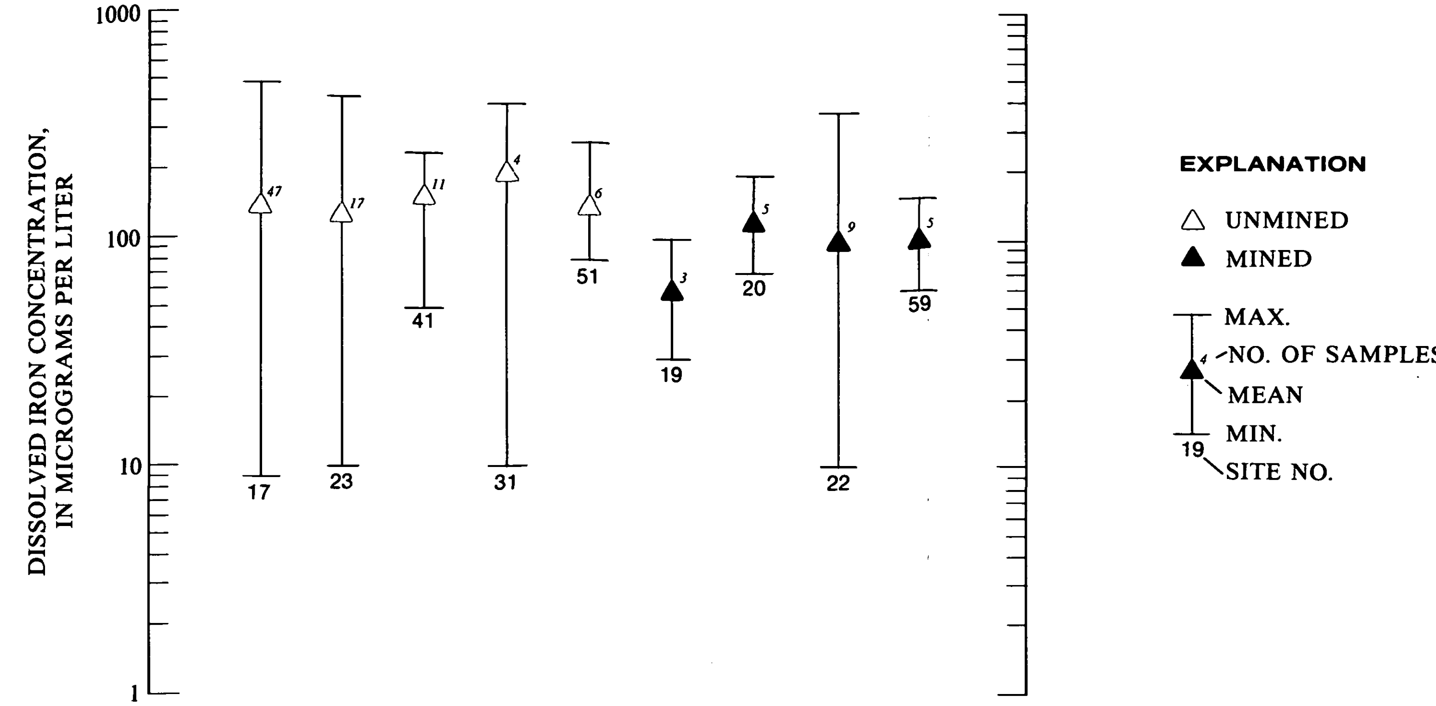


Figure 6.4-2 Mean and range of dissolved-iron concentrations at mined and unmined sites.

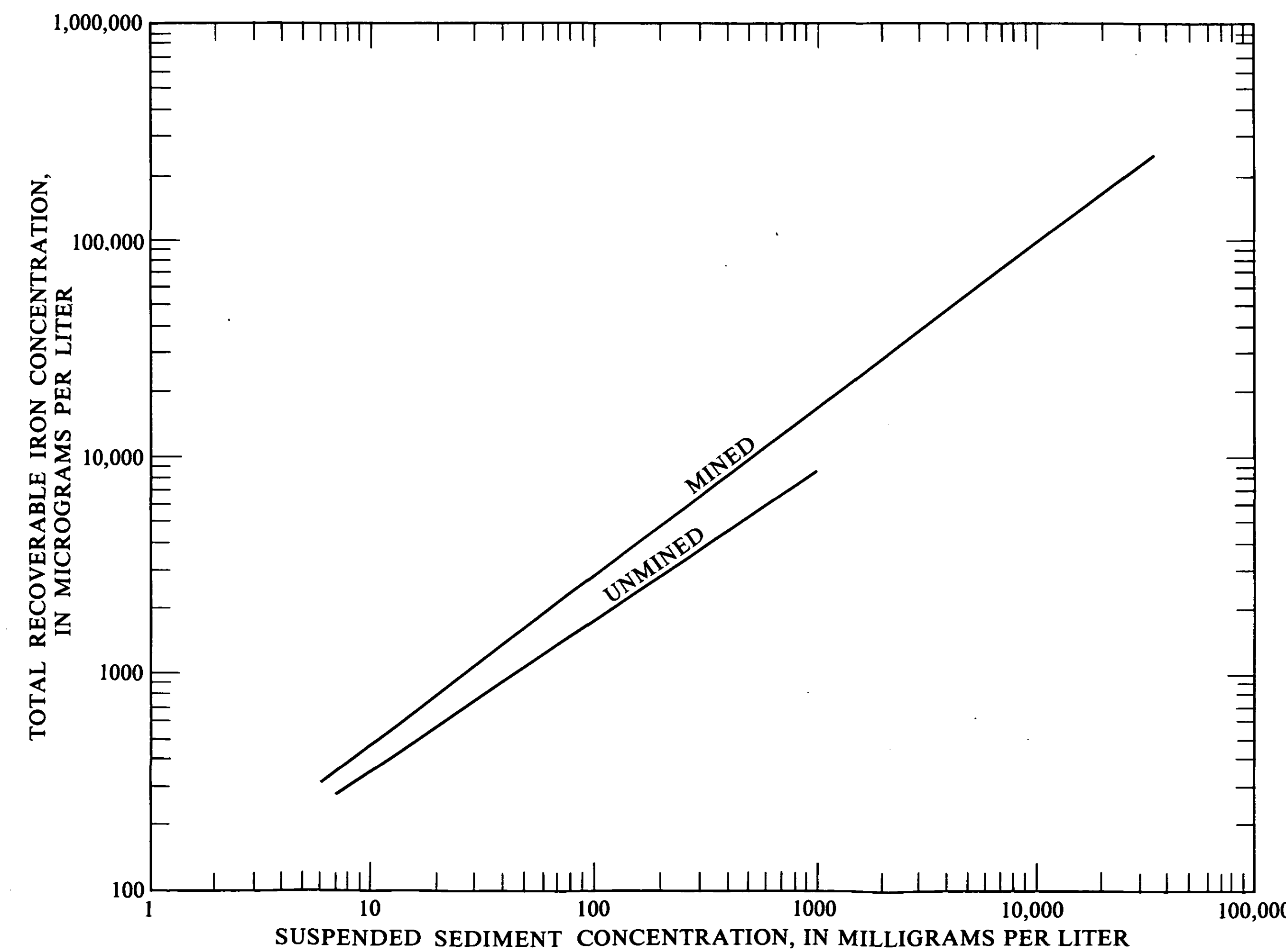


Figure 6.4-3 Relationship between total recoverable iron and suspended sediment at mined and unmined sites.

Manganese Concentrations are High in Streams Draining Mined Areas

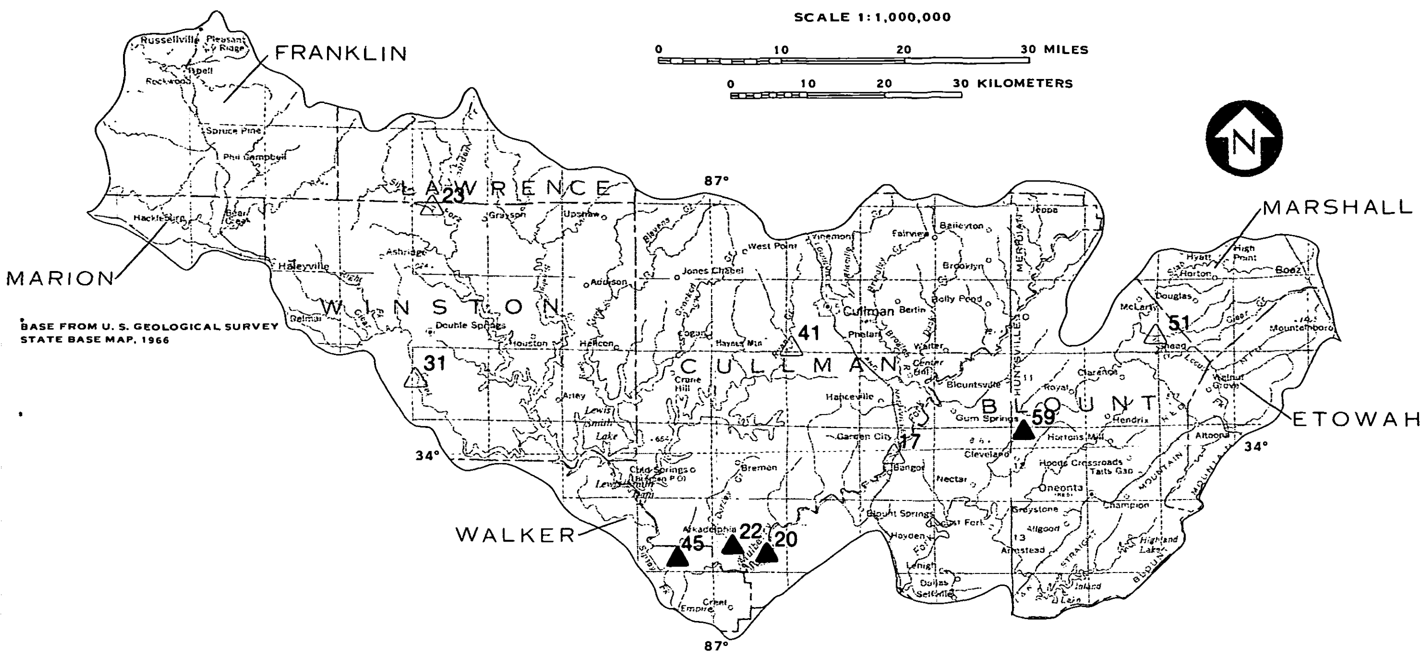
Dissolved-manganese concentrations from unmined basins range from less than 2 to 200 µg/L, while from mined basins range from 30 to 1000 µg/L. Total recoverable manganese ranges from about 25 to 200 µg/L in unmined basins and from 150 to 6000 µg/L in mined basins.

Dissolved-manganese concentrations exceeding 50 µg/L 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 the geologic strata underlying the basins.

Dissolved concentrations in streams draining relatively undisturbed basins are generally less than 50 µg/L (figs. 6.5-1 and 6.5-2). 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 ranged from less than 10 to 1,800 µg/L.

High dissolved-manganese concentrations observed in streams draining mined areas vary widely and contrast sharply with concentrations observed in streams draining unmined areas (fig. 6.5-2). Although dissolved-manganese concentrations are high in and near coal-mine areas, aeration and dilution by alkaline streams (pH greater than 7.0 units) rapidly decrease the high concentrations. Dissolved-manganese concentrations in acidic or near neutral (6.0 to 8.0 pH units) 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 total recoverable manganese (dissolved and suspended) ranging as high as 200 µg/L in unmined areas and 6,000 µg/L in mined areas. Relations between total recoverable-manganese concentrations and suspended-sediment concentrations in streams draining mined and unmined basins are shown in figure 6.5-3. These relations may be used for estimating manganese loads from mined and unmined basins in the area. 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

△[23] Unmined site and number

▲[20] Mined site and number

Figure 6.5-1 Location of selected sites for manganese concentrations.

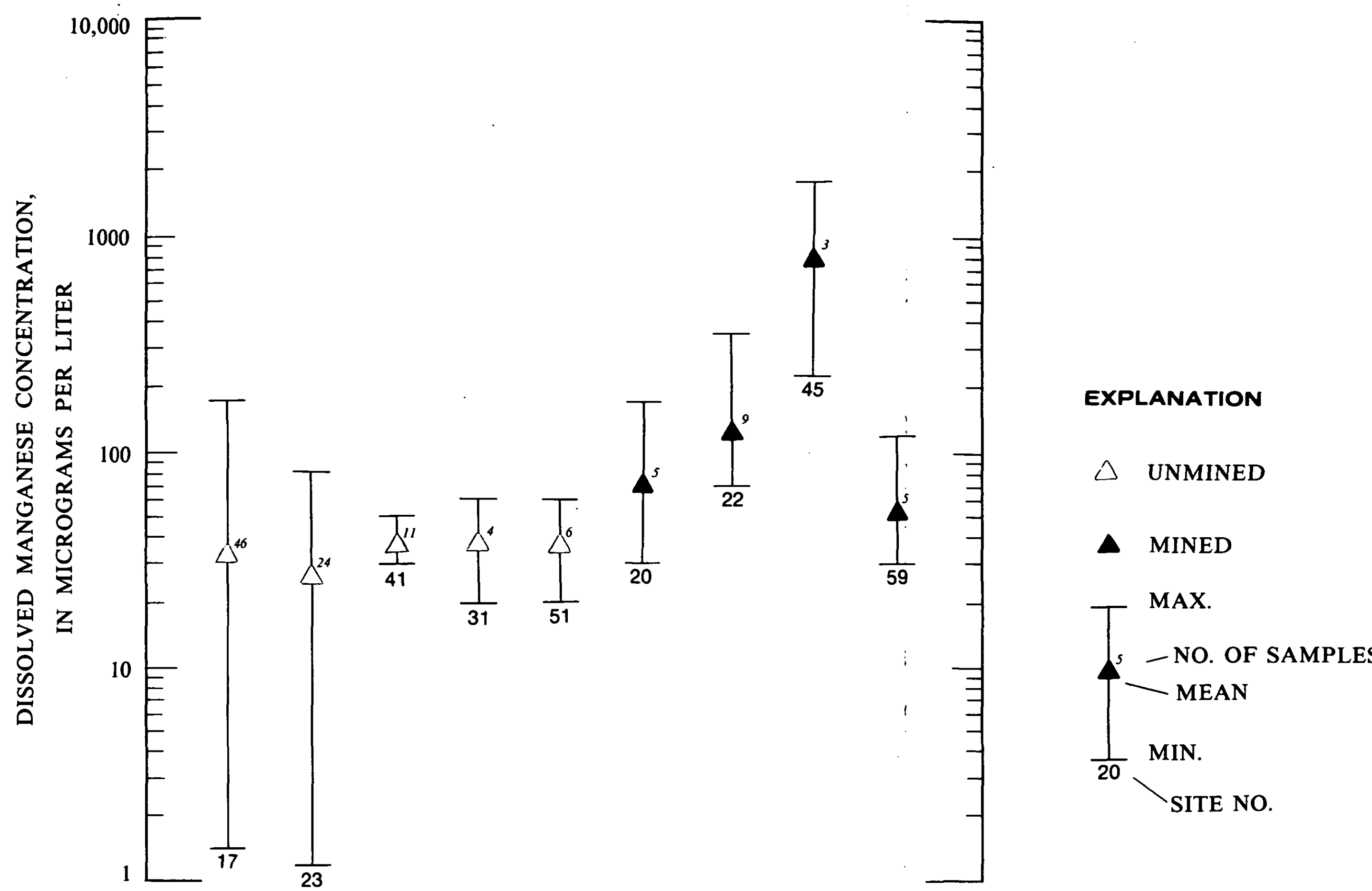


Figure 6.5-2 Mean and range of dissolved-manganese concentrations at mined and unmined sites.

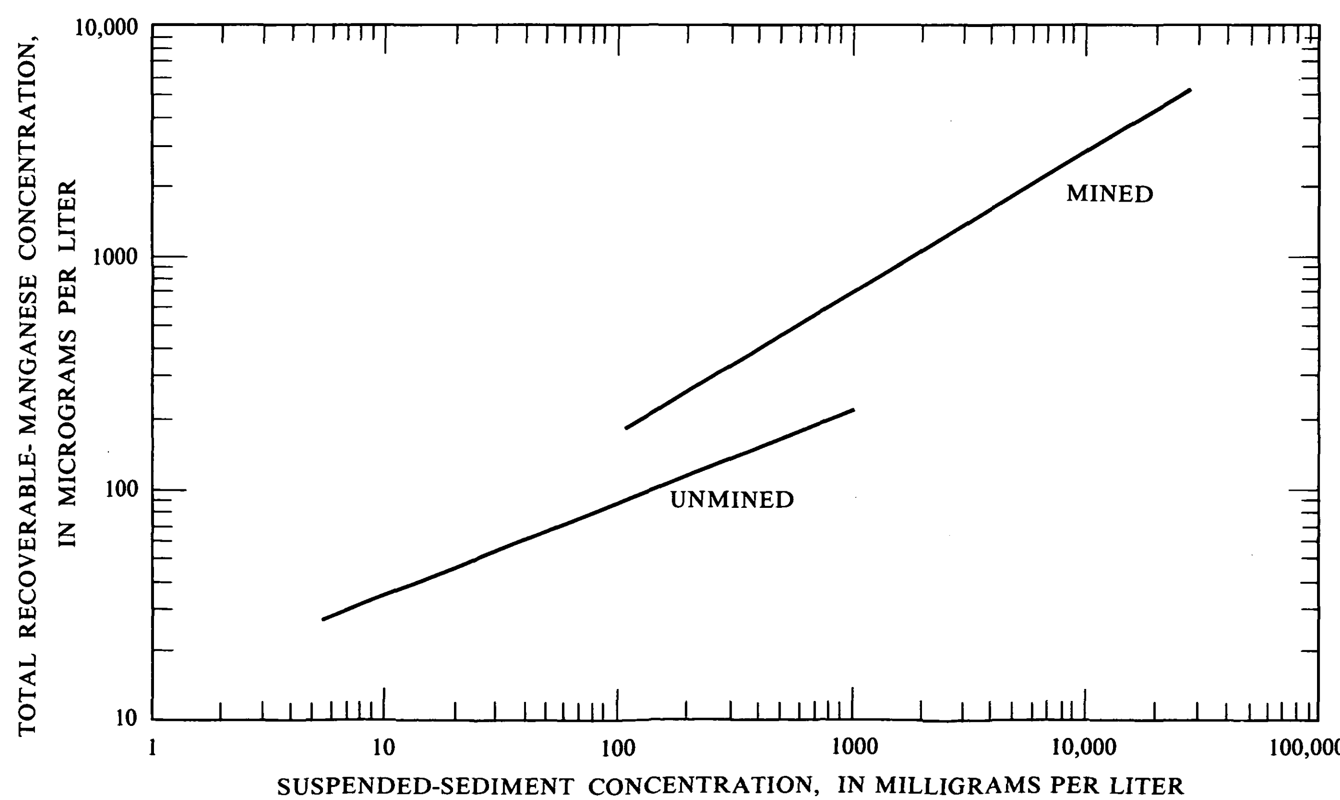


Figure 6.5-3 Relation between total recoverable manganese and suspended sediment.

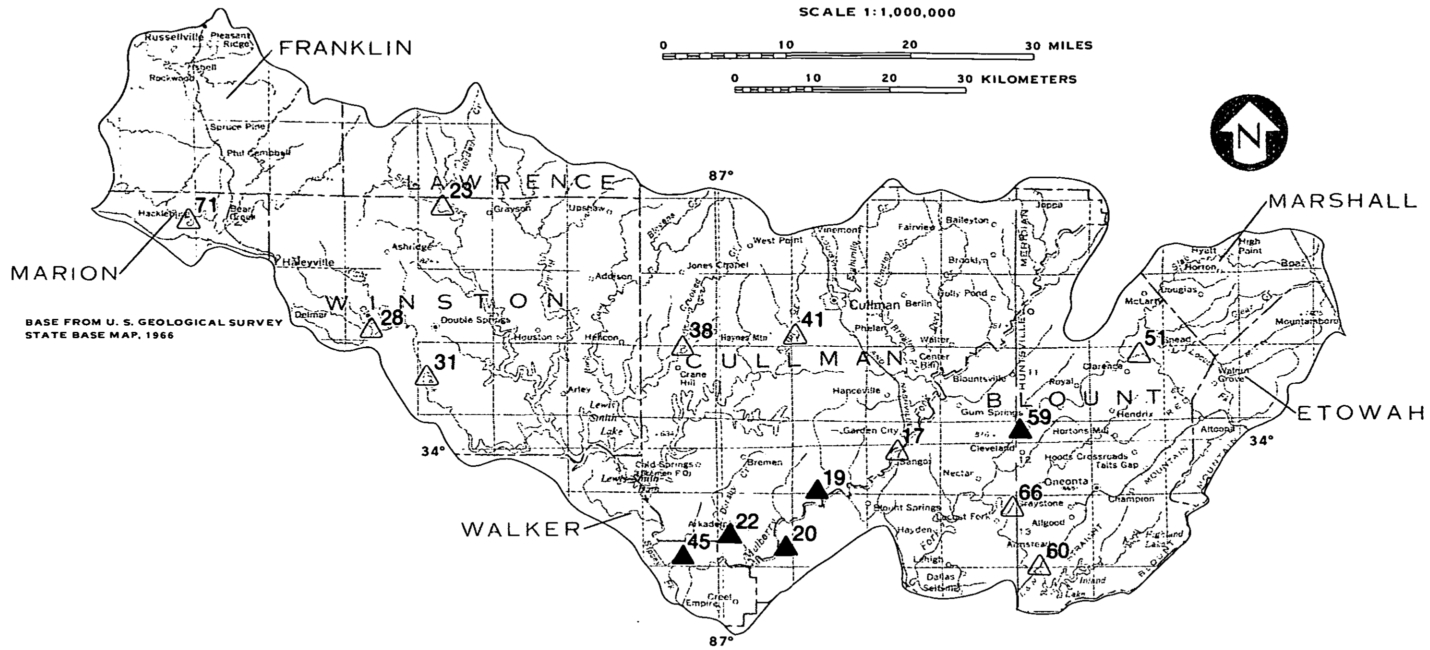
Sulfate Concentrations Increase in Streams Draining Mined Areas

Sulfate concentrations in streams draining unmined areas generally ranged from 1 to 20 mg/L while those in streams draining mined areas ranged from 20 to 190 mg/L.

Sulfate concentrations in streams draining relatively undisturbed basins in Area 22 usually ranged from 1 to 20 mg/L. In contrast, observed sulfate concentrations in streams draining mined areas were more variable and ranged from 20 to 190 mg/L (fig. 6.6-1). The relatively low range of sulfate concentrations in streams draining mined areas is due to dilution of the otherwise high concentrations in mine drainage. Sulfate concentrations in mine drainage may approach 2,000 mg/L as observed in adjacent Area 23, an area geologically similar to Area 22. Sulfate is usually the highest in concentration and the most persistent dissolved constituent in the water and is commonly used as an indicator of mine drainage.

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. An example of the fluctuation of sulfate concentration in response to changes in streamflow at Dorsey Creek below Arkadelphia (site 22), draining a mined area, is shown in figure 6.6-2. In general, sulfate concentrations are highest during low flow, due to the presence of mine drainage and the lack of dilution by rainfall. In downstream areas sulfate concentrations usually decrease due to dilution.

Sulfate concentrations relate directly to specific conductance, which is an indicator of the degree of mineralization in water. This relation is illustrated in figure 6.6-3 and may be used to estimate the concentration of sulfate from known specific conductance in streams draining mined and unmined basins in the area. The relative positions of the lines in figure 6.6-3 indicate significant differences in sulfate concentration in water between streams draining mined and unmined areas.



EXPLANATION

Gaging station and number

▲ Mined △ Unmined

	Mined					Unmined									
Station number	59	19	20	22	45	28	31	38	41	23	51	17	60	66	71
Range in sulfate concentration, in milligrams per liter	6.1-62	39-75	4.9-9.4	8.2-190	35-190	3.3-5.1	2.3-5.4	2.5-3.3	3.7-6.9	0.8-39	5.8-14	3.2-18	4.5-8.2	8.8-42	1.0-21
Mean value	22	51	7.0	56	122	4.0	3.7	2.9	4.6	4.2	9.1	6.8	6.4	23	6.4
Number of samples	13	3	5	23	3	3	4	3	10	94	5	48	3	3	31

Figure 6.6-1 Sulfate concentrations at selected sites.

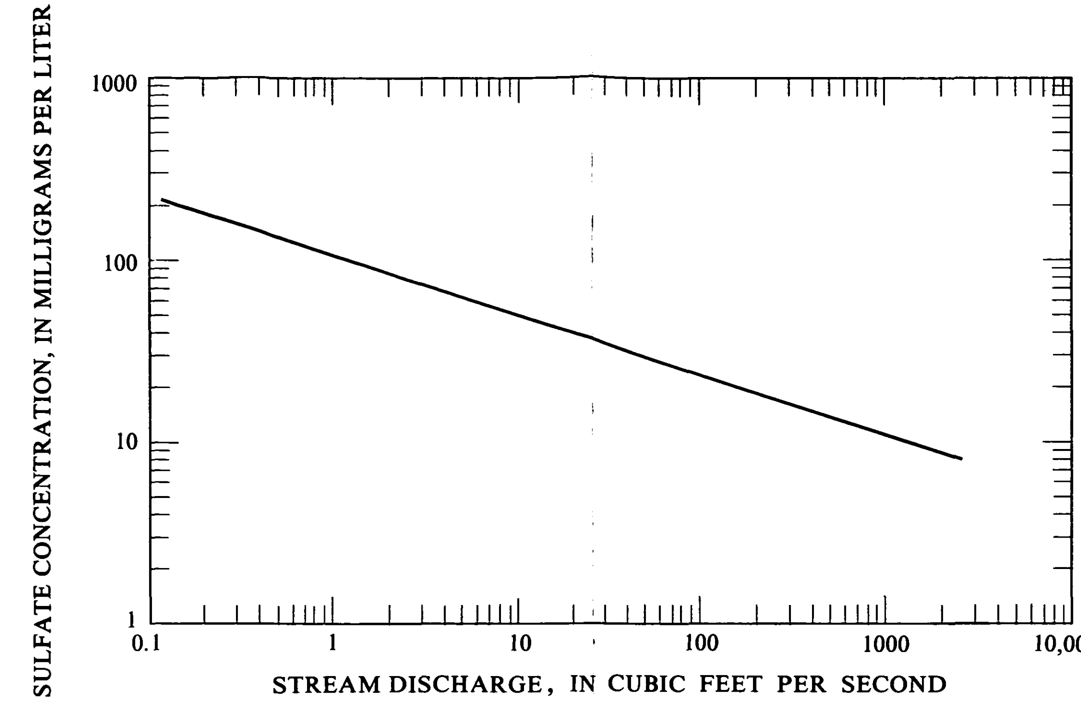


Figure 6.6-2 Relationship between sulfate concentration and stream discharge at Dorsey Creek below Arkadelphia (site 22)

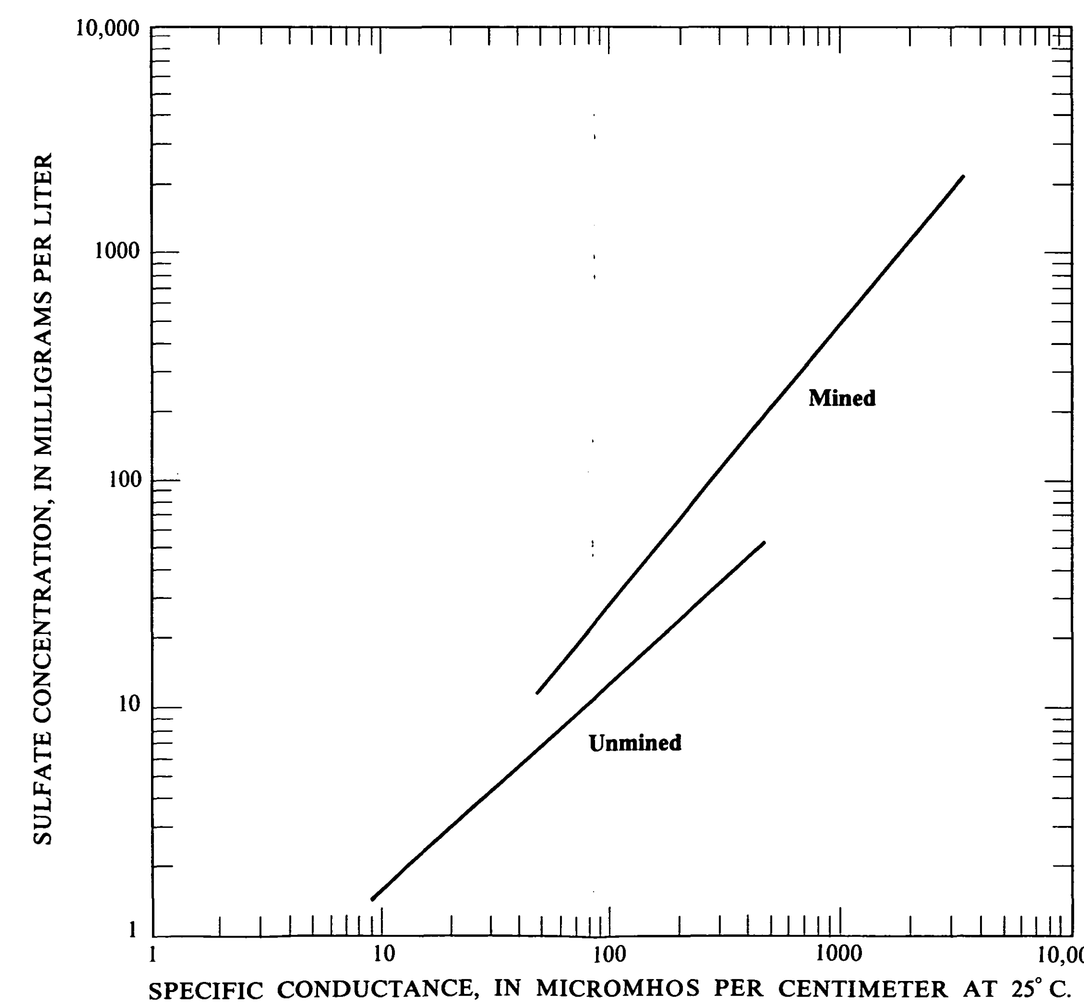


Figure 6.6-3 Relationship between sulfate concentration and specific conductance.

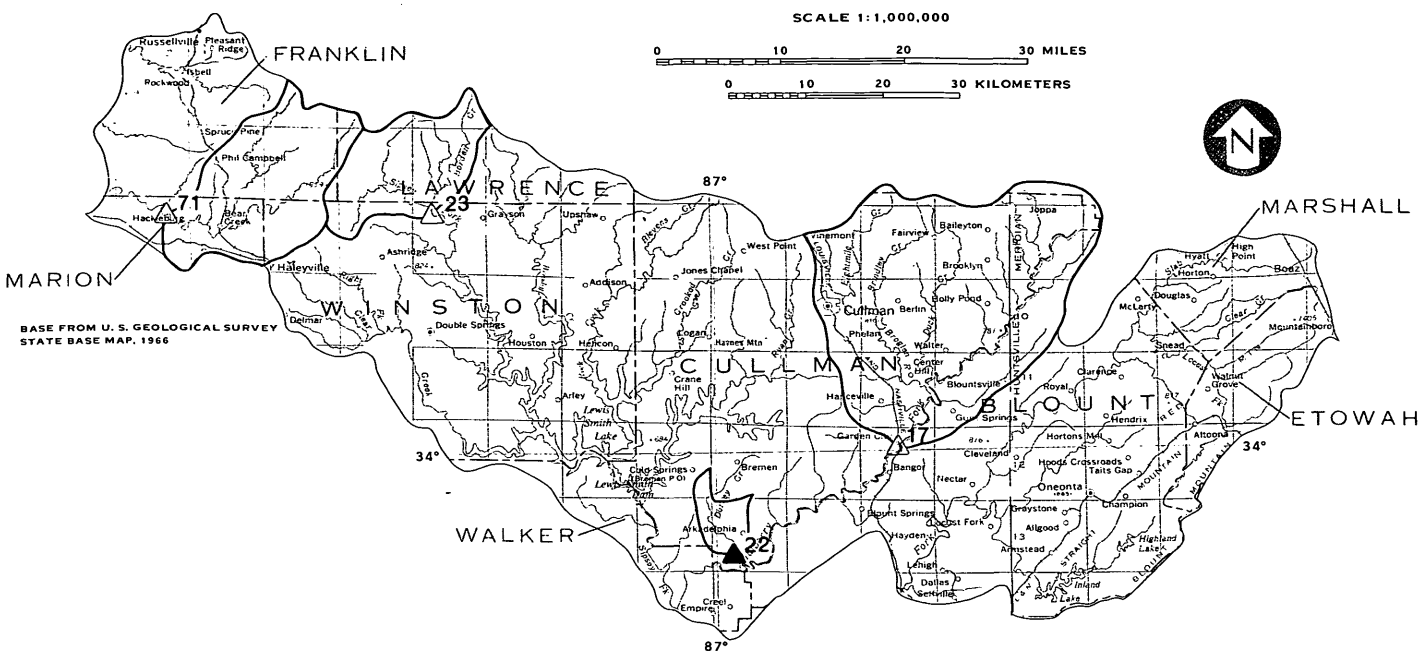
Trace Elements Occur in Low Concentrations

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. For example, selenium is considered an essential element for animals, but is toxic when ingested in concentrations as low as 700 micrograms per day. Maximum dissolved selenium concentrations in drinking water recommended by the U.S. Environmental Protection Agency (1977) is 10 μg/L. High concentrations in streams can occur naturally; however, most high concentrations generally are associated with municipal and industrial-waste discharges, or storm runoff from urban areas. In coal-mine areas accelerated weathering of pyritic minerals present in coal-mine spoils produces acidic mine drainage that is contributed to streamflow. The acid water reacts with other minerals and can produce adverse concentrations of trace elements in mine drainage.

In Area 22, 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. The concentrations of all trace elements listed in the table are within maximum limits recommended by the U.S. Environmental Protection Agency (1977).

In general, dissolved 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. The decrease generally results from chemical reactions and precipitation caused by near neutral pH (6.0-8.0 units) water in streams and the strong sorption attraction between trace elements and suspended sediments.



EXPLANATION

▲22 Mined site and number

△23 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, at selected sites, in micrograms per liter.

Element	Mulberry Fork near Garden City △ site 17				Dorsey Creek below Arkadelphia ▲ site 22				Sipsey Fork near Grayson △ site 23				Bear Creek near Hackleberry △ site 71			
	N	$\overline{X}$[2]	MIN.	MAX	N[1]	$\overline{X}$[2]	MIN	MAX	N[1]	$\overline{X}$[2]	MIN	MAX	N[1]	$\overline{X}$[2]	MIN	MAX
ALUMINUM	–	–	–	–	9	70	10	400	–	–	–	–	–	–	–	–
ARSENIC	41	1	0	3	2	0	0	0	5	2	0	10	27	<1	0	3
CADMIUM	41	<1	0	1	2	2	0	4	6	1	0	5	27	<1	0	1
CHROMIUM	41	<1	0	3	2	10	10	10	5	1	0	2	27	<1	0	1
COBALT	39	1	0	2	2	<1	0	1	6	2	1	3	20	<1	0	2
COPPER	27	2	1	7	2	2	1	4	4	5	0	10	7	2	1	4
LEAD	41	1	0	6	2	0	0	0	6	3	0	10	27	2	0	6
MERCURY	41	.3	0	1.8	2	.3	.1	.5	5	.2	.1	.5	25	.3	0	.8
SELENIUM	2	0	0	0	2	0	0	0	2	0	0	0	5	0	0	0
ZINC	41	20	0	300	2	10	10	10	5	10	8	20	27	30	5	150

1/ *N–Number of samples*

2/ *$\overline{X}$–Mean*

Three Aquifer Systems Underlie Area 22

The Tuscaloosa Group, Pottsville Formation, and pre-Pennsylvanian rocks outcrop and receive direct recharge in Area 22. The movement of water in these aquifers is generally to the southwest.

Ground water in Area 22 is derived from precipitation. 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.

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 outcrops of aquifers. Where the water level in an aquifer is below that of the stream, water may percolate through the stream channel and into the aquifer.

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 rock units are well sorted sand and gravel, limestone with interconnected solution openings, and rocks with interconnected fracture systems. Among the least permeable units are clay, shale, and dense, consolidated rocks with no interconnecting fractures or solution openings.

Ground-water movement in Area 22 generally is to the southwest following the regional dip of the rock units. Locally, water flows toward points of discharge such as streams or wells. The path which water must take as it flows varies with the three different rock units in Area 22 (fig. 7.1-1).

Water flows freely through the sand and gravel beds of the Tuscaloosa Group, but the Tuscaloosa Group is not a major aquifer in Area 22 because of its limited thickness. Ground water in the pre-Pennsylvanian carbonate (limestone and dolomite) rocks occurs in solution openings developed along fractures and bedding planes. The interconnected solution openings in these rocks form a system of conduits that permits relatively free movement of large quantities of ground water. Beds of sandstone and conglomerate of the Pottsville Formation allow water movement but in smaller quantities because the water-bearing openings have not been enlarged by solution. Direction of water movement in the Pottsville Formation and in the pre-Pennsylvanian rocks is controlled locally by orientation of the fractures or solution openings.

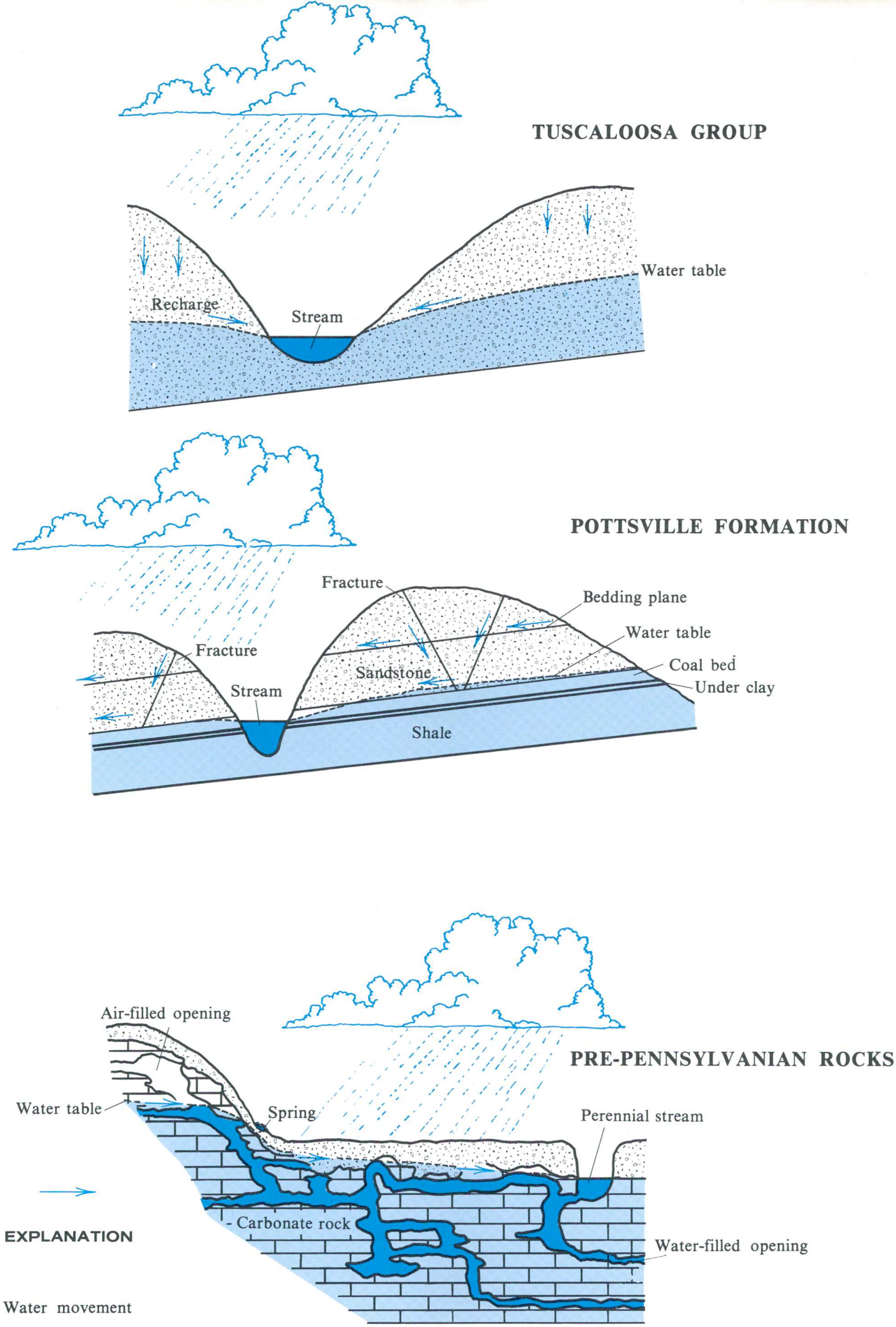


Figure 7.1-1 Water movement in aquifers.

7.0 GROUND WATER

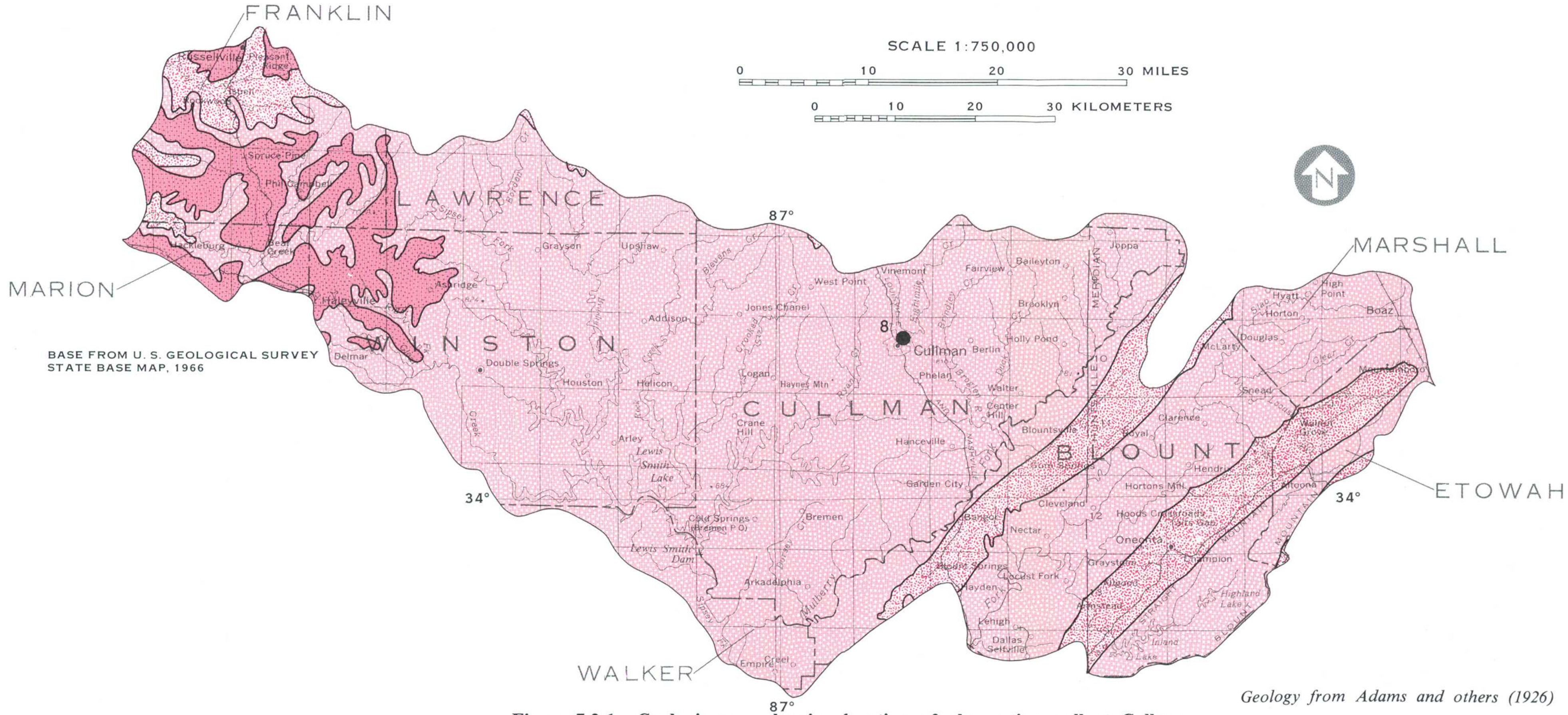
7.1 SOURCE, RECHARGE, AND MOVEMENT

Ground-Water Levels in Area 22 Fluctuate Seasonally

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

Seasonal variations in recharge produce fluctuations of water levels. Highest water levels occur in the spring prior to the onset of the growing season in response to recharge from precipitation. Lowest levels occur in the fall prior to the first killing frost when losses to evapotranspiration are reduced.

An observation well located at Cullman near the center of Area 22 taps the Pottsville Formation which underlies more than 85 percent of the area (fig. 7.2-1). Water levels in the well were recorded continuously from March 1952 until April 1978 (fig. 7.2-2). Seasonal fluctuation was most extreme prior to 1956, the year in which pumping in the area was discontinued. The seasonal pumping increased the normal fluctuation caused by precipitation and evapotranspiration. After 1956, a general rise in water level took place as the aquifer recovered from the effects of pumping. The recovery was most rapid during 1957 and 1958, and was not complete until about 1963.



EXPLANATION

Tuscaloosa Group

Pottsville Formation

Pre-Pennsylvanian rocks

8 Observation well and number

Figure 7.2-1 Geologic map showing location of observation well at Cullman.

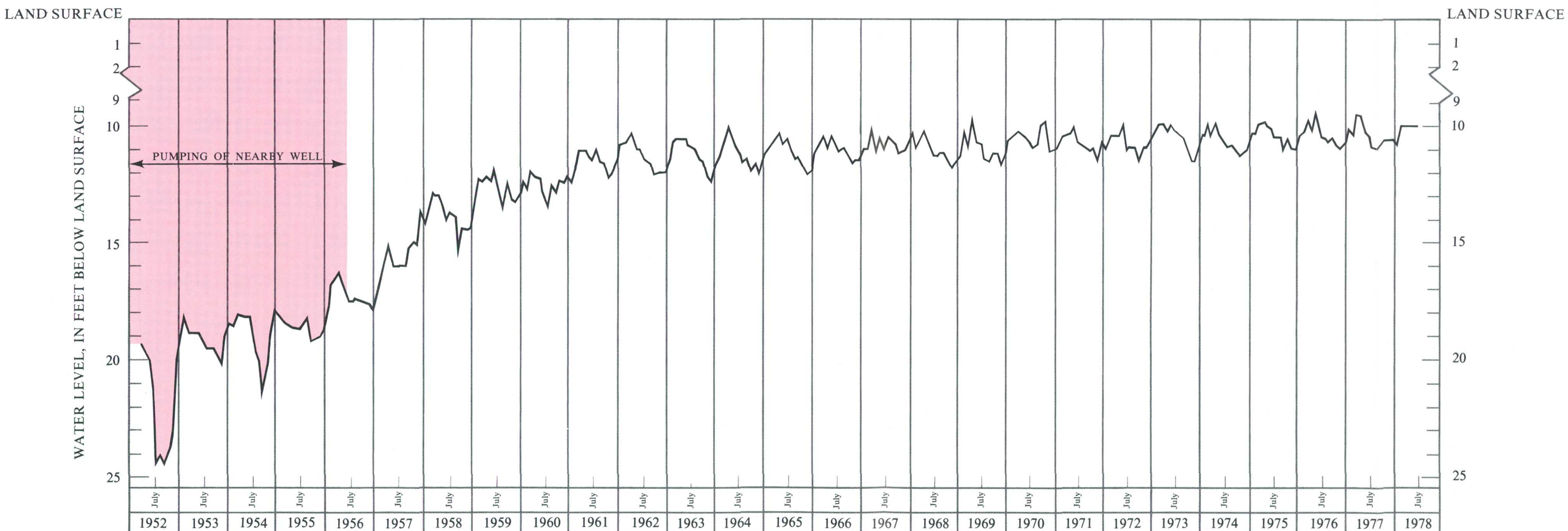


Figure 7.2-2 Hydrograph of observation well at Cullman showing seasonal water-level fluctuations.

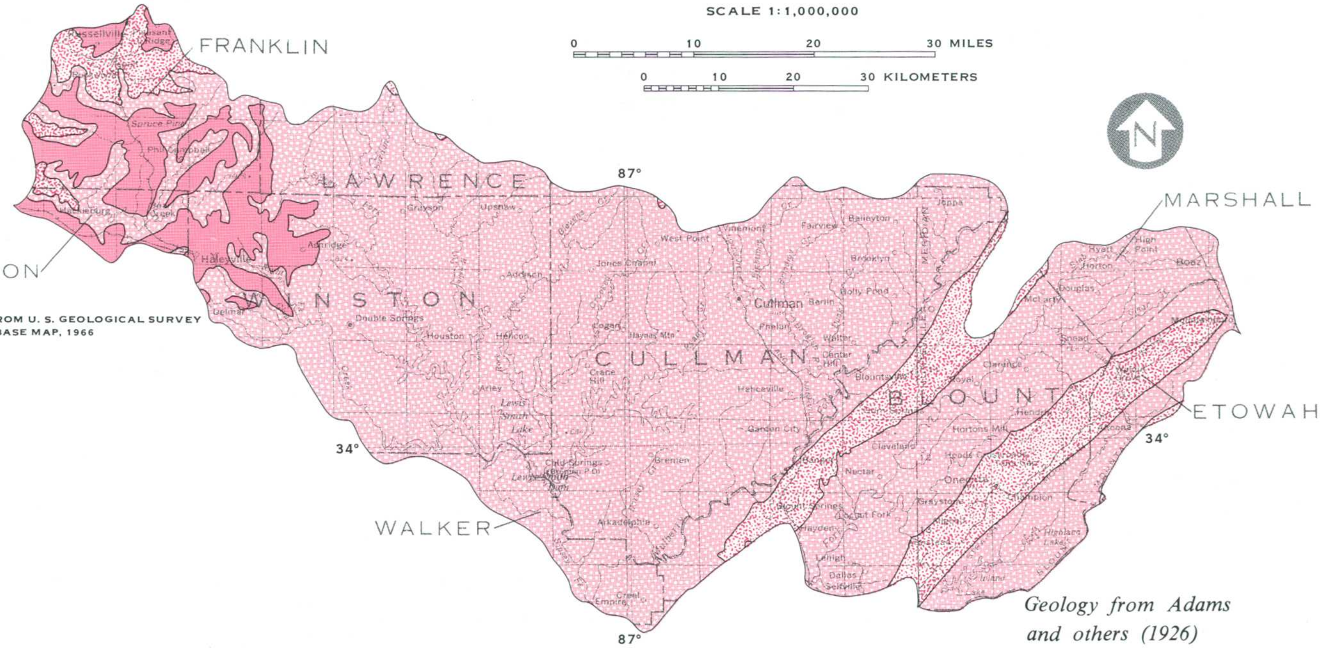
Three Major Rock Units Underlying Area 22 Have Diverse Water-Bearing Characteristics

Expected well yields in the three major rock units in Area 22 range from less than 5 to 1000 gallons per minute.

The principal source of ground-water supplies in most of Area 22 is the Pottsville Formation, which consists of alternating beds of sandstone and shale (fig. 7.3-1). Ground water in the Pottsville occurs in coal beds, in fractures and bedding planes, and in pore spaces in sandstone. Openings generally are small, and yields to wells range from less than 5 gal/min to as much as 50 gal/min. Depth to water generally is less than 30 feet in stream valleys and terraces and more than 50 feet on hills and ridges.

The availability of ground water in the pre-Pennsylvanian rocks is related to topography, depth and extent of weathering and fracturing, existence of solution cavities, and rock type. The important aquifers are the carbonate rocks, such as limestone and dolomite, containing interconnected, solutionally enlarged openings. The limestone underlying Moulton Valley in the western part of Area 22 is dense and contains few fractures. Most wells in this valley yield less than 10 gal/min. In Murphrees and Sequatchie Valleys in the eastern part of Area 22, most of the pre-Pennsylvanian limestones and dolomites contain an abundance of chert which remains as the rock weathers forming a rubble zone above the bedrock. This rubble zone absorbs and stores large quantities of water to recharge the underlying limestone. Generally, the limestones in this eastern area are more fractured than those in the west. Wells constructed in valleys where the chert rubble zone is thickest may yield as much as 1000 gal/min (Faust and Harkins, 1980). Springs issuing from the limestone have measured flows of up to 3,990 gal/min.

The Tuscaloosa Group is not a major source of water where it is present in Area 22 because of its limited thickness. The basal sand and gravel beds which are excellent aquifers to the south and west of Area 22 are too thin or are not areally extensive enough to retain large quantities of water. Yields to wells tapping the Tuscaloosa Group in the Area are from 5 to 10 gal/min.



EXPLANATION

YIELDS TO WELLS

In gallons per minute

Tuscaloosa Group
From 5 to 10

Pottsville Formation
From less than 5 to 50

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

Figure 7.3-1 Availability of ground water.

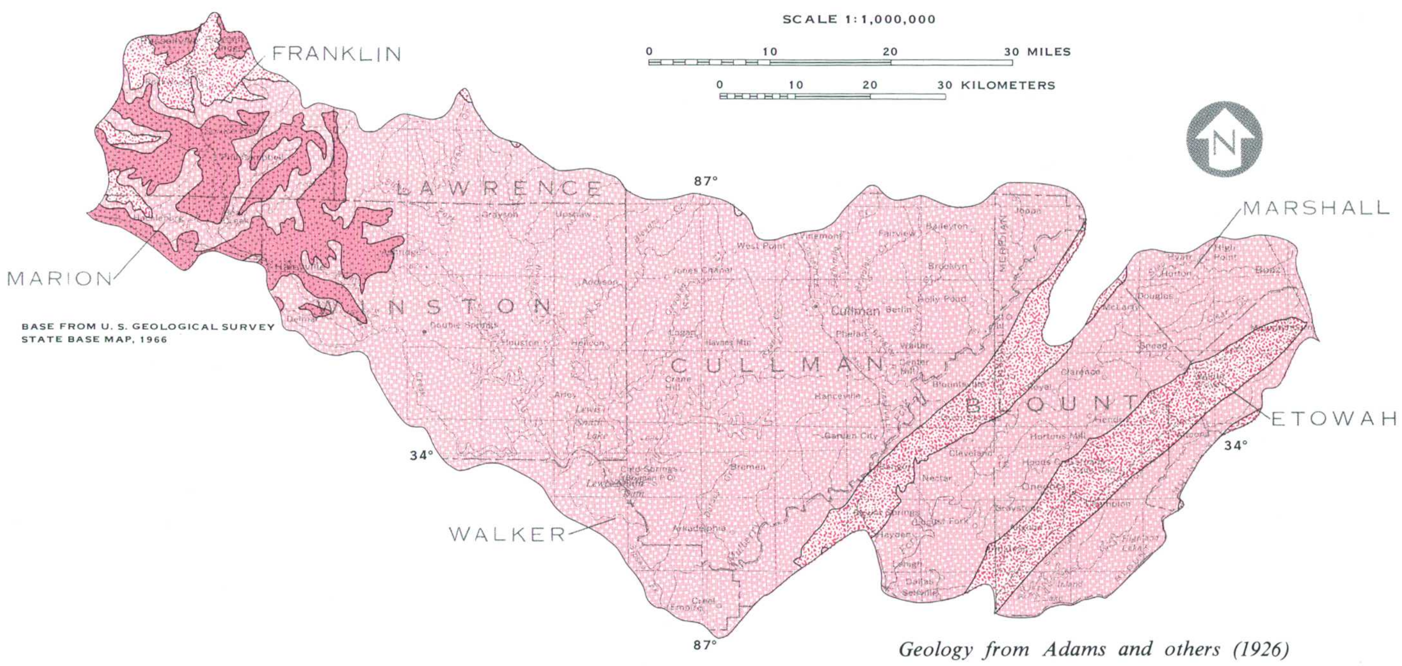
Chemical Quality of Ground Water is Variable, but Generally Good

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

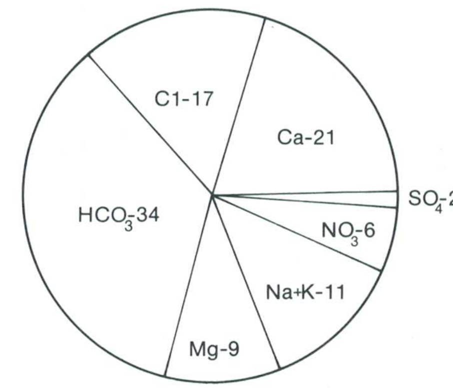
Quality of ground water in Area 22 is highly variable, but is generally good and suitable for most uses. Average chemical quality by aquifer systems is shown in figure 8.0-1. Total ion concentrations (milliequivalents per liter) of water from wells in each unit are shown in the pie diagrams. Generally, the most undesirable constituent is iron, which in some localities exceeds the 0.3 mg/L (milligrams per liter) recommended limit for drinking water (U.S. Environmental Protection Agency, 1977).

Ground water in the Tuscaloosa Group has the lowest median pH (6.8 units) and the lowest average specific conductance (39 micromho/cm). The low specific conductance of water from the Tuscaloosa Group reflects the relative insolubility of the rocks. Ground water in the Pottsville Formation has a median pH value of 7.1 units, with an average specific conductance of 209 micromhos/cm. Ground water in pre-Pennsylvanian rocks has a median pH of 7.4 units and an average specific conductance of 250 micromhos/cm. Generally, water in the Pottsville Formation and pre-Pennsylvanian rocks is more highly mineralized in the deeper wells. Soluble minerals in the Pottsville Formation and pre-Pennsylvanian rocks, with resulting increases in dissolved-solids concentration, generally does not present a water-quality problem.

The chemical character of ground water depends on several variables, such as composition of the aquifer, distance from recharge areas, residence time the water has been in contact with the rocks, and the overall pattern of ground-water circulation (Kaufman and Dion, 1967). A calcium-bicarbonate type of water is characteristic of pre-Pennsylvanian carbonate rocks (limestone and dolomite), and a calcium-magnesium-sodium-bicarbonate type of water is characteristic of 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-bicarbonate type water is characteristic of the Tuscaloosa Group, which consists chiefly of insoluble siliceous materials. Ground water in this formation is soft; dissolved-solids concentrations are generally less than 100 mg/L.



Values in percent of total milliequivalents per liter

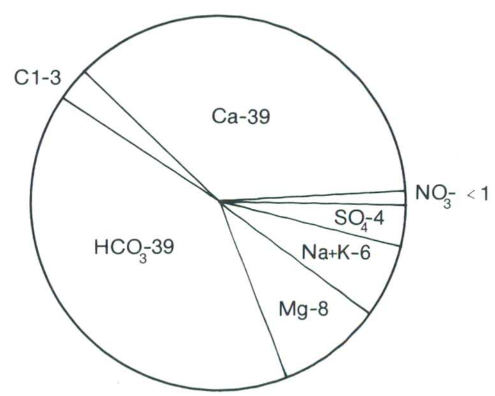


Tuscaloosa Group

(Concentrations in milligrams per liter unless otherwise specified)

Constituent	Range	Average	Number of samples
Iron (Fe)	0.02 - 3.0	0.69	15
Calcium (Ca)	1.3 - 11	3.4	19
Magnesium (Mg)	0.10 - 2.8	0.87	17
Sodium (Na)	0.4 - 3.4	1.8	18
Potassium (K)	0.3 - 0.8	0.6	3
Bicarbonate (HCO_3)	1.0 - 90	17	75
Sulfate (SO_4)	0.0 - 4.8	0.85	19
Chloride (C1)	0.2 - 15	4.9	75
Nitrate (NO_3)	0.1 - 7.6	2.7	15
pH (units)	4.8 - 7.9	6.8 (median)	73
Specific Conductance (micromhos per centimeter at 25°C)	19 - 91	39	16
Hardness ($CaCO_3$)	4.0 - 75	20	75

Values in percent of total milliequivalents per liter

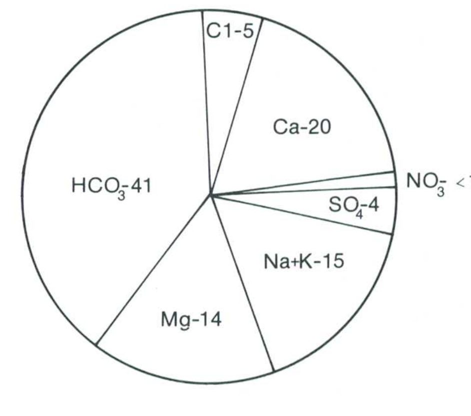


Pre Pennsylvanian rocks

(Concentrations in milligrams per liter unless otherwise specified)

Constituent	Range	Average	Number of samples
Iron (Fe)	0.0 - 11	1.0	32
Calcium (Ca)	8.0 - 83	41	17
Magnesium (Mg)	1.3 - 14	5.2	17
Sodium (Na)	0.9 - 14	5.5	14
Potassium (K)	0.9 - 5.8	2.2	7
Bicarbonate (HCO_3)	6.0 - 272	123	43
Sulfate (SO_4)	2.4 - 49	9.7	17
Chloride (C1)	0.8 - 60	6.2	43
Nitrate (NO_3)	0.1 - 11	2.8	13
pH (units)	6.4 - 8.2	7.4 (median)	36
Specific Conductance (micromhos per centimeter at 25°C)	50 - 453	250	28
Hardness ($CaCO_3$)	22 - 228	109	42

Values in percent of total milliequivalents per liter



Pottsville Formation

(Concentrations in milligrams per liter unless otherwise specified)

Constituent	Range	Average	Number of samples
Iron (Fe)	0.0 - 28	2.6	162
Calcium (Ca)	0.6 - 48	14	23
Magnesium (Mg)	0.4 - 27	6.1	23
Sodium (Na)	0.6 - 58	11	22
Potassium (K)	0.7 - 3.8	1.8	10
Bicarbonate (HCO_3)	2.1 - 530	90	198
Sulfate (SO_4)	0.2 - 49	7.7	23
Chloride (C1)	0.5 - 58	6.1	198
Nitrate (NO_3)	0.0 - 5.2	1.0	20
pH (units)	5.2 - 9.1	7.1 (median)	199
Specific Conductance (micromhos per centimeter at 25°C)	20 - 910	209	79
Hardness ($CaCO_3$)	4.0 - 265	59	199

Figure 8.0-1 Chemical composition 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

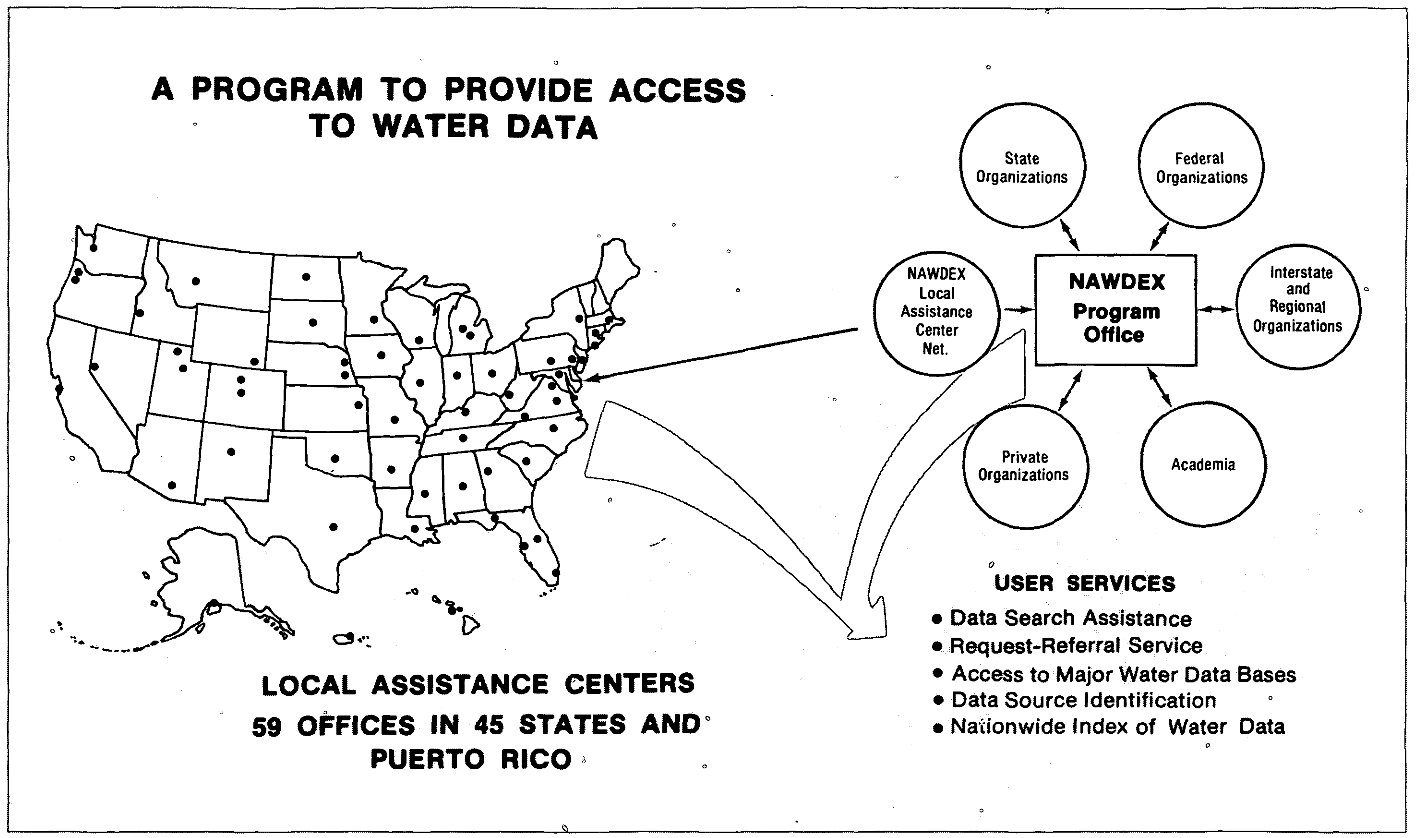


Figure 9.2-1 Access to water data

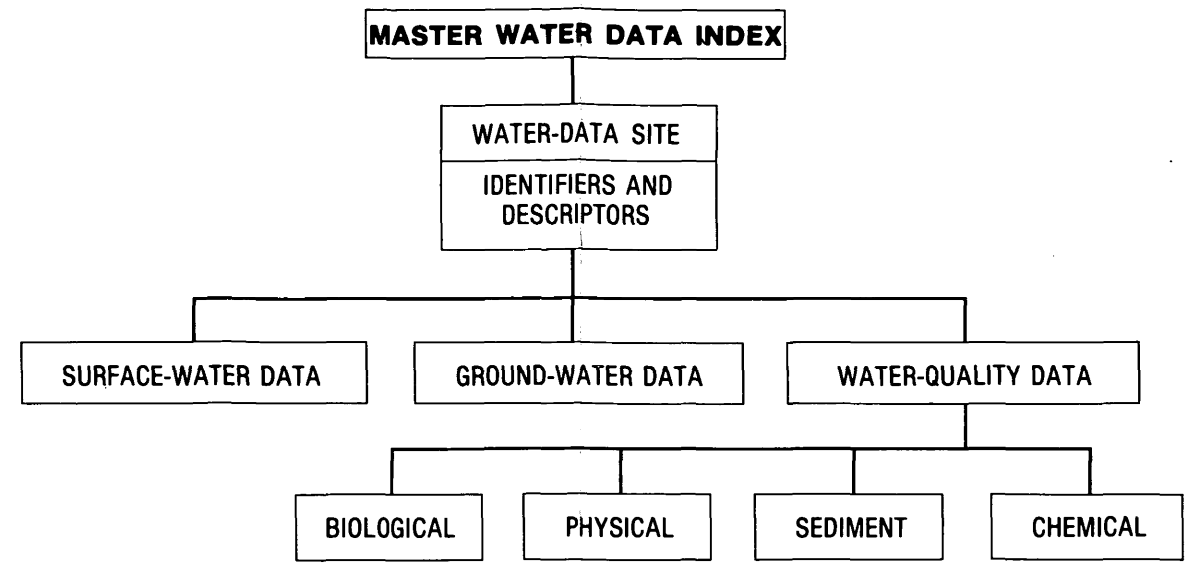


Figure 9.2-2 Master water-data index

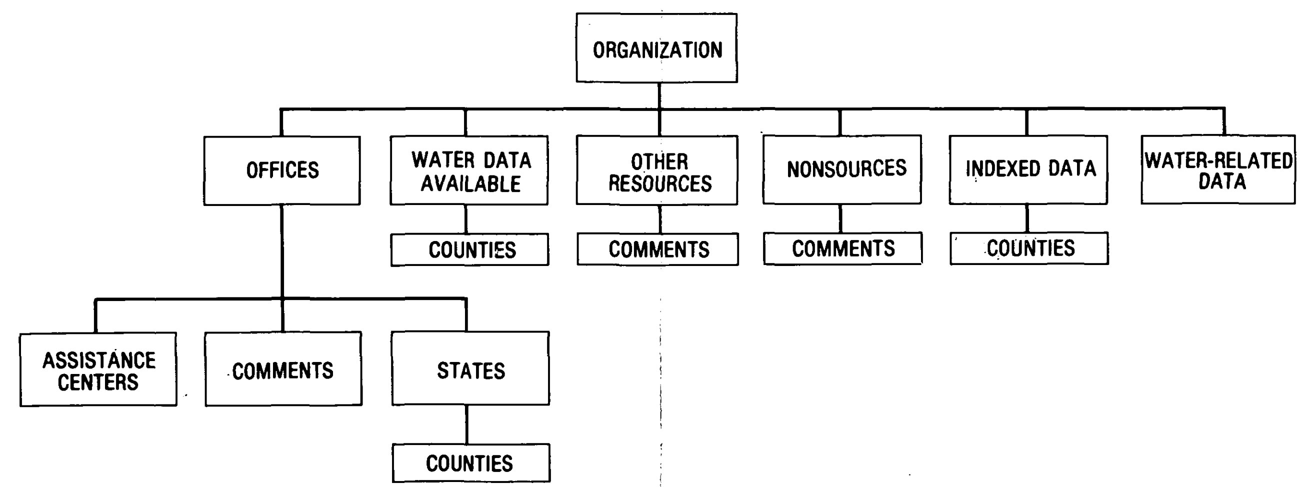


Figure 9.2-3 Water-data sources directory

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.

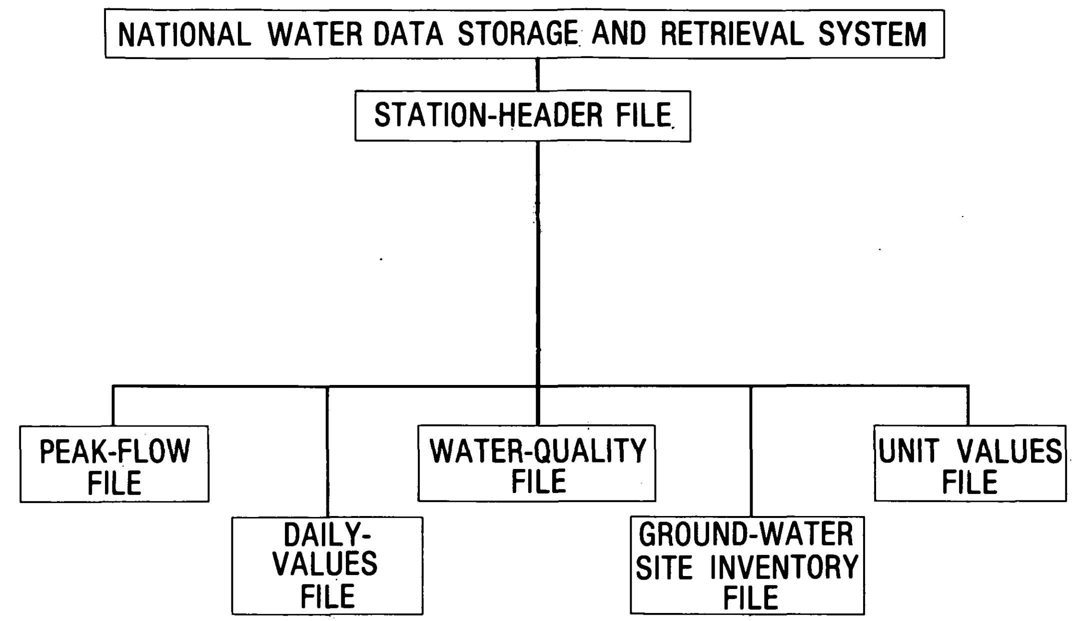


Figure 9.3-1 Index file stored data

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

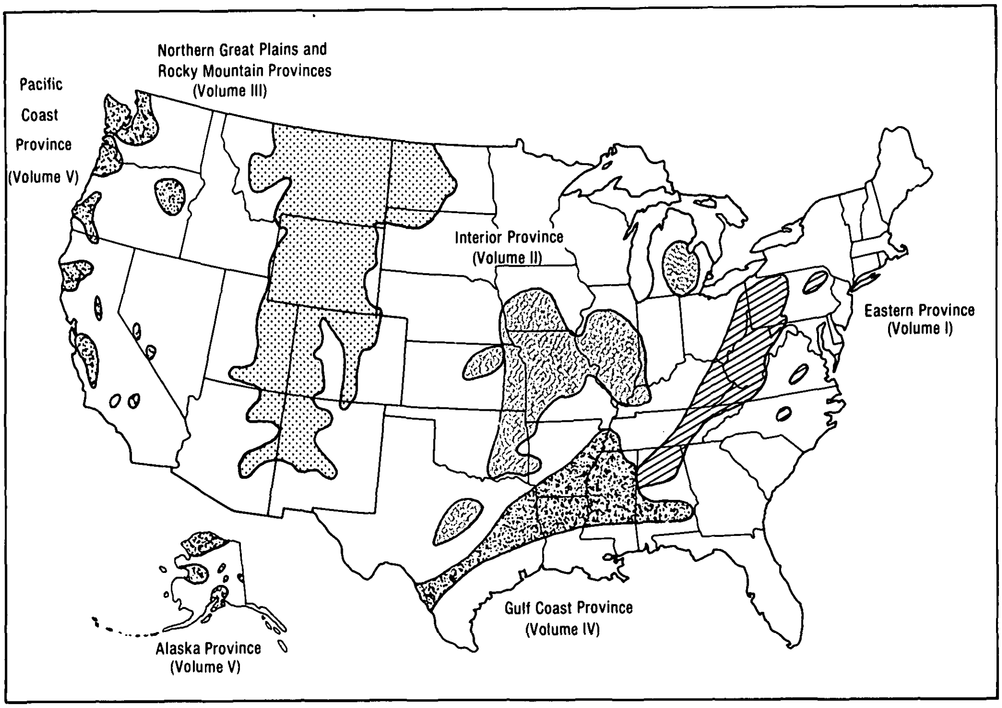


Figure 9.4-1 Index volumes and related provinces

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Appendix 1. Stream Classification Alabama Intrastate Waters

Use classification of streams
(in descending order of quality)

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

THE WATER RIVER BASIN

Stream	From	To	Classification(s)
Locust Fork	County road between Hayden and county line	Junction of Slab and Clear Creeks	F&W
Sipsey Fork	Junction of Mulberry and Sipsey Forks	Lewis Smith Dam	FWS/F&W
Lake Lewis Smith on Sipsey Fork			S/F&W
Sipsey Fork	Lake Lewis Smith	its source	F&W
Little Warrior River	Locust Fork	Junction of Blackburn Fork and Calvert Prong	F&W
Calvert Prong	Little Warrior River	City of Oneonta's water supply intake	F&W
Calvert Prong	City of Oneonta's water supply intake	its source	PWS
Blackburn Fork	Little Warrior River	Inland Lake Dam	F&W
Blackburn Fork	Inland Lake Dam	its source	PWS/S
Chitwood Creek	Calvert Prong	its source (jct. with Mill & Cheney Branch)	F&W
Mill Creek	Chitwood Creek	its source	A&I
Graves Creek	Locust Fork	its source	F&W
Whippoorwill Creek	Locust Fork	its source	F&W
Clear Creek	Locust Fork	its source	F&W
Slab Creek	Locust Fork	Alabama Highway 75	F&W
Slab Creek	Alabama Highway 75	its source	A&I
Brogden River	Mulberry Fork	Junction of Eightmile and Brindley Creeks	A&I
Brindley Creek	Brogden River	its source	PWS
Eightmile Creek	Brogden River	Cullman water supply reservoir dam	A&I

Appendix 1. Stream Classification Alabama Intrastate Waters (continued)

THE WARRIOR RIVER BASIN--Continued

Stream	From	To	Classification(s)
Eightmile Creek	Cullman water supply reservoir dam	its source	PWS
Pope Creek	Cullman water supply dam	its source	PWS
Copeland Creek	Mulberry Fork	its source	F&W
Ryan Creek	Lake Lewis Smith	its source	F&W
Crooked Creek	Lake Lewis Smith	its source	F&W
Brushy Fork	Lake Lewis Smith	its source	F&W
Clear Creek	Lake Lewis Smith	City of Haleyville water supply reservoir dam	F&W
Clear Creek	City of Haleyville water supply reservoir dam	its source	PWS
Clifty Fork	Lake Lewis Smith	its source	F&W
Cane Creek	Sipsey Fork	Town of Double Springs water supply reservoir dam	F&W
Cane Creek	Town of Double Springs water supply reservoir dam	its source	PWS

THE TENNESSEE RIVER BASIN

Stream	From	To	Classification(s)
Bear Creek	Alabama-Mississippi State line	its source*	F&W
Cedar Creek	Alabama-Mississippi State line	its source*	F&W
Little Bear Creek (Franklin County)	Cedar Creek	its source	S/F&W

* Reservoirs being constructed or planned for construction by the Tennessee Valley Authority (TVA) on Bear Creek, Cedar Creek, and Little Bear Creek are to be suitable for swimming and other whole-body water-contact sports or as future sources of public water supply.

Appendix 2. Surface-water stations

Site number	Station		Location		Drainage area	Period and type of record		
	Number	Name	Latitude ° ' "	Longitude ° ' "	(mi²)	Discharge	Chemical quality	Sediment
1	02449745	Roswell Creek near Summit, Ala.	34 12 50	086 30 30	5.13	1972		
2	02449750	Mulberry Fork near Brooksville, Ala.	34 10 25	086 33 11	69	1967-68	1967	
3	02449800	Mulberry Fork above Hanceville, Ala.	34 05 17	086 41 54	129	1972		
4	02449840	Duck River near Berlin, Ala.	34 10 19	086 41 42	37.1	1967-68	1967	
5	02449850	Duck River above Hanceville, Ala.	34 05 17	086 41 56	63.1	1972		
6	02449870	Blue Spring near Blountsville, Ala.	34 08 08	086 32 16		1967, 1969-74, 1977-79	1969-74	
7	02449880	Copeland Creek at Blountsville, Ala.	34 05 35	086 35 42	12.4	1954-57		
8	02449890	Big Spring near Blountsville, Ala.	34 03 18	086 39 07		1967-71, 1973-75, 1977, 1979	1975	
9	02449900	Copeland Creek near Blountsville, Ala.	34 03 33	086 41 07	23.5	1954-57		
10	02449910	Eightmile Creek near Vinemont, Ala.	34 15 41	086 47 21	11.7	1967-68	1967	
11	02449922	Eightmile Creek near Cullman, Ala.	34 11 24	086 48 33		1949		
12	02449924	Unnamed tributary (Wolf Creek) near Cullman, Ala.	34 11 23	086 51 34		1953		
13	02449925	Eightmile Creek at U.S. Highway near Cullman, Ala.	34 10 52	086 48 23	42.7	1945, 1947, 1949, 1972		
14	02449940	Broglen River near Cullman, Ala.	34 08 41	086 46 08	79.3	1966-68 1972, 1978	1967	
15	02449950	Broglen River near Hanceville, Ala.	34 04 57	086 44 20	108	1942-43, 1949, 1954-57	1967	
16	02449965	Mulberry Fork near Hanceville, Ala.	34 03 14	086 42 22	3.30	1943, 1949		
17	02450000	Mulberry Fork near Garden City, Ala.	33 59 42	086 44 56	368	1928-80	1962-80	
18	02450135	Mulberry Fork near Blount Springs, Ala.	33 56 38	086 50 18	417	1972		
19	02450160	Marriott Creek at Black Bottom near Blount Springs, Ala.	33 56 53	086 51 37	24	1967-68, 1978-79	1967, 1978-79	
20	02450180	Mulberry Fork near Arkadelphia, Ala.	33 52 19	086 55 20	487	1967-68, 1971-72	1967, 1971, 1972, 1979-80	
21	02450200	Dorsey Creek near Arkadelphia, Ala.	33 57 10	087 00 14	13.0	1958-67	1962-69, 1978, 1980	1979
22	02450215	Dorsey Creek below Arkadelphia, Ala.	33 53 40	086 58 39	26.0	1978-80	1978-80	
23	02450250	Sipsey Fork near Grayson, Ala.	34 17 07	087 23 56	90.3	1967-80	1965-80	1967-80
24	02450300	Sipsey Fork near Antioch Church, Ala.	34 13 40	087 22 20	124.0	1949, 1966-67	1967	
25	02450450	Brushy Creek near Moreland, Ala.	34 15 10	087 14 50	59.6	1966-67	1967	
26	02450500	Sipsey Fork near Falls City, Ala.	34 03 07	087 16 01	358	1943-57		
27	02450585	Pumphouse Creek at Haleyville, Ala.	34 13 28	087 36 00		1954-56, 1966		
28	02450600	Clear Creek near Natural Bridge, Ala.	34 08 49	087 29 33	22.2	1968, 1979	1979-80	
29	02450620	Little Clear Creek near Double Springs, Ala.	34 07 50	087 32 00	6.74	1966-68	1967	
30	02450800	Clear Creek near Double Springs, Ala.	34 07 30	087 25 50	89.60	1954-57, 1966-67, 1979	1967, 1979-80	
31	02450825	Clear Creek at New Hope Church near Popular Springs, Ala.	34 04 52	087 25 22		1980	1979-80	
32	02450850	Clear Creek near Popular Springs, Ala.	34 03 01	087 23 10	116	1949, 1966-67, 1979	1967	
33	02451000	Clear Creek at Falls City, Ala.	34 02 05	087 18 00	149	1904-05, 1939-60		
34	02451535	Blevens Creek near Jones Chapel, Ala.	34 12 45	087 05 25	31	1967-68	1967	
35	02451538	Rock Creek at Addison, Ala.	34 11 20	087 08 48	70.7		1967	
36	02451540	Rock Creek near Addison, Ala.	34 09 32	087 09 59	78.7	1966-67		
37	02451550	Jaybird Creek near West Point, Ala.	34 15 08	086 59 54	1.42	1965-68	1965-67	
38	02451580	Crooked Creek near Logan, Ala.	34 06 58	087 03 11	54.2	1967-68. 1979	1967, 1979-80	
39	02451725	Kilpatrick Creek near Cullman, Ala.	34 12 48	086 52 52	6.35	1973		
40	02451750	Vest Creek near Baldwin, Ala.	34 11 54	086 56 03	1.64	1963-68	1963-66, 1968	
41	02451770	Ryan Creek near Cullman, Ala.	34 07 16	086 53 57	42.8	1967-68, 1979	1967, 1979-80	
42	02451950	Sipsey Fork at Lewis Smith Dam near Jasper, Ala.	33 56 29	087 06 21	943	1961, 1979		
43	02451952	Sipsey Fork near Jasper, Ala. (below Lewis Smith)	33 56 25	087 06 21	943	1961-80	1979	
44	02452000	Sipsey Fork near Jasper, Ala.	33 54 40	087 05 00	967	1952-60	1966-68	
45	02452495	Leeth Creek near Sipsey, Ala.	33 52 54	087 03 19	4.75	1979	1979-80	
46	02452500	Sipsey Fork near Sipsey, Ala.	33 52 14	087 04 04	990	1928-37	1967	
47	02452505	Sipsey Fork near Sipsey, Ala.	33 49 16	087 04 13	995	1938		
48	02454400	Locust Fork at Walnut Grove, Ala.	34 03 26	086 17 32	43.6	1967	1967	
49	02454420	Cove Spring near Walnut Grove, Ala.	34 06 30	086 15 39		1965, 1968, 1970-74, 1977-79	1969-74	
50	02454460	Locust Fork at Snead, Ala.	34 06 41	086 21 44	123	1942-44		
51	02454500	Locust Fork below Snead, Ala.	34 08 00	086 23 12	147	1952-57	1962, 1964, 1966-70, 1979-80	
52	02454515	Slab Creek at Boaz, Ala.	34 12 44	086 10 57		1948, 1974		
53	02454520	Slab Creek near Needmore, Ala.	34 12 50	086 14 03	14.2	1948, 1974		
54	02454535	Slab Creek near Douglas, Ala.	34 13 06	086 19 03	32.5	1948, 1974		
55	02454550	Slab Creek near Nixon Chapel, Ala.	34 10 58	086 22 52	54.7		1980	
56	02454850	Whippoorwill Creek near Wynnville, Ala.	34 06 51	086 24 12	21.1	1967-68	1967	

Appendix 2. Surface-water stations (continued)

Site number	Station Number	Station Name	Location Latitude ° ' "	Location Longitude ° ' "	Drainage area (mi²)	Period and type of record Discharge	Chemical quality	Sediment
57	02454990	Graves Creek near Blountsville, Ala.	34 03 26	086 33 55	9.84	1965		
58	02454995	Graves Creek below Blountsville, Ala.	34 02 42	086 34 19		1965		
59	02455000	Locust Fork near Cleveland, Ala.	34 02 00	086 34 00	309	1936-80	1959-80	
60	02455204	Black Fork near Remlap, Ala.	33 51 23	086 33 47	78.4	1979	1979-80	
61	02455210	Walker Spring Creek near Allgood, Ala.	33 52 15	086 34 12		1967		
62	02455240	Calvert Prong above Oneonta, Ala.	33 59 08	086 26 32	22.9	1949		
63	02455243	Calvert Prong below Oneonta, Ala.	33 00 27	086 26 55	28.2	1949		
64	02455247	Calvert Prong below Jones Creek near Oneonta, Ala.	34 00 55	086 28 02	40.6	1954		
65	02455250	Calvert Prong near Oneonta, Ala.	33 59 07	086 30 32	47.1	1949, 1954-57	1967	
66	02455270	Calvert Prong near Locust Fork, Ala.	33 56 05	086 34 57	81.0	1967-68, 1979	1967, 1979-80	
67	02455280	Little Warrior River near Locust Fork, Ala.	33 55 11	086 36 28	186	1967-68	1967	
68	02455300	Locust Fork near Locust Fork, Ala.	33 56 13	086 40 04			1967	
69	02455500	Locust Fork at Trafford, Ala.	33 49 49	086 45 21	624	1930-69, 1979	1960-69, 1974, 1979-80	
70	03591570	Bear Creek at Posey Mill, Ala.	34 19 37	087 34 49	26.8	1962, 1963-74		
71	03591800	Bear Creek near Hackleburg, Ala.	34 17 01	087 46 26	143	1952, 1956-62, 1979	1962-72, 1976-80	
72	03591825	Bear Creek at Military Bridge near Hackleburg, Ala.	34 18 59	087 51 30	182	1979	1979-80	
73	03592150	Dunklin Creek near Russellville, Ala.	34 30 27	087 49 11	7.28	1963-65		
74	03592250	Little Bear Creek near Glasgow, Ala.	34 24 04	087 52 24	34.4	1944, 1953-54, 1957		

Appendix 3. Ground-water stations

Wells

Site number (fig. 4.2-1)	Site identification number	County	Local number	Aquifer	Period of record
1	340628086151401	Etowah	H-3	Fort Payne Chert and Maury Formation	1960, 1968-71, 1973-80
2	340239086200401	Blount	G-3	Copper Ridge Dolomite and Chepultepec Dolomite	1968-69, 1973-74, 1976-78
3	335647086282101	Blount	P-5	Copper Ridge Dolomite and Chepultepec Dolomite	1968-71, 1973-80
4	340959086305901	Blount	D-2	Fort Payne Chert, Tuscumbia Limestone, and Maury Formation	1966, 1968-71, 1973-80
5	341837086294301	Marshall	Mal-4	Sandstone of Pottsville Formation	
6	334914086443201	Jefferson	B-1	Pottsville Formation	1968-80
7	335823086453201	Blount	M-3	Bangor Limestone	1966, 1968-71, 1973-80
8	341031086504301	Cullman	Cul-1	Sandstone of Pottsville Formation	1952-78*
9	340821087214601	Winston	H-9	Sandstone of Pottsville Formation	1965, 1968-71, 1973-80
10	341702087244001	Winston	C-1	Sand of Pottsville Formation	1965, 1967-75
11	341644087294001	Winston	D-1	Sand of Pottsville Formation	1965, 1967-74
12	342137087311401	Lawrence	U-2	Sand of Pottsville Formation	1961, 1967-74
13	343131087442801	Franklin	Fra-1	Bangor Limestone and sand and gravel of Tuscaloosa Group	1962-78*

Springs

Site number (fig. 4.2-1)	Ground-water site identification number	Surface water site identification number	County	Local number	Name of spring	Aquifer	Period of record
14	340808086321601	02449870	Blount	D-5	Blue Spring near Blountsville	Bangor Limestone	1967, 1969-74**, 1977-79
15	340318086385601	02449890	Blount	J-4	Big Spring near Blountsville	Tuscumbia Limestone	1967-71, 1973-80
16	340630086153901	02454420	Etowah	H-25	Cove Spring near Walnut Grove	Bangor Limestone	1964, 1968, 1969-74**, 1976-80
17	335215086341201	02455210	Blount	T-2	Walker Spring near Allgood	Chepultepec Dolomite Copper Ridge Dolomite	1966-67

* Continuous recording of water-level for period of record.

** Continuous record of discharge.