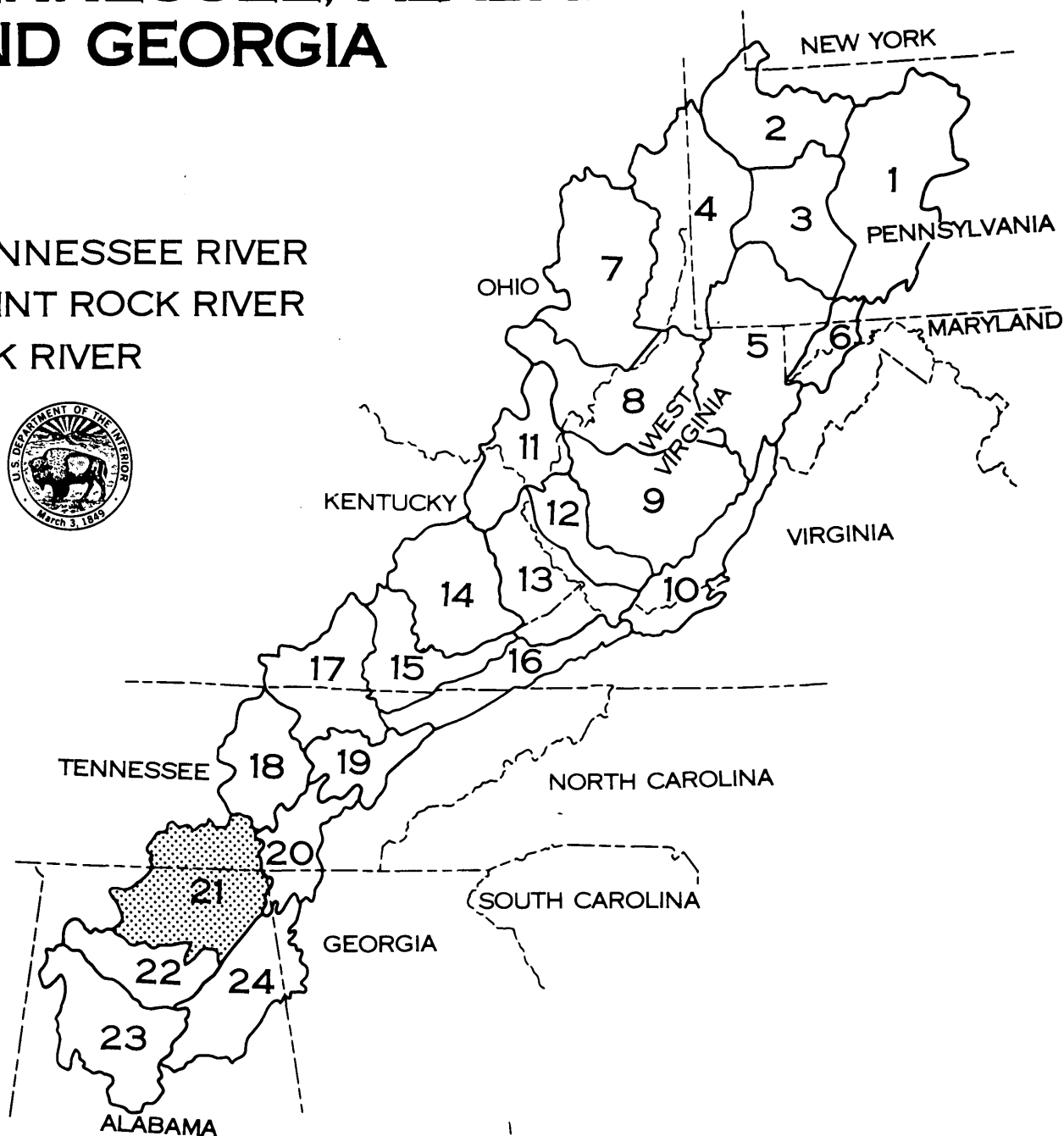


HYDROLOGY OF AREA 21, EASTERN COAL PROVINCE, TENNESSEE, ALABAMA AND GEORGIA

- TENNESSEE RIVER
- PAINT ROCK RIVER
- ELK RIVER



UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

WATER-RESOURCES INVESTIGATIONS
OPEN-FILE REPORT 82-679

HYDROLOGY OF AREA 21, EASTERN COAL PROVINCE, TENNESSEE, ALABAMA AND GEORGIA

BY

V. JEFF MAY AND OTHERS

U.S. GEOLOGICAL SURVEY
WATER-RESOURCES INVESTIGATIONS
OPEN-FILE REPORT 82-679



NASHVILLE, TENNESSEE
JULY 1983

UNITED STATES DEPARTMENT OF THE INTERIOR

JAMES G. WATT, *SECRETARY*

GEOLOGICAL SURVEY

Dallas L. Peck, *Director*

For additional information write to:

U.S. Geological Survey
A413 Federal Building - U.S. Courthouse
Nashville, Tennessee 37203

CONTENTS

	Page
Abstract	1
1.0 Introduction	2
1.1 Objective	2
<i>F. A. Kilpatrick</i>	
1.2 Project area	4
<i>V. Jeff May</i>	
1.3 Hydrologic problems related to coal mining	6
<i>V. Jeff May</i>	
1.4 Coal-mining impacts	8
<i>V. Jeff May</i>	
2.0 General features	10
2.1 Physiography	10
<i>J. V. Brahana</i>	
2.2 Geology	12
<i>J. V. Brahana</i>	
2.3 Soils	14
<i>A. K. Sparkes</i>	
2.4 Surface drainage	16
<i>V. Jeff May</i>	
2.5 Land use	18
<i>E. F. Hollyday</i>	
2.6 Climate	20
<i>Edward B. Boyd</i>	
2.7 Coal-mining activities and methods	22
<i>V. Jeff May</i>	
3.0 Stream-use classification	24
<i>Mark A. Hunter</i>	
4.0 Hydrologic networks	26
4.1 Surface water	26
<i>Jerry F. Lowery</i>	
4.2 Ground water	28
<i>Jerry F. Lowery</i>	
5.0 Surface-water quantity	30
5.1 Streamflow characteristics	30
<i>Charles R. Gamble</i>	
5.2 Average flow	32
<i>Charles R. Gamble</i>	
5.3 Low flow	34
<i>Charles R. Gamble</i>	
5.4 Floods	36

5.4.1	Magnitude, frequency, and seasonal distribution of floods	36
	<i>Charles R. Gamble</i>	
5.4.2	Flood depths and flood-prone areas	38
	<i>Charles R. Gamble</i>	
5.5	Flow duration	40
	<i>Charles R. Gamble</i>	
6.0	Quality of surface water	42
6.1	Introduction	42
	<i>Michael W. Gaydos</i>	
6.2	Specific conductance and dissolved solids	44
	<i>Jayne E. May</i>	
6.3	Dissolved sulfate	46
	<i>Jayne E. May</i>	
6.4	pH	48
	<i>Jayne E. May</i>	
6.5	Iron	50
	<i>Michael W. Gaydos</i>	
6.6	Manganese	52
	<i>Michael W. Gaydos</i>	
6.7	Trace constituents	54
	<i>Michael W. Gaydos</i>	
6.8	Sediment	56
	<i>Andrew Simon</i>	
6.9	Benthic invertebrates	58
	<i>Arthur D. Bradfield</i>	
7.0	Ground-water quantity	60
7.1	Occurrence	60
	<i>Michael W. Bradley</i>	
7.2	Yield and transmissivity	62
	<i>Michael W. Bradley</i>	
7.3	Water levels	64
	<i>Brenda S. Peacock</i>	
8.0	Quality of ground water	66
	<i>Brenda S. Peacock</i>	
9.0	Water-data sources	69
9.1	Introduction	69
9.2	National water-data exchange (NAWDEx)	70
9.3	WATSTORE	72
9.4	Index to water-data activities in coal provinces	74
10.0	Supplemental information for Area 21	76
10.1	Stream-use classification - Tennessee and Alabama streams	76
	<i>Mark A. Hunter</i>	
10.2	List of surface-water network sites	78
	<i>Jerry F. Lowery</i>	
10.3	List of ground-water network sites	82
	<i>Jerry F. Lowery</i>	

10.4	Average flow data	88
	<i>Charles R. Gamble</i>	
10.5	Suspended-sediment data	89
	<i>Andrew Simon</i>	
11.0	Selected references	90

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

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

Multiply	By	To obtain
inches (in)	25.4	millimeters (mm)
inches per hour (in/h)	25.4 2.54	millimeters per hour (mm/h) centimeters per hour (cm/h)
feet (ft)	0.3048	meters (m)
feet per mile (ft/mi)	0.1894	meters per kilometer (m/km)
miles (mi)	1.609	kilometers (km)
square miles (mi ²)	2.590	square kilometers (km ²)
gallons per minute (gal/min)	0.06309	liters per second (L/s)
million gallons per day (mgal/d)	0.04381 3,785.	cubic meters per second (m ³ /s) 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]	0.3503	metric tons per square kilometer per year [(t/km ²)/a]

National Geodetic Vertical Datum of 1929 (NGVD of 1929): A geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called mean sea level. NGVD of 1929 is referred to as sea level in this report.

ACKNOWLEDGMENTS

A great deal of effort was extended by many people other than the authors in compiling data, cartographic services, formatting illustrations, and typing this report. The authors are grateful for that support. The support and assistance of Barbara Balthrop, Tennessee District, and Greg Allord and Wendy Danchuk, Wisconsin District, for handling the cartography deserves special mention, as well as Eva G. Baker for typing the report. The Geological Survey and the authors extend their appreciation to Mr. Jeff Coker, Tennessee Department of Conservation, Division of Surface Mining and Reclamation, for the photographs used in Section 1.4.

HYDROLOGY OF AREA 21, EASTERN COAL PROVINCE, TENNESSEE, ALABAMA AND GEORGIA

BY

V. JEFF MAY AND OTHERS

Abstract

A nationwide need for hydrologic information characterizing conditions in coal-resources areas was mandated with the enactment of the Surface Mining Control and Reclamation Act of 1977 (Public Law 95-87). This report is designed to be useful to mine owners and operators, consulting engineers, and regulatory authorities by presenting information concerning hydrologic conditions and identifying additional sources of hydrologic information. The report format consists of brief texts and supporting illustrations or tables on a series of topics which together describe hydrologic conditions in the area.

The Eastern Coal province is divided into 24 separate reporting areas. The division is based on hydrologic factors, location, size and mining activity. Hydrologic Units (drainage basins) or parts of units are combined to form each area. Area 21 is located in the southern part of the Eastern Coal province in south-central Tennessee and northeastern Alabama in the Tennessee River basin, and covers an area of 6,021 square miles.

Area 21 is in three physiographic sections. From east to west these sections are the Cumberland Plateau, Highland Rim, and Central Basin. Coal beds occur in the Pennsylvanian rocks which form the Cumberland Plateau. The Highland Rim and Central Basin are underlain by carbonates of Mississippian and pre-Mississippian age, respectively. Geologic structure is relatively simple, with most rocks essentially undeformed and nearly horizontal.

The area is drained by the Tennessee River and tributaries. Major streams in addition to the Tennessee River include Paint Rock, Elk, and Flint Rivers, and Flint, Limestone and Crow Creeks. The Tennessee River is impounded in the area by two major flood control and navigation dams.

The area has a moist, temperate climate and receives an average of 55 inches of precipitation, almost all of which is rain. The range in average annual precipitation is from about 35 to 70 inches.

In response to the hydrologic data needs defined

in the Surface Mining Control and Reclamation Act, 17 sites were established to collect additional streamflow and quality of water data in the coal-resources area in Area 21. Data from these sites, as well as from other existing and discontinued sites, were used to define the hydrologic conditions that are presented in this report.

Streamflow varies with time and basin, in a pattern similar to the seasonal variation in rainfall, due to differences in drainage basin size and other basin characteristics. The principal factors affecting the average annual flow of streams are rainfall and drainage basin size. Low flows vary widely across the area due primarily to the variation of geologic formations. Low flows in streams in the coal-resources area are generally less than for streams elsewhere. Most floods occur in the winter and spring, with about 73 percent occurring from December through March.

The quality of surface waters sampled in Area 21 was generally good, with only small variations in most chemical constituents from site to site. Dissolved sulfate concentrations, usually indicative of mining activity, were generally low. Water at 75 percent of the sites had maximum concentrations less than 20 milligrams per liter. The highest concentrations, ranging from 110 to 450 milligrams per liter, were determined in Dry Creek near Fabius, Alabama, a stream draining part of the coal-resources area.

Suspended-sediment loads are also indicative of surface mining activity. Comparison of mined versus unmined basins in the coal-resources area indicates suspended-sediment loads several times greater in streams draining mined basins.

Ground-water quality is highly variable but suitable for most uses in most areas. Locally, especially in waters from Pennsylvanian rocks and regolith, iron exceeds 300 micrograms per liter and sulfate exceeds 250 milligrams per liter, the recommended limits for drinking water:

1.0 INTRODUCTION

1.1 Objective

Area 21 Report to Aid in Preparing and Appraising Mine Permit Applications

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

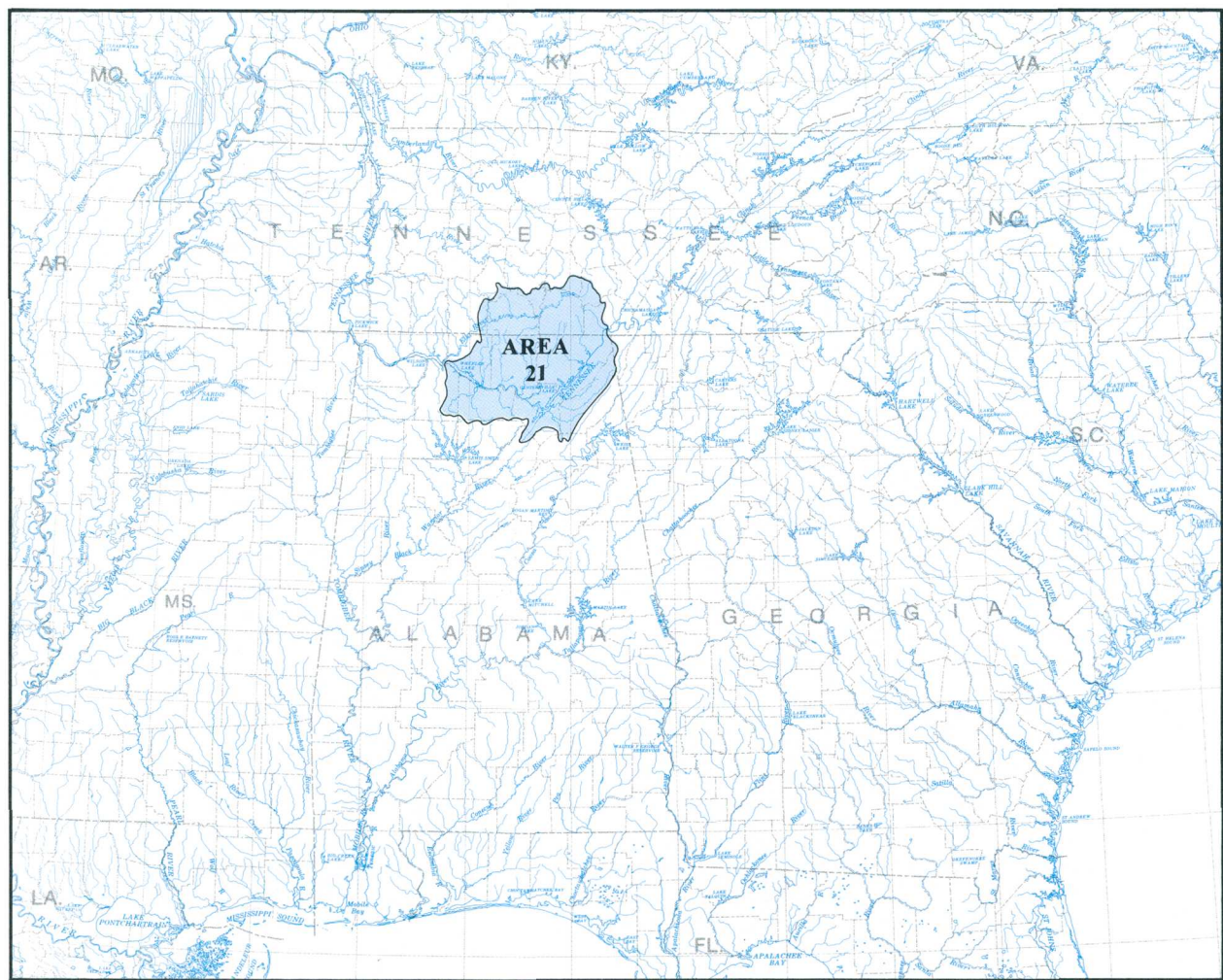
A need for hydrologic information and analysis on a scale never before required nationally was initiated when the "Surface Mining Control and Reclamation Act of 1977" was signed into law as Public Law 95-87, August 3, 1977. The objective of this report is to help meet that need by describing the hydrology of Area 21 (fig. 1.1-1). The coal-resources area is shown in figure 1.1-2.

This report is one of a series that covers the coal provinces nationwide. It contains a brief text with an accompanying map, graph, or other illustration for each of a number of water-resources related topics. The summation of the topical discussions provides a description of the hydrology of the area.

The hydrologic information presented in this

report, or available through identified sources, 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 in the vicinity of the mine and the anticipated hydrologic consequences of the mining operation.

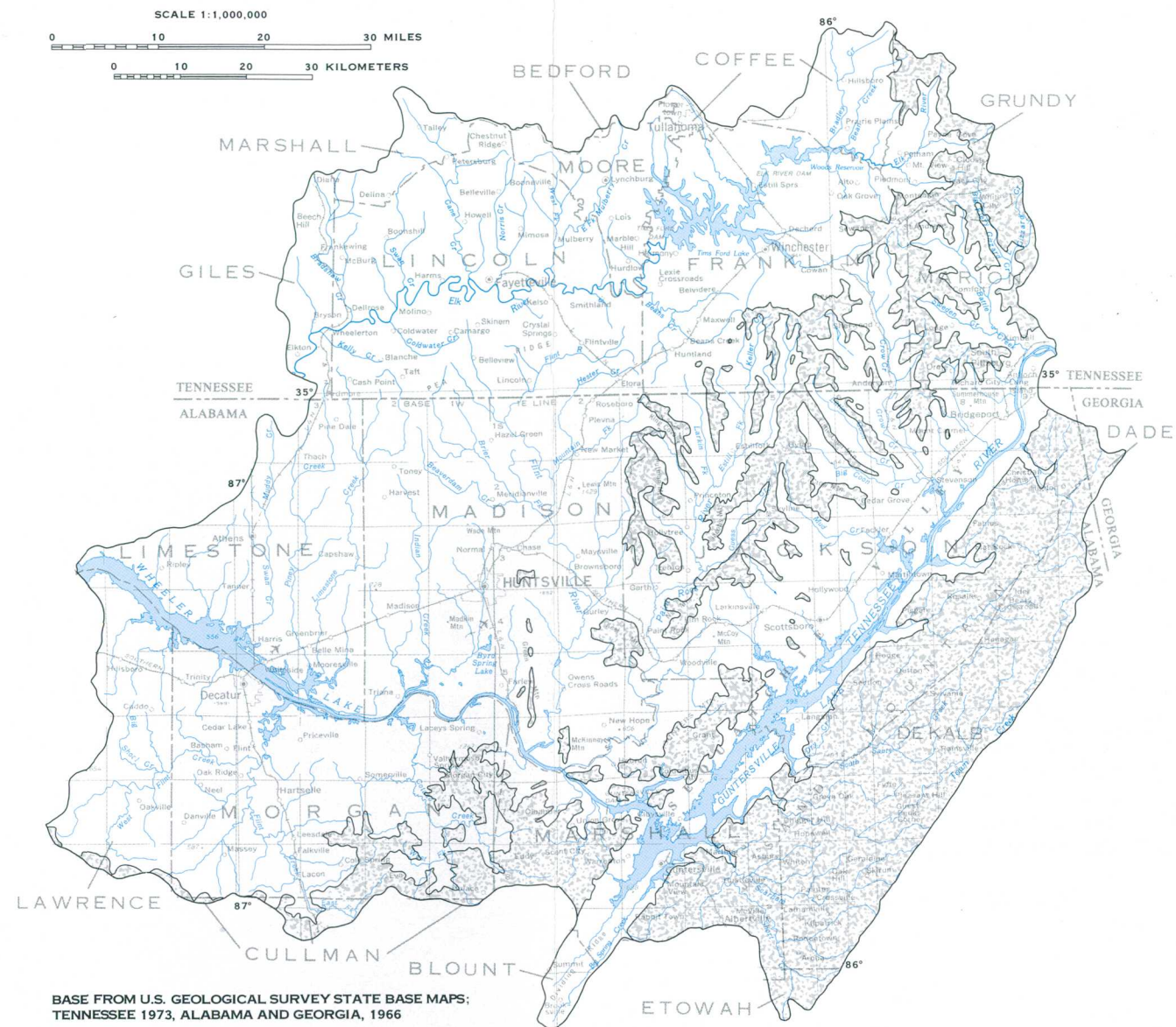
The information contained herein will be useful to surface mine owners, operators, and consulting engineers in the preparation of permits, and to regulatory authorities in appraising the adequacy of permit applications.



BASE FROM U.S. GEOLOGICAL SURVEY
UNITED STATES BASE MAP, 1980

0 50 100 150 MILES
0 50 100 150 KILOMETERS

Figure 1.1-1 Location of Area 21.



BASE FROM U.S. GEOLOGICAL SURVEY STATE BASE MAPS;
TENNESSEE 1973, ALABAMA AND GEORGIA, 1966

EXPLANATION



Coal-resources area

Figure 1.1-2 Coal resources in Area 21.

1.0 INTRODUCTION--Continued

1.2 Project Area

Area 21 Located in Southern Part of Eastern Coal Province

Area 21 includes 6,021 square miles in the Tennessee River basin in south-central Tennessee and northeastern Alabama.

The Eastern Coal province is divided into 24 hydrologic reporting areas (fig. 1.2-1). The division is based on hydrologic factors, location, size, and mining activity. Hydrologic Units, as defined by the U.S. Geological Survey in cooperation with the U.S. Water Resources Council (1974a, b), or parts of units, are combined to form each area. Area 21 lies near the southern end of the Eastern Coal province which extends from Pennsylvania to Alabama covering parts of nine states.

Area 21 is located in south-central Tennessee and northeastern Alabama. In Tennessee, the area covers all of Lincoln, Moore, Franklin and part of Giles, Marshall, Coffee, Grundy, and Marion Counties; in Alabama, all of Madison and part of Limestone, Jackson, Lawrence, Morgan, Cullman, Blount, Marshall, Etowah, and DeKalb Counties. The area also includes a small tip of western Dade County, Georgia (fig. 1.2-2).

Coal-bearing rocks in Area 21 underlie the Cumberland Plateau section. In Tennessee, and west of the Sequatchie Valley in Alabama (fig. 1.2-2), these rocks mostly form outliers on the tops of hills and ridges left by streams that have eroded deeply incised valleys. East of the Sequatchie Valley in Alabama, the Plateau is less dissected and, consequently, the

land surface is more uniform and typical of an upland plateau.

Most of the Cumberland Plateau is covered by forests. Agricultural land, which occurs throughout the Plateau in varying percentages, increases in the southwestern part. Strip mining for coal occurs in most parts of the Plateau in Area 21. Agriculture is the dominant land use in the Highland Rim and Central Basin, with forests ranking second.

Surface drainage is 6,021 mi², all of which is within the Tennessee River basin. The Tennessee River flows in a southwesterly course along the eastern edge of the area to about the center of Marshall County, Alabama, where it veers following a northwesterly course to the western boundary of the project area. Major tributaries to the Tennessee River are the Paint Rock, Elk, and Flint Rivers, and Flint, Limestone, and Crow Creeks. All major rivers, and several smaller streams along the southern edge of the area, drain coal-bearing rocks. Only the Tennessee River flows through Area 21. Except for the Elk River, all other streams originate and end within the area. Surface water from Area 21 eventually reaches the Gulf of Mexico by way of the Tennessee, Ohio, and Mississippi Rivers.

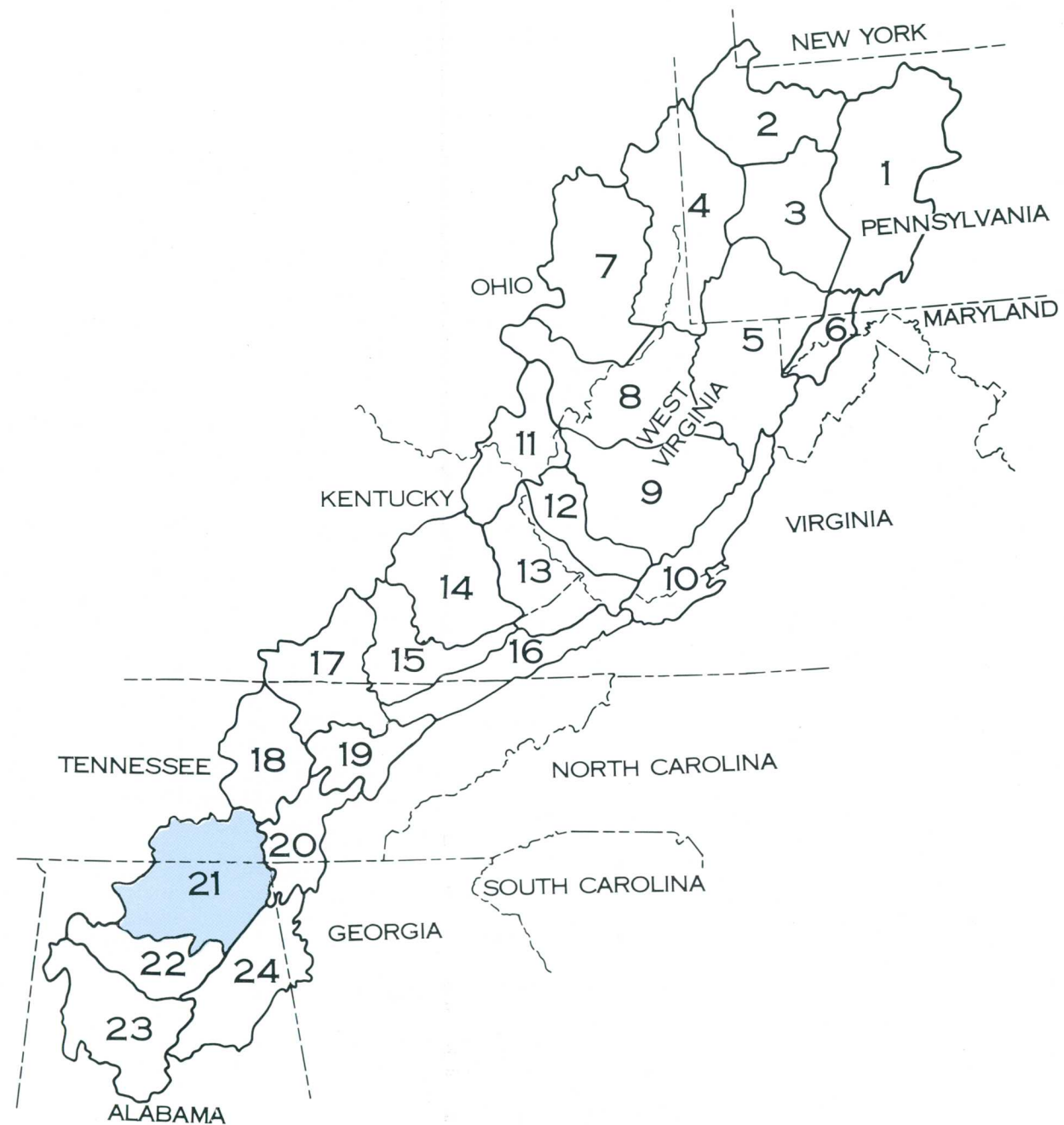


Figure 1.2-1 Hydrologic reporting areas in the Eastern Coal province.

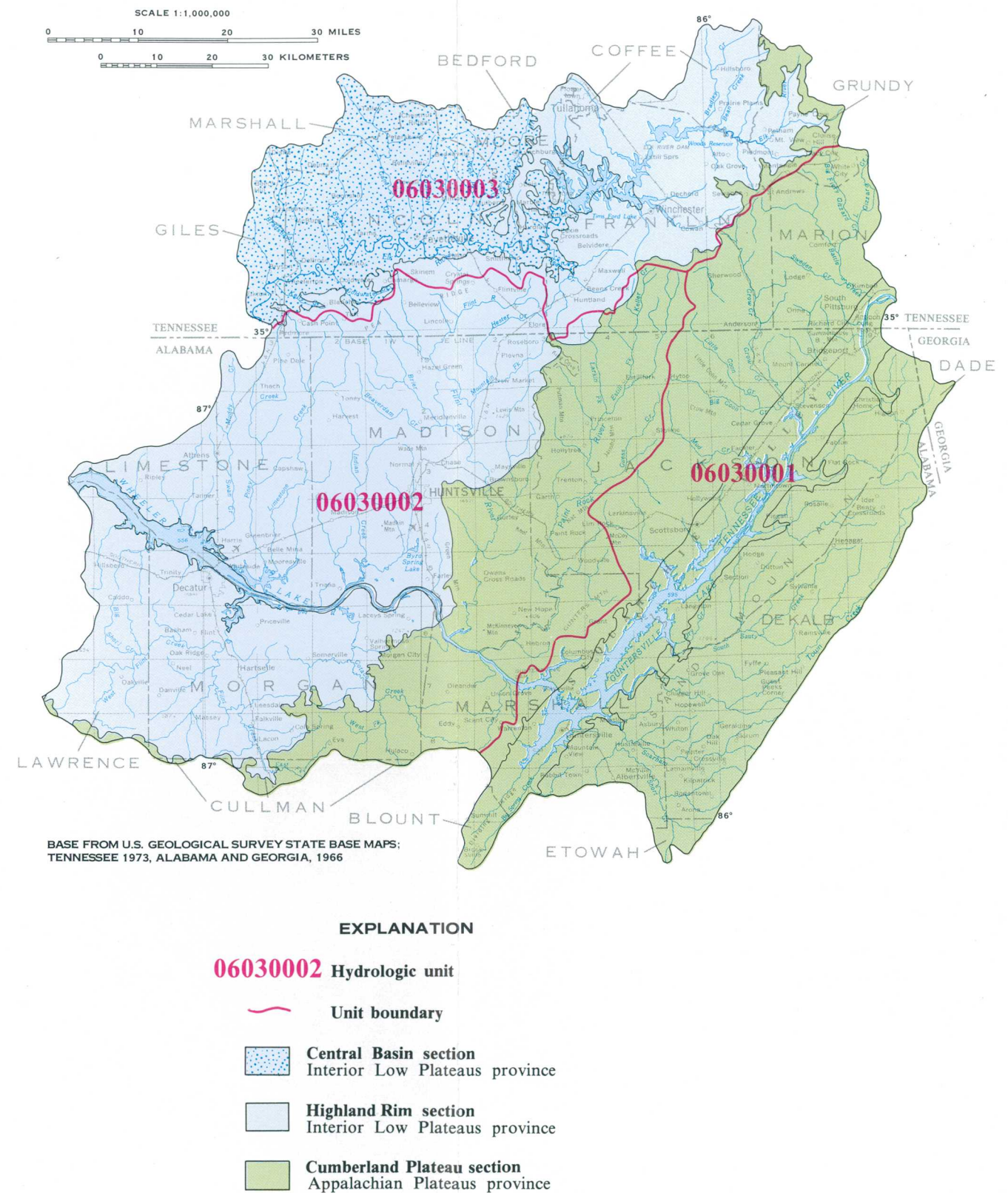


Figure 1.2-2 Project Area.

1.0 INTRODUCTION--Continued

1.3 Hydrologic Problems Related to Coal Mining

Hydrologic Environment Can Be Adversely Altered by Coal Mining

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

Mining, especially surface mining, drastically alters the environment of undisturbed areas and may cause detrimental changes to the natural environment (fig. 1.3-1). Mining activities such as the removal of vegetation, excavation, and dumping of large volumes of unconsolidated spoil materials create unstable areas of loose earth and rock which erode easily and contribute additional sediment to surface streams, channels, and flood plains. If the mined area is reclaimed during mining, or after mining is completed, some of the detrimental environmental effects can be decreased or prevented.

Adverse effects associated with erosion and increased sedimentation include: (1) excessive sediment deposition in streams and reservoirs which in turn increases the cost of maintaining navigation channels, and (2) increased costs of treating water for industrial and domestic uses. Other adverse effects include destruction of habitat, increased flooding due to filling of the stream channels and flood plains by sediment, and reduction of aesthetic value.

Along with increased sedimentation, another common and troublesome water-quality problem is acid mine drainage, both from surface and underground mines. After mining, accelerated weathering of iron bearing minerals (pyrite and marcasite, for example) in spoil materials, exposed coal beds, and the walls of underground mines, produce sulfuric acid and accelerates the dissolution of minerals. Water draining such a mined area generally has low pH values (2.5-5.0), and increased sulfate and dissolved-solids concentrations. The acidic water reacts with other minerals, increasing trace element concentrations such as aluminum, copper, lead, iron, man-

ganese, and zinc. Adverse effects associated with acidic and highly mineralized mine drainage may include reduction of aquatic biota, increased corrosiveness of water, limitations on the use of water for domestic and industrial purposes, and reduction of aesthetic value and recreational use.

The adverse effects are most apparent on and near the mine site. The receiving stream for surface and seepage drainage at the mine site usually is most affected. Problems associated with suspended sediment, mineral content, and pH will usually diminish in severity downstream from the mine due to deposition of sediment in the channel and on the flood plain, and due to the buffering and dilution capacity of the stream.

The decline of ground-water levels can occur in and near mined areas when excavation extends below the water table causing some wells and springs to go dry. The quality of ground water can also be affected even though the effects may take much longer to detect at points remote from mining activities (fig. 1.3-2).

The magnitude of the effects of surface mining on the surrounding hydrologic environment depends on several physical and chemical factors. The more influential factors include mining and reclamation methods, topography, geology, climate, rate of water movement and volumes, the distance to the mine site, and the time elapsed since mining began. Some generalized chemical and physical relations and trends that can result from coal mining are shown in figure 1.3-3.

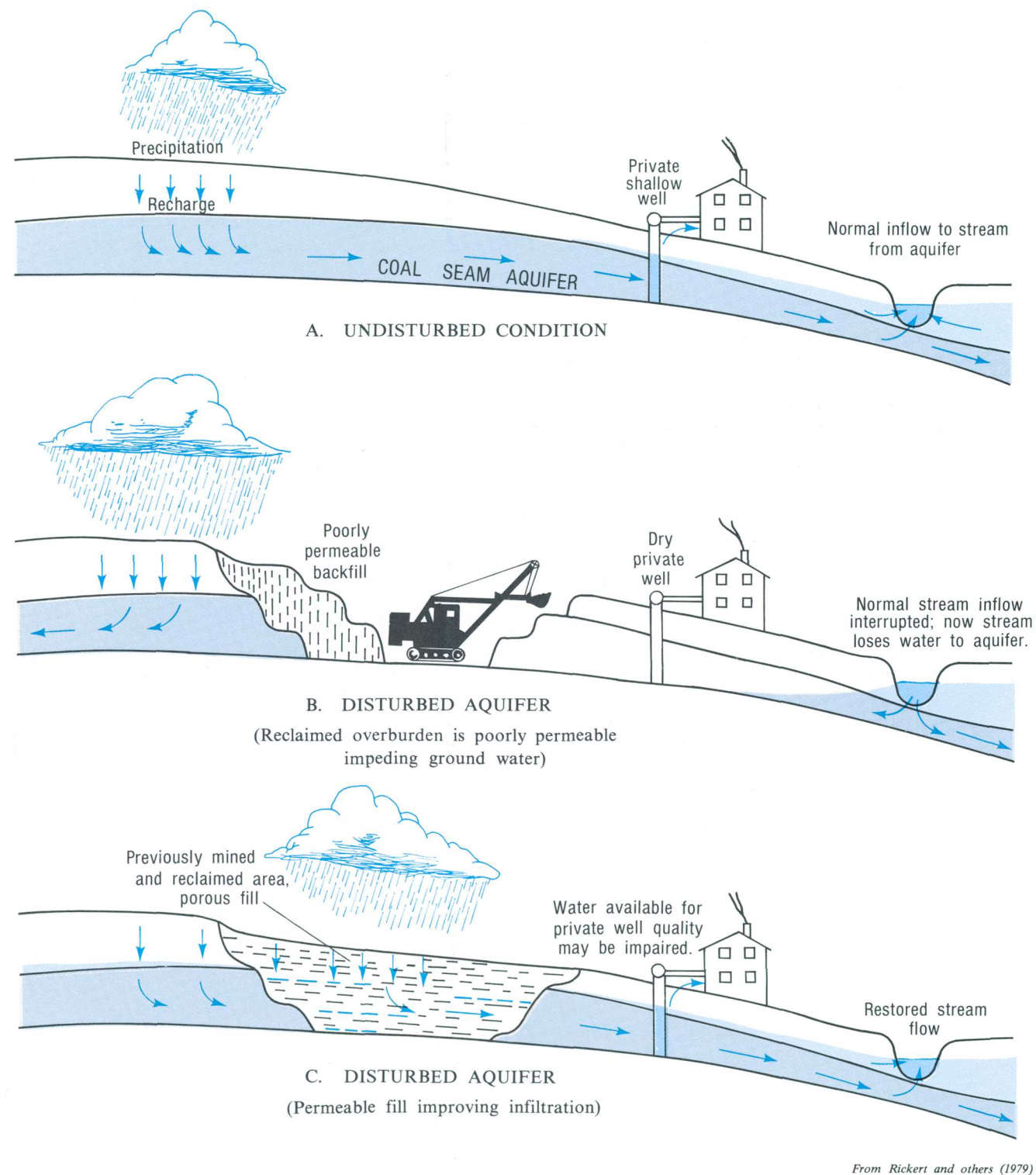


Figure 1.3-1 Possible impacts of mining aquifers.

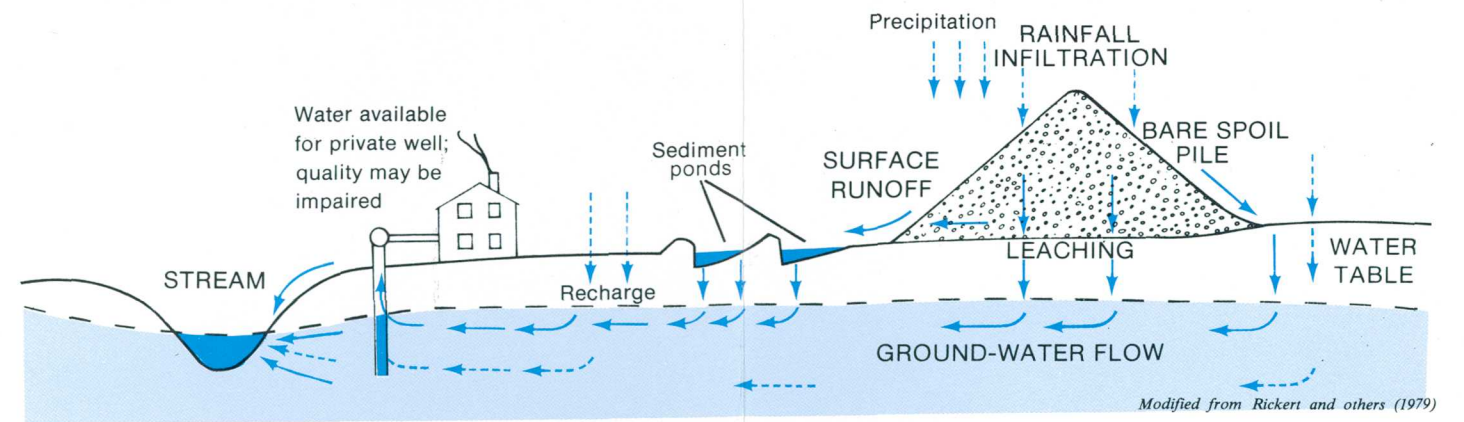


Figure 1.3-2 Leaching from spoil material.

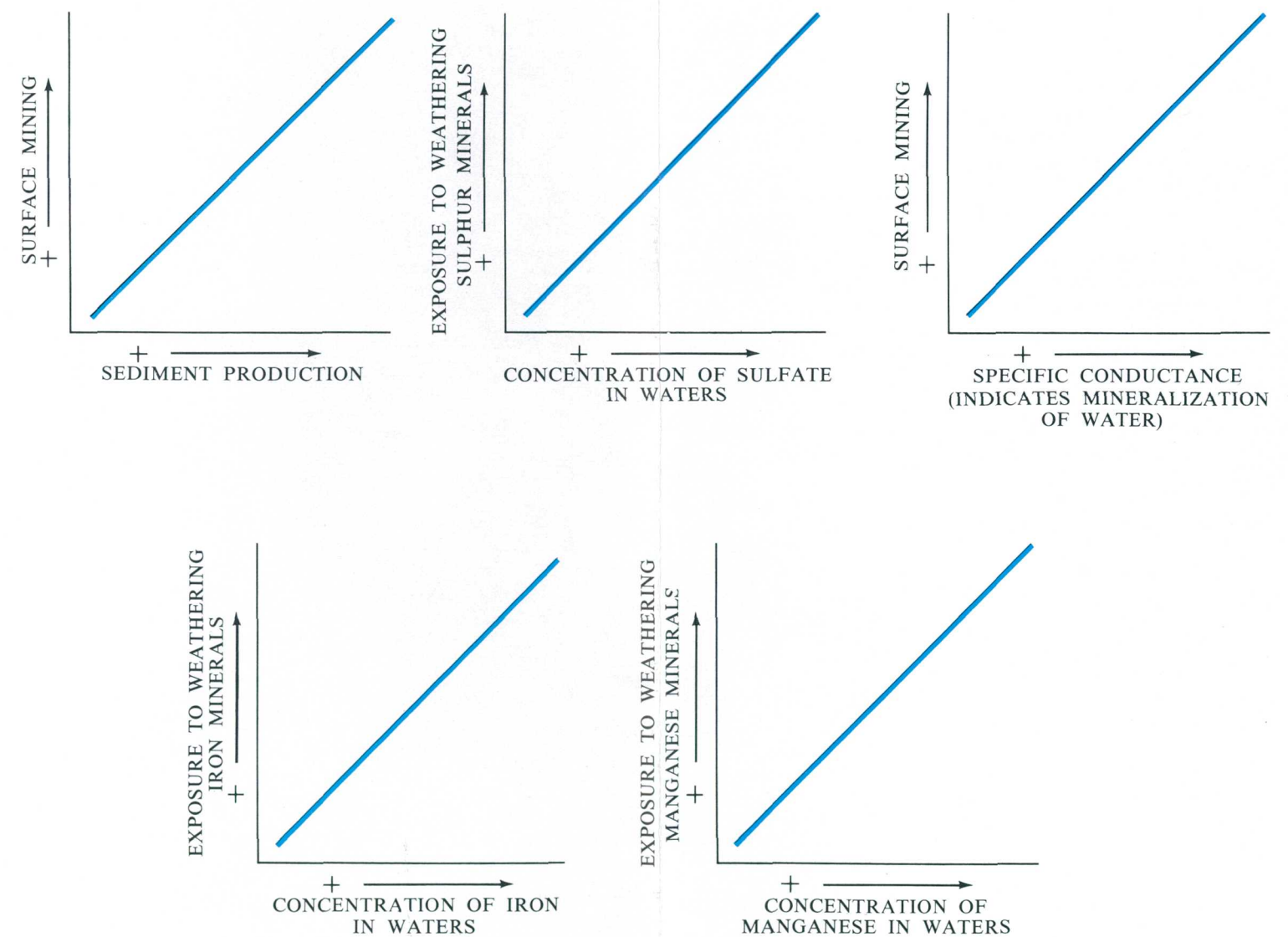


Figure 1.3-3 Generalized relations and trends that can result from surface coal mining.

1.0 INTRODUCTION--Continued

1.4 Coal-Mining Impacts

Adverse Effects of Coal Mining Evident

Acid mine drainage and erosion can affect local water supplies, but some detrimental environmental effects can be decreased by reclamation.

Acid mine drainage is produced during the coal-mining process by the exposure of pyritic rocks to natural weathering forces. Mining increases the amount of earth materials exposed to weathering and the exposure increases the rate of weathering. The percentage of acid mine drainage in Appalachia originating from strip mines is perhaps as high as 25 percent (Roth and others, 1981).

When mined land is not reclaimed, water accumulates in pits, ponds, or low areas on benches. Acid-producing elements and compounds formed through the weathering process accumulate in the water in these retention ponds. Eventually the water overflows or seeps through rocks or spoil materials and enters surface streams or the ground-water system. A similar process occurs in deep mines.

Unreclaimed strip mining can also produce large amounts of easily eroded loose spoil materials and

bare earth surfaces. The amount of sediment produced from these areas and released to surface streams and lakes can be many times greater than from undisturbed areas.

Figure 1.4-1 shows the Big Creek Utility District Reservoir in Grundy County and some results of strip mining in the basin above the reservoir. As a result of the strip mining, the pH of the water in the reservoir dropped to 3.2 and the concentration of manganese rose to 14,000 $\mu\text{g/L}$ (correspondence Tennessee Division of Surface Mining and Reclamation, 1982).

Reclamation can alleviate some of the detrimental environmental effects created by strip mining. The photos in figure 1.4-2 show the effects of reclaiming a haul road in Van Buren County.



STRIP
MINE
RETENTION
POND



ACID MINE
DRAINAGE

*All photographs courtesy of Tennessee
Division of Surface Mining and Reclamation*



EROSION



BIG CREEK UTILITY DISTRICT RESERVOIR

BEFORE



AFTER



Figure 1.4-2 Haul road before and after reclamation
(Van Buren County, Tenn.).

Figure 1.4-1 Strip mining upstream from a public water supply reservoir (Grundy County, Tenn.).

2.0 GENERAL FEATURES

2.1 Physiography

Area 21 Lies Within Three Physiographic Sections

Area 21 lies within the Cumberland Plateau section of the Appalachian Plateaus province and the Highland Rim and Central Basin sections of the Interior Low Plateaus province.

Area 21 lies within three physiographic sections, Cumberland Plateau, Highland Rim, and Central Basin (Fenneman, 1938; Miller, 1974). Each section is characterized by its landforms and geology. The sections drain to the Tennessee Valley at an altitude of about 600 feet, the local base level for the area.

The Cumberland Plateau section of the Appalachian Plateaus province is predominantly a topographic highland that occupies slightly less than half the 6,021 mi² in Area 21 (fig. 2.1-1). For the most part, this section is underlain by Pennsylvanian rocks, which contain massive sandstone beds that are resistant to weathering and erosion. These sandstones form steep escarpments along the edges of the Plateau (fig. 2.1-2).

The Cumberland Plateau in Area 21 is subdivided into three parts: Sand Mountain, Sequatchie Valley, and Jackson County Mountains. The easternmost part is a synclinal plateau named Sand Mountain in Alabama (Sapp and Emplainscourt, 1975) and Walden Ridge in Tennessee; this feature is an upland with an average altitude of about 1,300 feet and an average relief between 100 and 200 feet. Slopes commonly are within the range of 1 to 18 percent.

The Sequatchie Valley is considered part of the Cumberland Plateau although it is at least 500 feet lower in elevation than the adjacent uplands and is underlain by folded and faulted carbonate rocks of Ordovician age (Fenneman, 1938). It is a northeast-southwest trending linear valley that has an average altitude of about 600 feet in Area 21, and topographic relief commonly less than 100 feet. Steep escarpments bound both sides of this valley, rising to the upland plateau surfaces that are commonly 700 to 900 feet above the valley floor.

West of the Sequatchie Valley, the Jackson County Mountains (fig. 2.1-1) are dissected and occur as discontinuous outliers of Pennsylvanian

rocks overlying Mississippian cherty limestone, which crops out in the valleys. This part of the Plateau, known locally as the "Cumberland Plateau" in Tennessee and the Jackson County Mountains in northern Alabama, has an average altitude ranging from 1,600 feet in Tennessee to slightly more than 1,000 feet at the southern edge of the area in Alabama. Relief commonly exceeds 300 feet.

The Highland Rim section of the Interior Low Plateaus province lies in the northwestern half of Area 21 and is separated from the Plateau by the Cumberland Plateau escarpment. The escarpment, which is steep in the northern part of the area, becomes progressively subdued from north to south.

The topography of the Highland Rim section varies from gently rolling to almost level, except near the outliers of the Plateau. Slopes in the Highland Rim are commonly within the range of 1 to 15 percent. Altitudes range from 800 to 1,000 feet north of the Tennessee River and from 600 to 700 feet south of the river.

The Highland Rim is underlain by Mississippian rocks, primarily limestone, which in some places contain abundant chert. These limestones are subject to dissolution by chemical weathering. Consequently, caves, springs, and landforms characteristic of karst topography are common in this section of Area 21. Thick (50 to 100 feet) cherty regolith occurs in much of this section.

The escarpment separating the Highland Rim from the Central Basin is notched and dissected by streams. The Central Basin section of the Interior Low Plateaus province, in the northwest corner of Area 21, is characterized by many knobs and hills that are outliers of the Mississippian rocks of the Highland Rim. Land-surface altitudes generally range from 800 to 1,000 feet and slopes are between 5 and 30 percent. Within Area 21 the Central Basin is primarily underlain by Ordovician limestone.

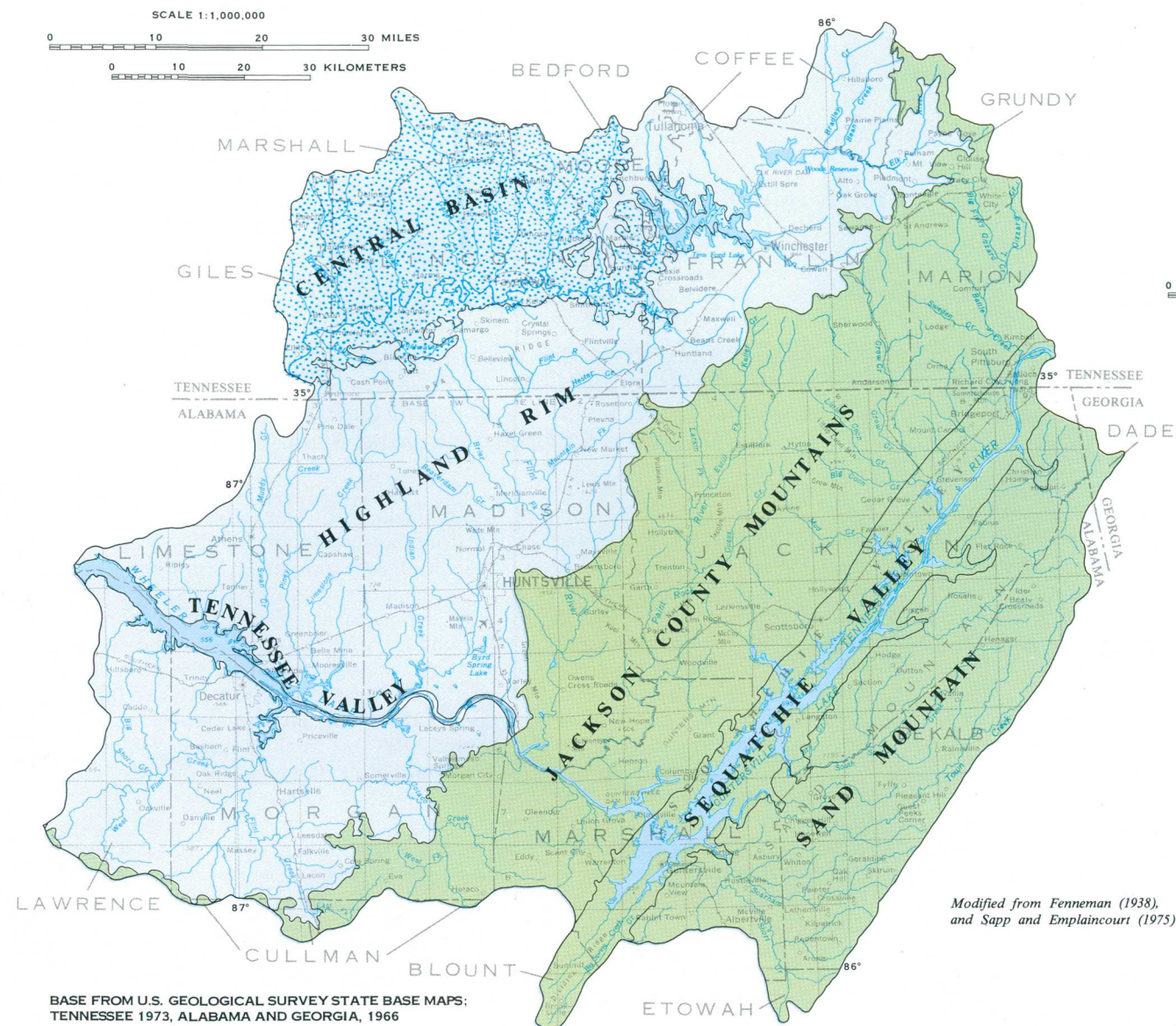


Figure 2.1-1 Physiographic divisions of Area 21.

Figure 2.1-2 Shaded relief of Area 21.

2.0 GENERAL FEATURES--Continued

2.2 Geology

Different Types of Rocks Underlie Each of Three Physiographic Sections

Pennsylvanian sandstone, shale, and coal underlie the Cumberland Plateau; Mississippian limestone and chert underlie the Highland Rim; and pre-Mississippian rocks, which are primarily Ordovician limestone and dolomite, underlie the Central Basin.

Gently dipping Pennsylvanian rocks, which contain the coal beds, cap the extensive uplands and outliers of the Cumberland Plateau in Area 21 (fig. 2.2-1). These rocks are classified as the Pottsville Formation in Alabama (Adams and others, 1926), but for this report the general term Pennsylvanian rocks has been retained. The Pennsylvanian rocks consist chiefly of alternating beds of sandstone, conglomerate, shale, and siltstone with beds of underclay and coal. The coal beds are difficult to correlate regionally (fig. 2.2-2). Thickness of the Pennsylvanian rocks ranges from 210 feet at the southern boundary (Faust and Jefferson, 1980) to more than 800 feet on Sand Mountain. The Pennsylvanian rocks capping the Plateau are resistant to both physical and chemical weathering and therefore, the regolith is generally thin.

Rocks underlying the Cumberland Plateau at depth are exposed in the Cumberland Plateau escarpment. These exposures show an abrupt change from Pennsylvanian sandstone, shale, and coal above to Mississippian limestone and shale below.

Mississippian rocks cover the entire Highland Rim, underlie the Cumberland Plateau to the east, and cap some of the outlying hills west of the Highland Rim escarpment (fig. 2.2-1). Beneath the Cumberland Plateau the Mississippian rocks have a max-

imum thickness of more than 1,000 feet. Limestone, siltstone, and shale are the predominant rock types. Bedded chert, and cherty limestone, occur in some places in the Mississippian rocks as a result of large scale replacement of calcium carbonate by silica. Weathering and dissolution of the carbonate rocks that are interbedded with the relatively insoluble chert and cherty limestone produce a thick regolith of chert rubble. It averages more than 40 feet and exceeds 100 feet in thickness in some places on the Highland Rim (Geological Survey of Alabama, 1975).

Pre-Mississippian rocks crop out in the Central Basin and underlie all of Area 21. Although some of these rocks are Devonian and Silurian carbonate rocks, most are Ordovician limestone, mudstone and dolomite. Pre-Mississippian rocks commonly weather to a thin clayey regolith less than 10 feet thick.

Geologic structure throughout most of Area 21 is relatively simple, with rocks essentially undeformed and nearly horizontal. The noticeable exception occurs in the southeastern part of the area where strata are folded and faulted to form a northeast-southwest trending anticline (Sequatchie Valley) and syncline (Sand Mountain). Elsewhere in most of the area, the strata have a regional dip 20 to 100 ft/mi to the southeast (Adams and others, 1926).

2.0 GENERAL FEATURES--Continued

2.3 Soils

Soils Reflect Geologic Origin

Soils of the uplands of the Cumberland Plateau are formed primarily from sandstone and shale; soils of the Highland Rim and Cumberland Plateau valleys are formed primarily from limestone, dolomite, sandstone, and shale; and soils of the Central Basin are formed from limestone, shale, and alluvium.

The soils of the Cumberland Plateau in Area 21 (fig. 2.3-1 and table 2.3-1) are derived primarily from sandstone and shale. Slopes vary from nearly level to steep. The soils are generally loamy, but clay layers may be present. Soil depths vary greatly with rocks cropping out in some associations. The soils are generally well drained.

Soils of the Highland Rim and Cumberland Plateau valleys are formed from limestone, dolomite, sandstone, shale, and alluvium. The soils are dominantly loamy but some are cherty and clayey. Most of the soils are deep. Hilly upland soils such as Bodine and associated soils are well to excessively drained. Soils such as Colbert or Lee found on level uplands or stream bottoms are moderately well to poorly drained.

Soils of the Central Basin are derived from phosphatic limestone, cherty limestone, shale, and alluvium. The soils are loamy, silty, clayey, and cherty. The Central Basin is hilly and rolling and the soils are well drained except in the stream valleys where Lindell and associated soils are moderately well drained.

Other characteristics of the soils throughout Area 21 vary greatly (table 2.3-1). The erosion hazard is slight to moderate for most soils, but can be severe for some soils. Most of the soils are acid with pH values generally ranging from 3.6 to 6.5. The permeability is very low (less than 0.06 in/h) to rapid (greater than 6.0 in/h). Available water capacity is very low (0.02 in/in) to high (0.24 in/in).

In order to aid the estimation of runoff from rainfall on small watersheds, the soils are grouped (table 2.3-2) by relative infiltration rate (Mockus, 1964). This hydrologic grouping of soils is based on an estimate of the infiltration rate for a bare soil after prolonged wetting. Group B soils have moderate infiltration rates; group C soils have slow infiltration rates; and group D soils have very slow infiltration rates. Slower infiltration rates cause higher surface runoff rates.

Additional soil information is available from the county offices of the Soil Conservation Service, U.S. Department of Agriculture.

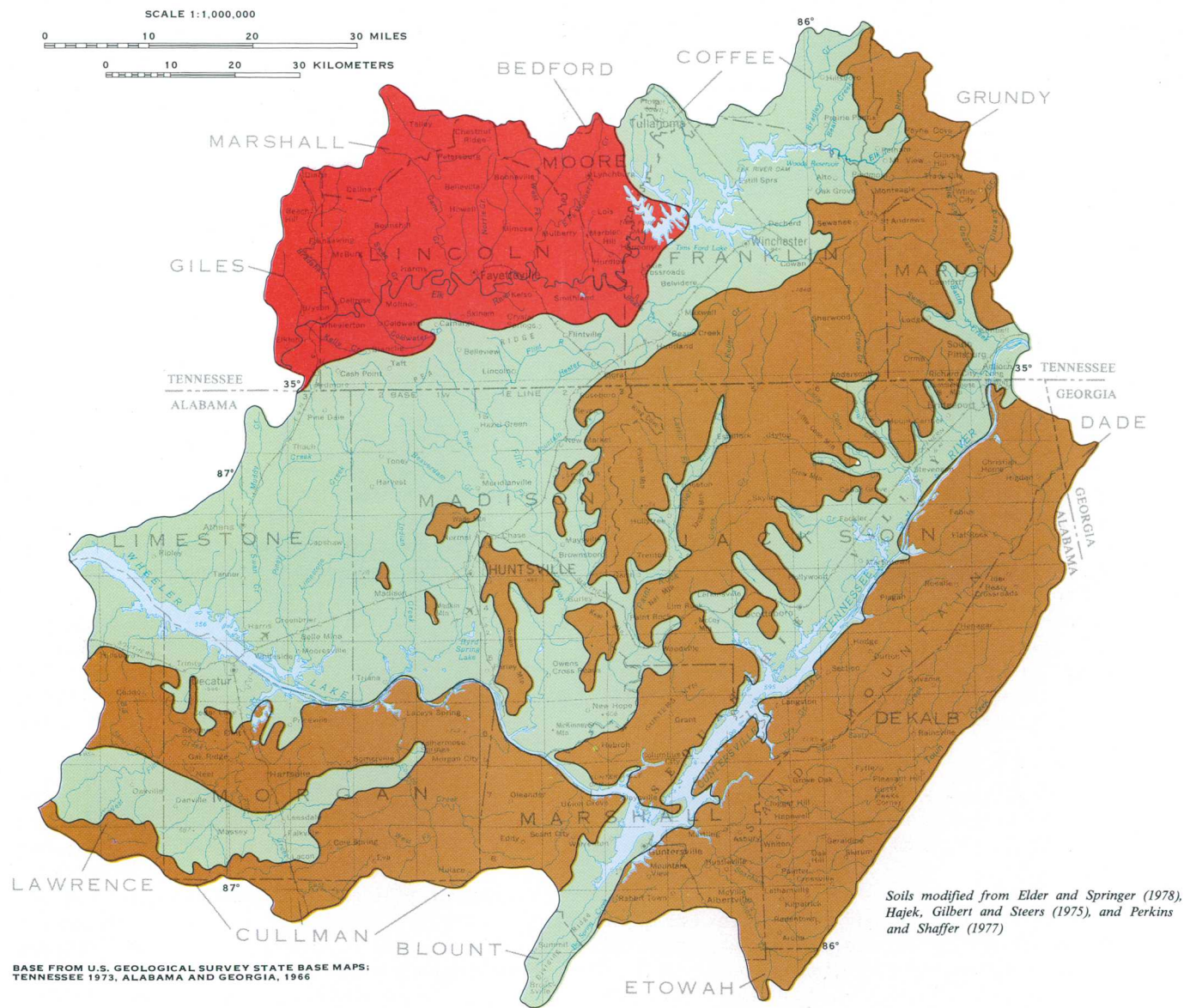


Figure 2.3-1 Soils.

Table 2.3-2 Infiltration rates for soils group.

B, moderate infiltration rate; C, slow infiltration rate; D, very slow infiltration rate (Mockus, 1964)

Soil	Group	Soil	Group	Soil	Group
Albertville	C	Egam	C	Lobelville	C
Allen	B	Enders	C	Lonewood	B
Armour	B	Etowah	B	Mimosa	C
Arrington	B	Firestone	C	Minvale	B
Bewleyville	B	Fullerton	B	Montevallo	D
Bodine	B	Gilpin	C	Mountview	B
Bouldin	B	Guthrie	D	Nella	B
Colbert	D	Hampshire	C	Ramsey	D
Conasauga	C	Hartsells	B	Sequatchie	B
Curtistown	B	Hector	D	Stiversville	B
Decatur	B	Inman	C	Townley	C
Dellrose	B	Lee	D	Waynesboro	B
Dewey	B	Lindell	C	Wynnvile	C
Dickson	C	Linker	B		

Table 2.3-1 Soil associations in Area 21.

Data are from U.S. Soil Conservation Service Soil Interpretation Records (SCS-Soils-5)

Soil association	Soil depth (in)	Depth to bedrock (in)	pH	Permeability ¹ (in/h)	Available water capacity ² (in/in)	Slope (percent)	Description
Soil Associations of the Cumberland Plateau							
Hartsells-Lonewood-Ramsey-Gilpin	0-65	7->60	3.6-5.5	0.6-6.0 Ramsey 6.0-20.0	0.05-0.20	0-70	Undulating and rolling, well-drained, loamy soils from sandstone and shale.
Bouldin-Rock outcrop-Ramsey	Bouldin 60->100 Ramsey 0-18	Bouldin 60-120 Ramsey 7-20	4.5-5.5	2.0-6.0 6.0-20.0	0.06-0.12	8-75	Steep, well-drained, stony and loamy soils from colluvium, sandstone, shale and limestone; with rock outcrops.
Nella-Townley-Hector	10-40 Nella 60-80	10-40 Nella >60	3.6-6.5	0.06-6.0	0.05-0.18	2-60	Nearly level to steep, well-drained, loamy soils from colluvium and sandstone.
Hartsells-Linker-Albertville	20-72	20-80	3.6-5.5	0.2-6.0	0.08-0.24	1-45	Nearly level and gently rolling, well-drained, loamy and clayey soils from sandstone and shale.
Hartsells-Rockland, limestone-Hector	10->60	10->60	3.6-6.5	0.6-6.0	0.05-0.18	2-60	Hilly and steep, well-drained, sandy loam soils from sandstone; with limestone outcrops. Also occurs in the Highland Rim near the Tennessee River in Alabama.
Hector-Rockland, limestone-Allen	10->60	10->60	4.5-6.5	0.6-6.0	0.05-0.19	2-60	Hilly and steep, well-drained, loamy soils from sandstone; with limestone outcrops.
Hartsells-Wynnvile-Albertville	40-72	40->60	3.6-5.5 Fragipan ³ 0.06-0.2	0.2-6.0 0.06-0.2	0.11-0.24 0.08-0.12	0-45	Nearly level and gently rolling, well-drained and moderately well-drained, loamy and clayey soils from sandstone and shale. Also occurs in the Highland Rim south of the Tennessee River in Alabama.
Montevallo-Townley-Enders	10-46	10-60	3.6-6.0	0.06-2.0	0.02-0.22	1-65	Hilly and steep, well-drained, loamy and clayey soils from sandstone and shale.
Soil Associations of the Highland Rim and Cumberland Plateau valleys							
Colbert-Conasauga-Firestone	20->80	20->80	3.6-6.5 Colbert 5.1-7.3	0.06-2.0	0.08-0.24	1-45	Nearly level upland, well-drained to poorly drained, loamy and clayey soils from limestone and shale.
Minvale-Fullerton	>60	>60	4.5-5.5	0.6-6.0	0.08-0.20	2-45	Hilly and sloping, well-drained, cherty, loamy, and clayey soils from limestone and dolomite.
Minvale-Bodine-Fullerton	>60	>60	3.6-5.5	0.6-6.0	0.05-0.20	2-60	Rolling, well-drained and excessively drained, cherty, loamy, and clayey soils from limestone.
Dickson-Fullerton	>60	>60	4.5-5.5 Fragipan ³ 0.06-0.6	0.6-2.0 0.06-0.6	0.10-0.22 0.02-0.11	0-45	Nearly level upland, well-drained and moderately well-drained, cherty, loamy, and clayey soils from limestone.
Bodine-Mountview-Dickson	60->100	60->100	3.6-5.5 Fragipan ³ 0.06-0.6	0.6-6.0 0.06-0.6	0.06-0.22 0.02-0.11	0-60	Hilly and steep, excessively drained, cherty soils from limestone and undulating, well-drained and moderately well-drained, silty soils from thin loess and limestone.
Dickson-Mountview-Guthrie	60->100	60->100	3.6-5.5 Fragipan ³ 0.06-0.6	0.6-2.0 0.06-0.6	0.10-0.22 0.02-0.11	0-15	Undulating, well-drained to poorly drained, silty soils from thin loess and limestone.
Decatur-Dewey	>60	>60	4.5-6.0	0.6-2.0	0.12-0.20	1-30	Gently rolling, well-drained, loamy and clayey soils from limestone.
Decatur-Dewey-Allen	>60	>60	4.5-6.0	0.6-2.0	0.10-0.20	1-40	Nearly level and gently sloping, well-drained, loamy and clayey soils from limestone.
Waynesboro-Decatur-Bewleyville-Curtistown	>60	>60	4.5-6.0	0.6-2.0	0.10-0.22	0-30	Undulating and rolling, well-drained, clayey and loamy soils from alluvium and thin loess.
Waynesboro-Etowah-Sequatchie-Allen	32->60	>60	4.5-5.5	0.6-2.0	0.09-0.20	0-40	Undulating to hilly, well-drained, clayey and loamy soils from alluvium and colluvium.
Lobelville-Lee	20-65	>60	4.5-6.0	0.6-2.0	0.06-0.15	0-3	Level and nearly level, moderately well-drained and poorly-drained, cherty and loamy soils from alluvium of limestone, sandstone, shale, and loess.
Soil Associations of the Central Basin							
Dellrose-Mimosa-Bodine	40->60	40->60	3.6-6.0	0.2-6.0	0.06-0.20	2-60	Hilly and steep, well-drained, cherty and clayey soils from colluvium, phosphatic limestone, cherty limestone and shale.
Mimosa-Armour	40->60	40-120	4.5-6.0	0.2-6.0	0.10-0.22	0-35	Hilly and rolling, well-drained, clayey and silty soils from phosphatic limestone and alluvium; with limestone outcrops.
Stiversville-Hampshire-Inman	20-50	20-60	4.5-7.8	0.2-6.0	0.06-0.22	2-40	Hilly and rolling, well-drained, loamy and clayey soils from phosphatic limestone and shale.
Arrington-Lindell-Egam-Armour	30->60	48-120	5.1-8.4 Egam 0.2-0.6	0.6-2.0 0.2-0.6	0.10-0.22	0-15	Major stream bottoms and terraces, moderately well-drained to well-drained, loamy, silty, and clayey soils from alluvium and loess.

1 Permeability is measured as the number of inches per hour that water moves downward through the saturated soil (U.S. Department of Agriculture, 1981).

2 Available water capacity in inches of water per inch of soil is commonly defined as the difference between the amount of soil water at field moisture capacity and the amount at wilting point (U.S. Department of Agriculture, 1981).

3 Fragipan - a dense and very compact horizon, rich in silt and/or sand and relatively low in clay. It commonly interferes with water and root penetration. A fragipan is present in the Wynnville, Dickson, and Guthrie soil series.

2.0 GENERAL FEATURES--Continued

2.4 Surface Drainage

All Surface Drainage Enters the Tennessee River

Principal streams are the Tennessee, Paint Rock, Elk, and Flint Rivers, and Flint Creek.

Area 21 has a total surface drainage of 6,021 mi². All surface drainage is to the Tennessee River which flows southwesterly along the eastern edge of the area to about the center of Marshall County, Alabama (fig. 2.4-1). There, at the southern edge of the area, the River veers and follows a northwesterly course to the western boundary. The entire reach of the Tennessee River in the area is impounded by two major navigation and flood control dams. Closure dates and storage capacities for these dams and two dams on the Elk River are listed below.

The major streams draining Area 21 are the Tennessee, Paint Rock, Elk, and Flint Rivers, and Flint, Limestone, and Crow Creeks. The drainage areas for these streams and other tributaries are given in table 2.4-1.

The Tennessee River flows southwest in the Sequatchie Valley through the central part of the Plateau. Plateau elevations range from about 1,500 feet at the northern edge to about 1,000 feet at the southern edge of the area. Tributaries to the Tennessee River in the Plateau section generally enter the River from deeply incised valleys which trend perpen-

dicular to the Sequatchie Valley. On the northwest side of the Tennessee River, these valleys extend deep into the headwater areas of the tributaries, whereas, on the southeast side they end abruptly near the edge of the Sequatchie Valley escarpment.

Streams in the Highland Rim have formed a parallel drainage pattern and stream valleys are shallow. The intervening land surfaces are relatively flat and tillable and range in elevation from about 600 feet at the southern boundary to about 800 feet at the northern boundary of the area.

A small part of the Elk River basin in the northwest corner of the area is part of the Central Basin. Stream valleys here are generally wide and flat with well developed flood plains. Relief from valley floors to ridge tops is about 200 feet.

All streams in Area 21 except the Tennessee River originate within the area. The Elk River originates within the area and, like the Tennessee River, flows generally westward entering the Tennessee downstream from the western boundary of Area 21.

Dam	Closure date	Maximum storage capacity (acre-feet)	Level pool elevation* (feet)
Tennessee River			
Guntersville	1939	1,052,000	595.44
Wheeler	1936	1,071,000	556.28
Elk River			
Elk River	1952	88,100	962.0
Tims Ford	1970	608,000	895

* National Geodetic Vertical Datum of 1929.

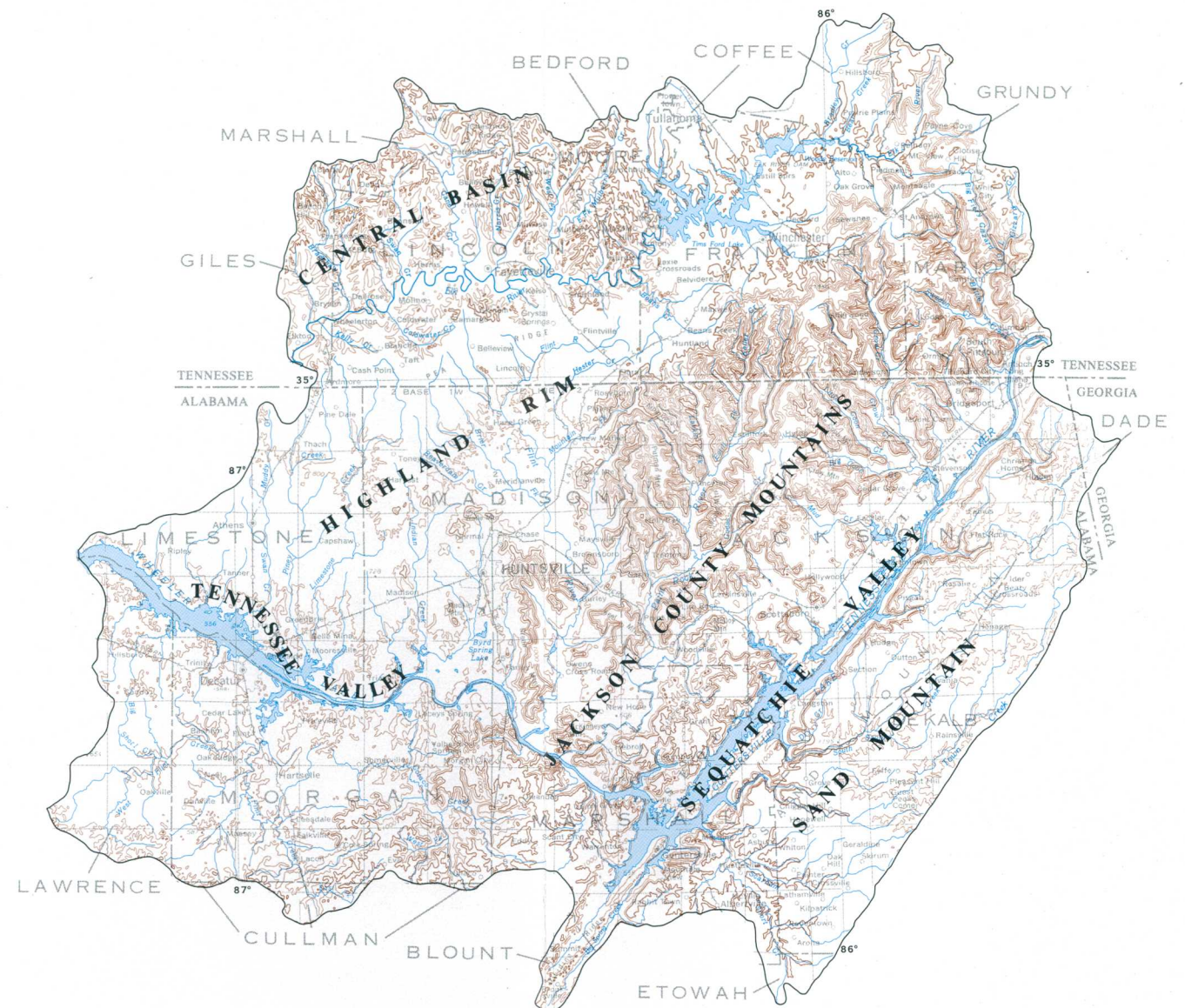
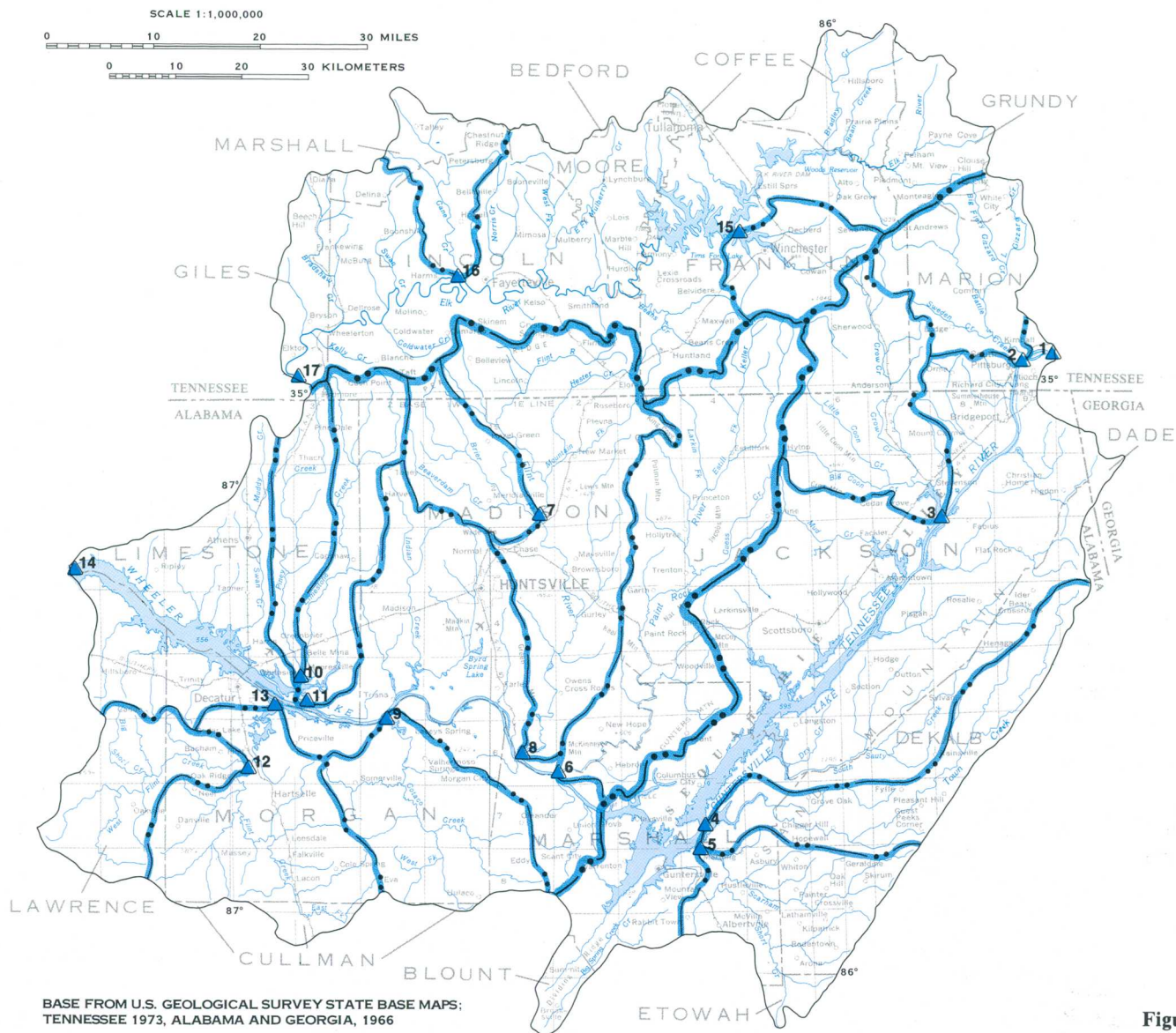


Figure 2.4-1 Drainage basins.

EXPLANATION

- Basin boundary
- Subbasin boundary
- ▲ Mouth of drainage basin
- 11 Basin number

Table 2.4-1 Drainage areas of major stream basins shown in figure 2.4-1.

Basin number	Basin	Drainage area (square miles)
▲1	Tennessee River below Sequatchie River (at upstream area boundary)	22,475.0
▲2	Battle Creek at mouth	170
▲3	Crow Creek at mouth	275
▲4	Town Creek at mouth	219
▲5	Short Creek at mouth	224
▲6	Paint Rock River at mouth	458
▲7	Brier Fork at mouth	112
▲8	Flint River at mouth	568
▲9	Cataco Creek at mouth	243
▲10	Piney Creek at mouth	99
▲11	Limestone Creek at mouth	286
▲12	West Flint Creek at mouth	167
▲13	Flint Creek at mouth	455
▲14	Tennessee River above Elk River (at downstream area boundary)	27,210
▲15	Boiling Fork Creek at mouth	105
▲16	Cane Creek at mouth	106
▲17	Elk River near Ardmore (at downstream area boundary)	1,286
Total Area 21		6,021

2.0 GENERAL FEATURES--Continued

2.5 Land Use

Forest and Agricultural Land Cover Most of the Area

Forest land is predominant in the Jackson County Mountains and northeastern quarter of Sand Mountain in the Cumberland Plateau; agricultural land is predominant in the Highland Rim and southwestern three quarters of Sand Mountain.

About two-thirds of the Cumberland Plateau section (the coal-resources area) is covered by forest land (fig. 2.5-1). Forest land is most predominant in the Jackson County Mountains and northeastern quarter of Sand Mountain. Agricultural land increases in the southwestern half of the Jackson County Mountains and is predominant on the southwestern three-quarters of Sand Mountain. Water and wetland associated with Gunter'sville Lake occupy much of the Sequatchie Valley. The remaining land use is largely agricultural and forest. A few centers of urban or built-up land are associated with small agricultural communities in the valley. Barren land, mostly associated with cut-and-backfill strip mines, occurs in the northeastern quarter of the Cumberland Plateau.

Most of the Highland Rim is agricultural with some scattered, small woodlots. Urban and built-up land occurs in and about the communities of Tulsa, Huntsville, Decatur, and Athens. Water and wetland occur along Wheeler Lake in the Tennessee Valley.

The Central Basin is about equally divided between forest and agricultural land. There are many wooded hills that are too steep to farm in this part of

the Central Basin. Some urban and built-up land occurs in and about Fayetteville, Tenn.

Land-use and land-cover information and maps of the Cumberland Plateau in Tennessee may be obtained from:

Mapping Services Branch
Tennessee Valley Authority
200 Haney Building
Chattanooga, TN 37401

Land-use maps in greater detail for Area 21 in Alabama may be obtained from:

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

An index map showing the availability of U. S. Geological Survey land-use and land-cover maps may be obtained from:

National Cartographic Information Office
U.S. Geological Survey
507 National Center
Reston, VA 22092

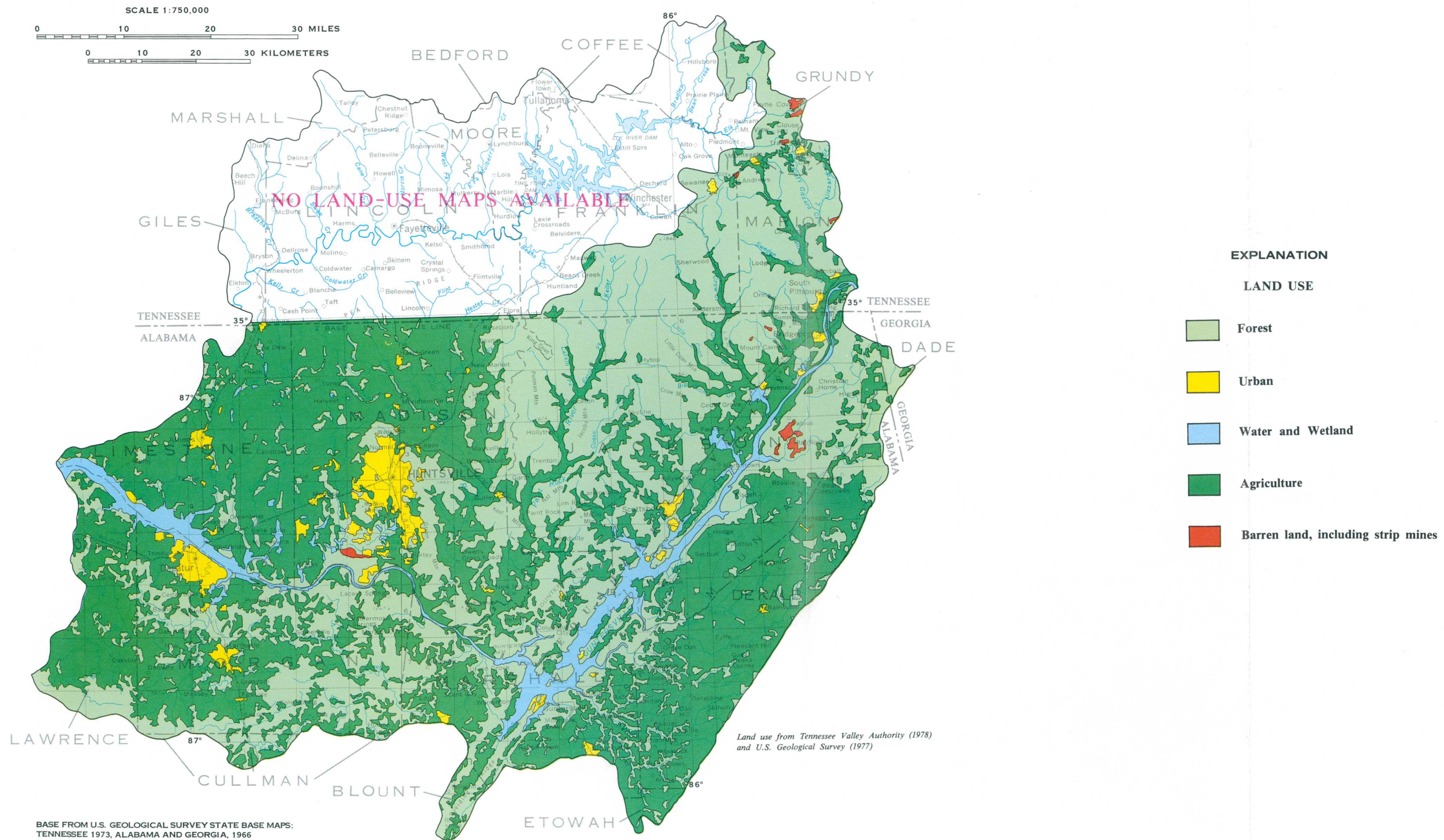


Figure 2.5-1 Land use in the Cumberland Plateau and Highland Rim of Area 21.

2.0 GENERAL FEATURES--Continued

2.6 Climate

Climate of Area 21 is Moist and Temperate

Average annual precipitation is about 55 inches, and average annual temperature is about 59°F.

The average annual precipitation for the area is about 55 inches (fig. 2.6-1), but ranges from about 35 inches to about 70 inches (U.S. Department of Commerce, 1976 and 1977). Thunderstorms which often produce locally heavy rainfall occur about 60 days per year and are sometimes accompanied by damaging winds and extreme changes in temperature. The 25-year 24-hour rainfall (fig. 2.6-2) is about 6 inches (U.S. Department of Commerce, 1961). Maximum, minimum, and normal monthly precipitation at Huntsville, Ala., are considered to be representative of the area (fig. 2.6-3).

The average annual temperature for Area 21 is about 59°F with extremes seldom above 100°F or below 10°F. Daily maximum temperatures are above 90°F about 50 days per year. There is a frost-free season of about 200 days from early April to late October. Minimum temperatures below 10°F can occur in December, January, and February, but the number of days with such values is generally less than 2 in any year.

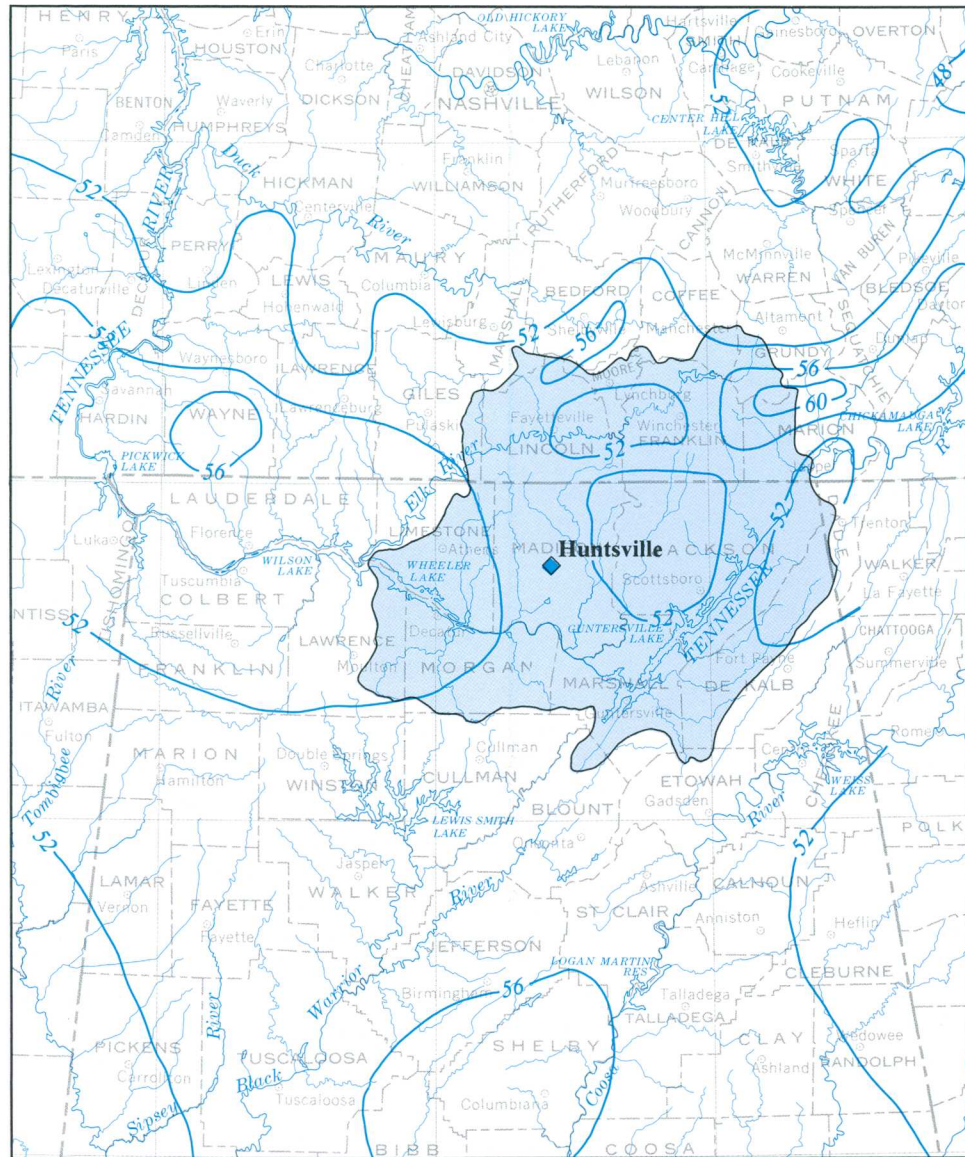


Figure 2.6-1 Mean annual precipitation, in inches.

EXPLANATION

◆ Weather Station

— 52 — Line of equal precipitation

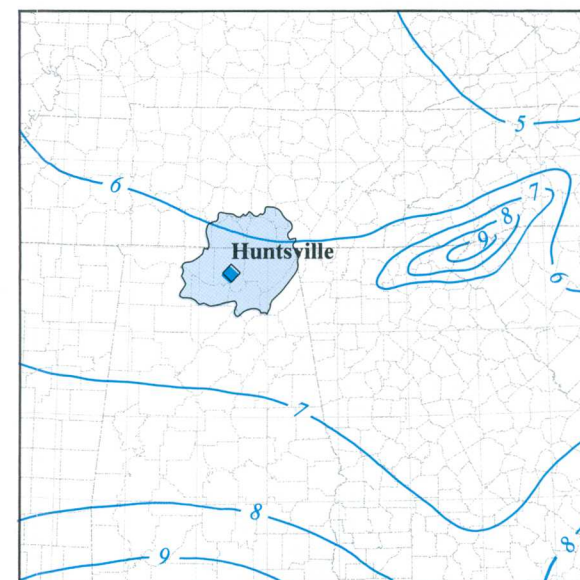


Figure 2.6-2 The 25-year 24-hour rainfall intensities in inches.

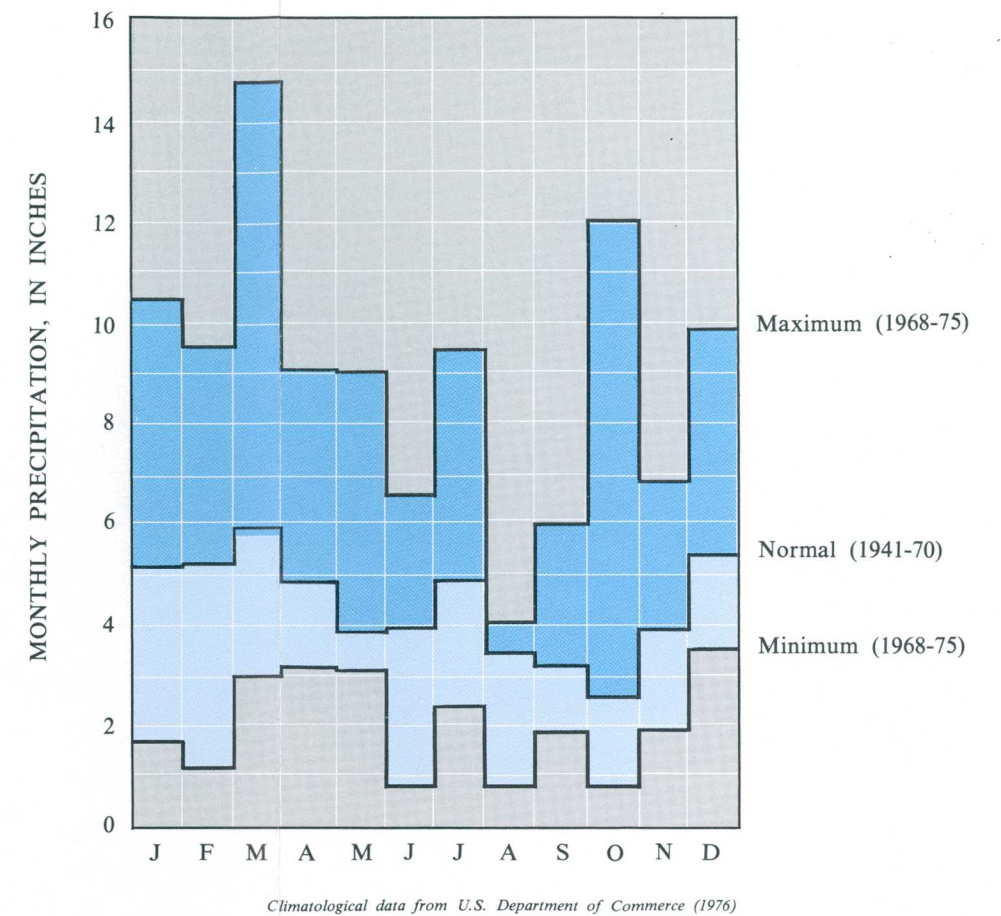


Figure 2.6-3 Monthly precipitation for Huntsville, Ala.

2.0 GENERAL FEATURES--Continued
2.7 Coal-Mining Activities and Methods

Coal-Mining Activities Occur Throughout Cumberland Plateau

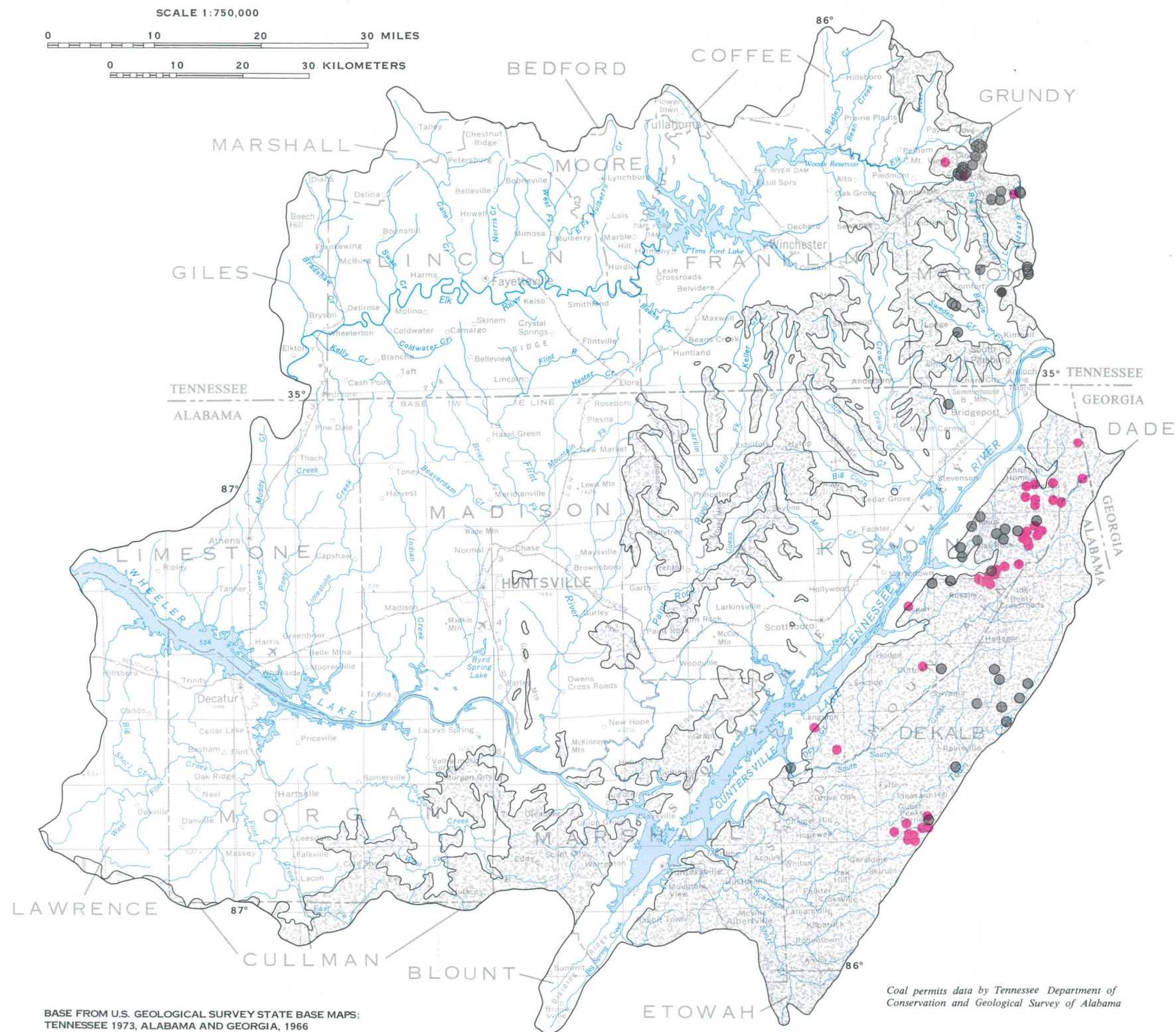
Coal is mined by contour-stripping or cut-and-backfill methods.

Sites for which mining permits were issued by the Tennessee Department of Conservation since 1972 and the Alabama Surface Mining Reclamation Commission are shown in figure 2.7-1. Permits for Tennessee sites were considered "active" if they were issued in 1980 or 1981, since State laws require that permits be renewed annually. In Alabama, permits are issued for the "life of the mine" and those permits on record in 1980 were considered active. One inactive deep mine is located in Marion County.

In Area 21 coal is usually mined by stripping away overburden or overlying rock formations in order to load and haul the coal overland in trucks. Commonly, surface mining is done by stripping along the contours of hills and mountains (contour mining) where the edges of coal seams are mined as far back into the mountain as it is economically feasible (fig. 2.7-2). In some mining operations, additional coal is extracted from contour strip mines by augering the coal seam after the stripping opera-

tion is completed. The other strip-mining method is cut-and-backfill where relatively flat areas are stripped to the coal seam and the spoil material is used to backfill the cut after the coal is removed (fig. 2.7-3).

Contour strip mining leaves bare earth and rocks, high-walls (vertical to near vertical bare earth and rock walls created by slicing a strip off the side of a mountain), benches (level to near-level floor of the stripped area used for access and hauling), and spoil banks (unstable, loose earth and rocks pushed or dumped on the bench or down the mountainside). Cut-and-backfill strip mining often leaves large areas of many acres bare and covered with loose spoil material. The land surface after mining is usually quite irregular and unfit for normal land uses such as farming, grazing, or housing and industrial development. Drastic alteration to the environment can be prevented or lessened by reclaiming the mined area during or after mining.



EXPLANATION

- Coal-resources area
- COAL MINE PERMITS
- Active surface mine
- Inactive surface mine
- Inactive deep mine

Figure 2.7-1 Coal-mining activities.

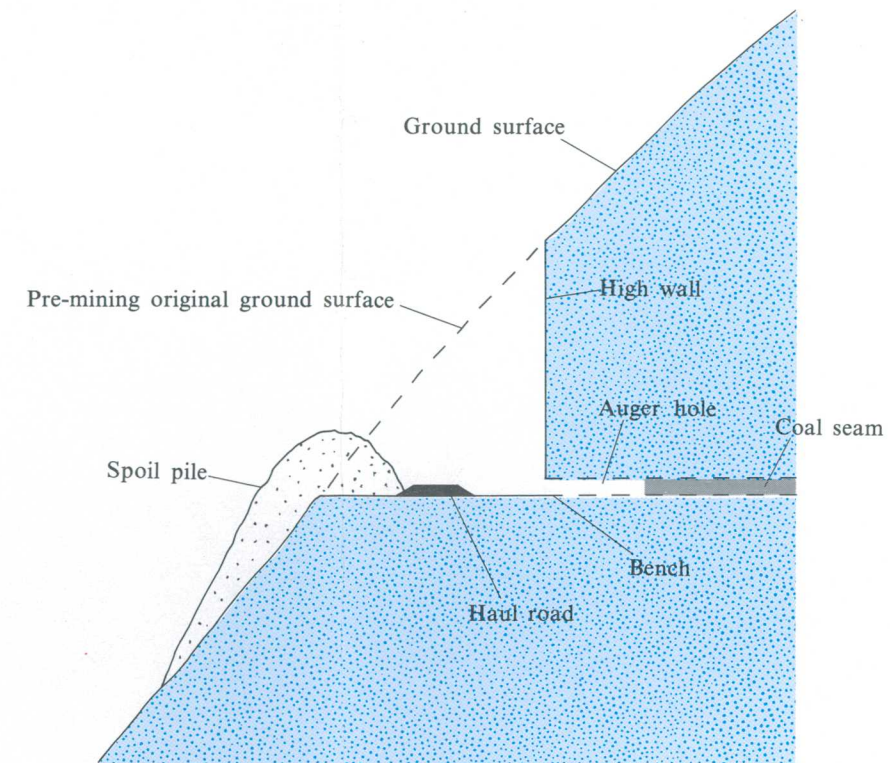


Figure 2.7-2 Section of typical contour (strip) mining site.

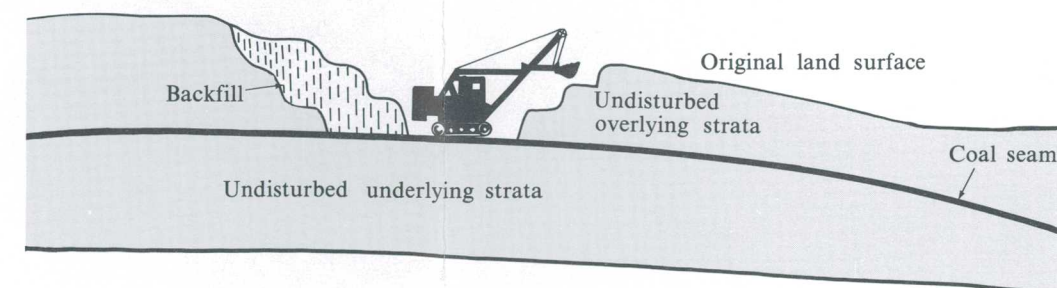


Figure 2.7-3 Section of typical cut-and-backfill (strip) mining site.

3.0 STREAM-USE CLASSIFICATION

Stream Uses Classified by State Agencies

Most streams in Area 21 are classified for use as fish, recreation, irrigation, and livestock and wildlife purposes. Other classifications include domestic and industrial water supply, and navigation.

Section 208 of the Federal Water Pollution Control Act Amendments of 1972 (Public Law 92-500) defined guidelines for developing and implementing areawide water-quality management plans. In compliance with that Act and Amendments, the Tennessee Department of Public Health, Division of Water Quality Control developed and published a water-quality management plan for Tennessee (1978). The State of Alabama Water Improvement Commission also developed water-quality criteria (written commun., 1981). Included in these documents are use classifications for most primary streams in Area 21 (table 3.0-1).

Parameters for which water-quality criteria are

defined for each use classification are given in table 3.0-1. Stream reaches coded to show use classifications are shown in figure 3.0-1 and are listed in section 10.1.

The guidelines used to develop each classification, and the quality of water parameters, are defined in Tennessee's water management and in Alabama's water-quality criteria plans. When the State regulatory agencies develop plans to implement the Surface Mining Control and Reclamation Act of 1977 (Public Law 95-87), standards for some of the quality of water criteria described above will be reviewed in light of standards defined in the Act.

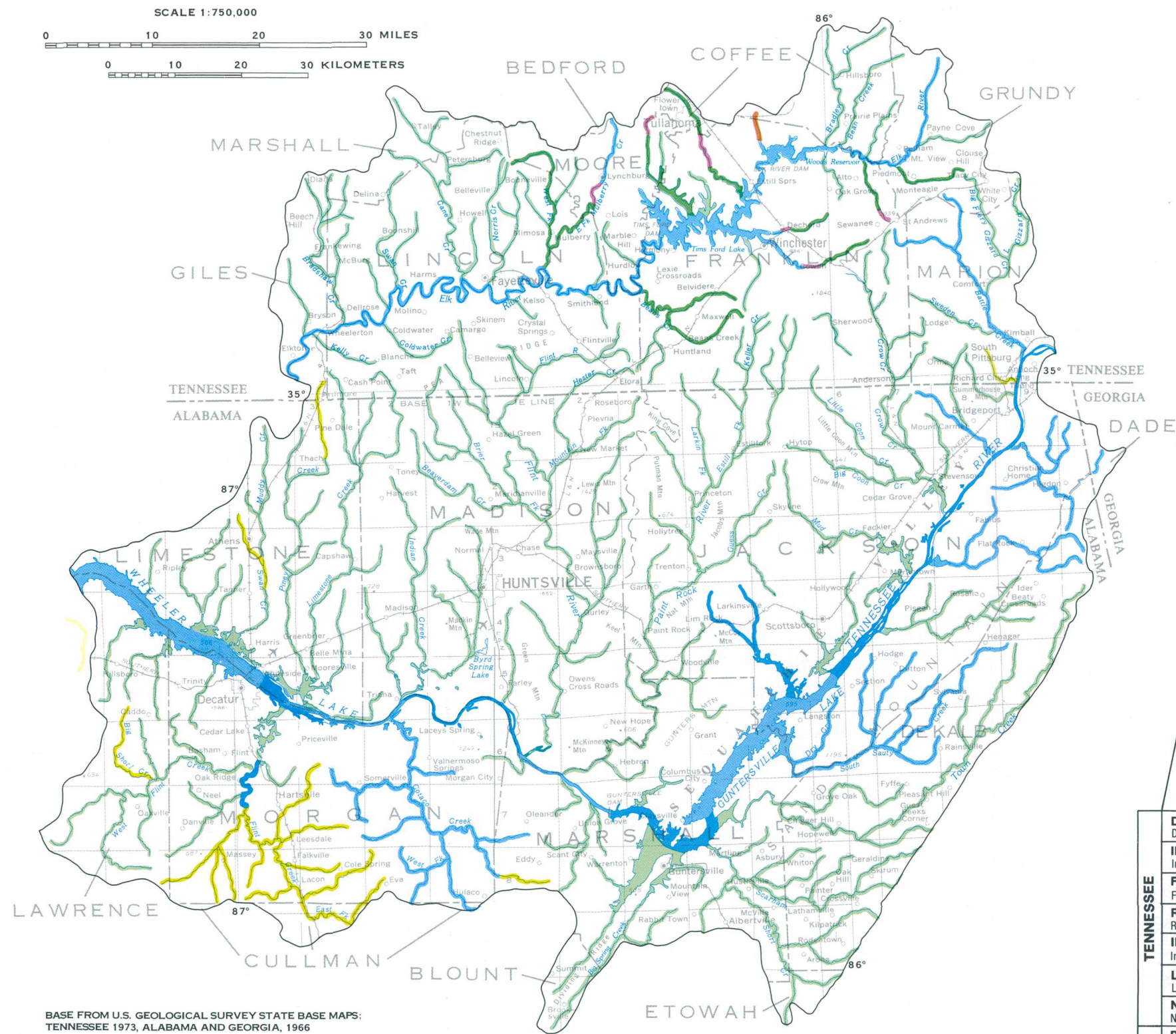


Figure 3.0-1 Stream-use classification.

EXPLANATION									
TENNESSEE								ALABAMA	
DOM	IND	FISH	REC	IRR	LW&W	NAV		PWS	
DOM	IND	FISH	REC	IRR	LW&W			S	
		FISH	REC	IRR	LW&W			F&W	
		FISH		IRR	LW&W			A&I	
	IND	FISH	REC	IRR	LW&W				
	IND	FISH		IRR	LW&W				
		FISH			LW&W				

See section 10.1 for detailed site description

Table 3.0-1 Parameters for which criteria are defined

Use classification and definition of codes		Parameters for which criteria are defined												
		Dissolved oxygen	pH	Hardness or mineral compounds	Total dissolved solids	Solids, floating materials and deposits	Turbidity or color	Temperature	Coliform bacteria	Taste or odor	Toxic substances	Other pollutants	Sewage, industrial wastes, or other wastes	Radioactivity
TENNESSEE	DOM Domestic water supply													
	IND Industrial water supply													
	FISH Fish and aquatic life													
	REC Recreation													
	IRR Irrigation													
	LW&W Livestock watering and wildlife													
	NAV Navigation													
ALABAMA	PWS Public water supply													
	S Swimming and other wholebody contact sports													
	F&W Fish and wildlife													
	A&I Agricultural and industrial water supply													

Source: Tennessee Department of Public Health (1978); Alabama Water Improvement Commission

4.0 HYDROLOGIC NETWORKS

4.1 Surface Water

Information on Surface Water Available for 207 Locations

Streamflow data have been collected at 10 sites for more than 30 years and at 4 sites for more than 50 years in Area 21.

Streamflow, water-quality and suspended-sediment data are available for 207 sites in Tennessee and Alabama in Area 21, but all types of data are not necessarily collected at each site (fig. 4.1-1). Ten streamflow sites have been operated for more than 30 years and 4 sites for more than 50 years. The location of each data-collection site, period of operation, type of record, and other pertinent information are included in Section 10.2. In 1979, in response to the Surface Mining Control and Reclamation Act of 1977, the Tennessee and Alabama networks were expanded by 11 and 6 additional sites, respectively.

Streamflow data include:

- continuous records of stages and discharges
- records of flood stages and flood discharges
- measurements of discharge at various stages

Water-quality information is available for 115 sites in Area 21. Water-quality information includes:

- water temperature
- specific conductance
- pH

- dissolved major chemical constituents
- dissolved and total recoverable trace constituents
- trace constituents in bottom material
- suspended-sediment data

Information in addition to that given in section 10.2 can be obtained from U.S. Geological Survey computer files through the National Water Data Exchange (see section 9.0) or from the annual data publications "Water Resources Data for Tennessee" and "Water Resources Data for Alabama", available from:

U.S. Geological Survey
Water Resources Division
A-413 Federal Building - U.S. Courthouse
Nashville, TN 37203

or

U.S. Geological Survey
Water Resources Division
520 19th Avenue
Tuscaloosa, AL 35401

4.0 HYDROLOGIC NETWORKS--Continued

4.2 Ground Water

Ground-Water Data Available for 172 Wells and 65 Springs

Ground-water data include geologic source, water-level measurements, water-quality analyses, and spring discharges.

Water-level, discharge, and water-quality data are available for 172 wells (fig. 4.2-1) and 65 springs (fig. 4.2-2) in Area 21, but all types of data are not necessarily collected at each site. Data are available for one active and 27 inactive wells in the coal-resources area. The location, period, and type of record available for each site are listed in Section 10.3.

Types of information available for wells include:

- geologic source
- periodic or continuous water-level measurements
- water-quality analyses

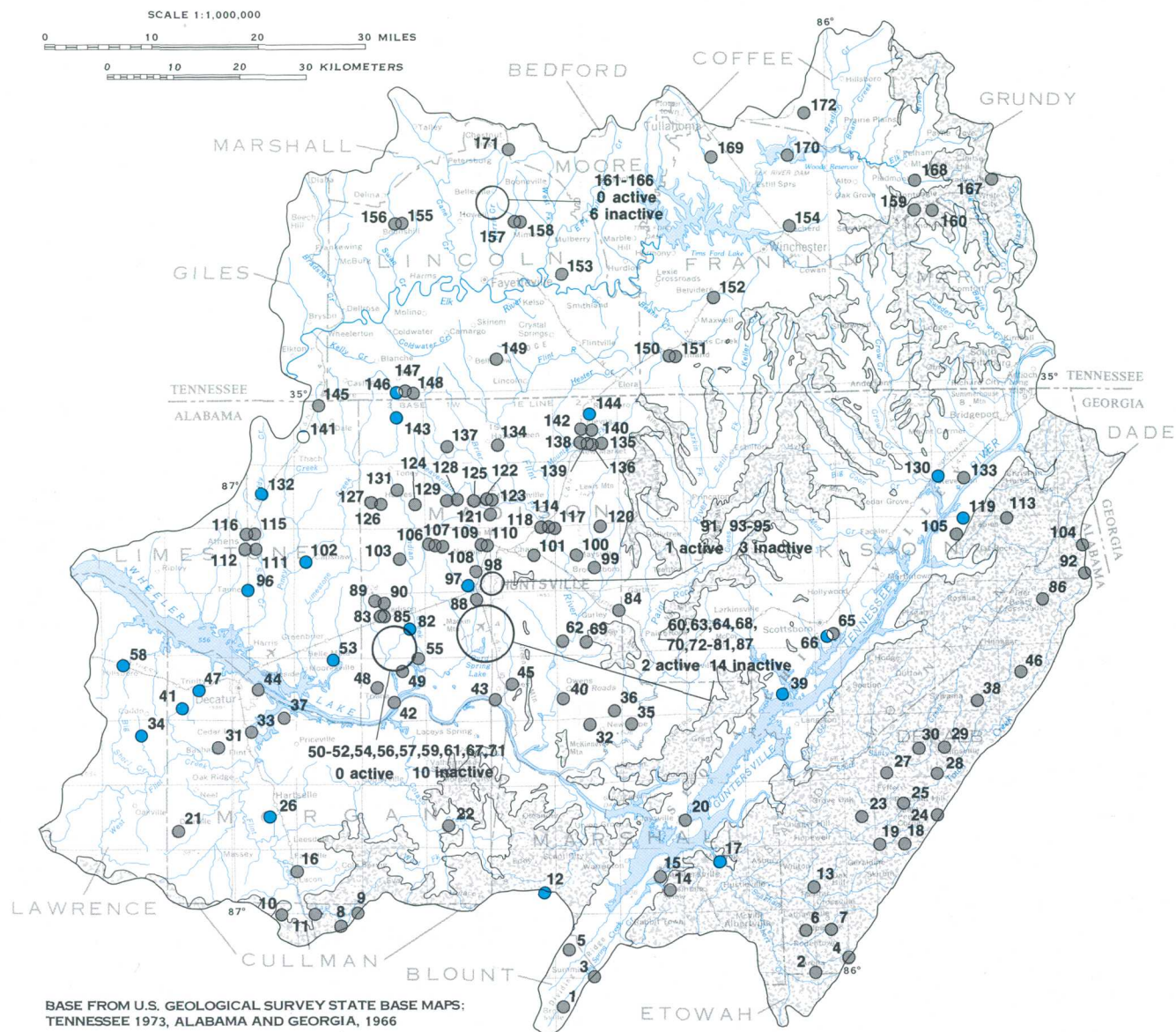
Discharge or water-quality data or both are available

for 65 springs. Site information and data can be obtained from the U.S. Geological Survey computer files through the National Water Data Exchange (see section 9.0) or from the annual data publications "Water Resources Data for Tennessee" and "Water Resources Data for Alabama" available from:

U.S. Geological Survey
Water Resources Division
A-413 Federal Building - U.S. Courthouse
Nashville, TN 37203

or

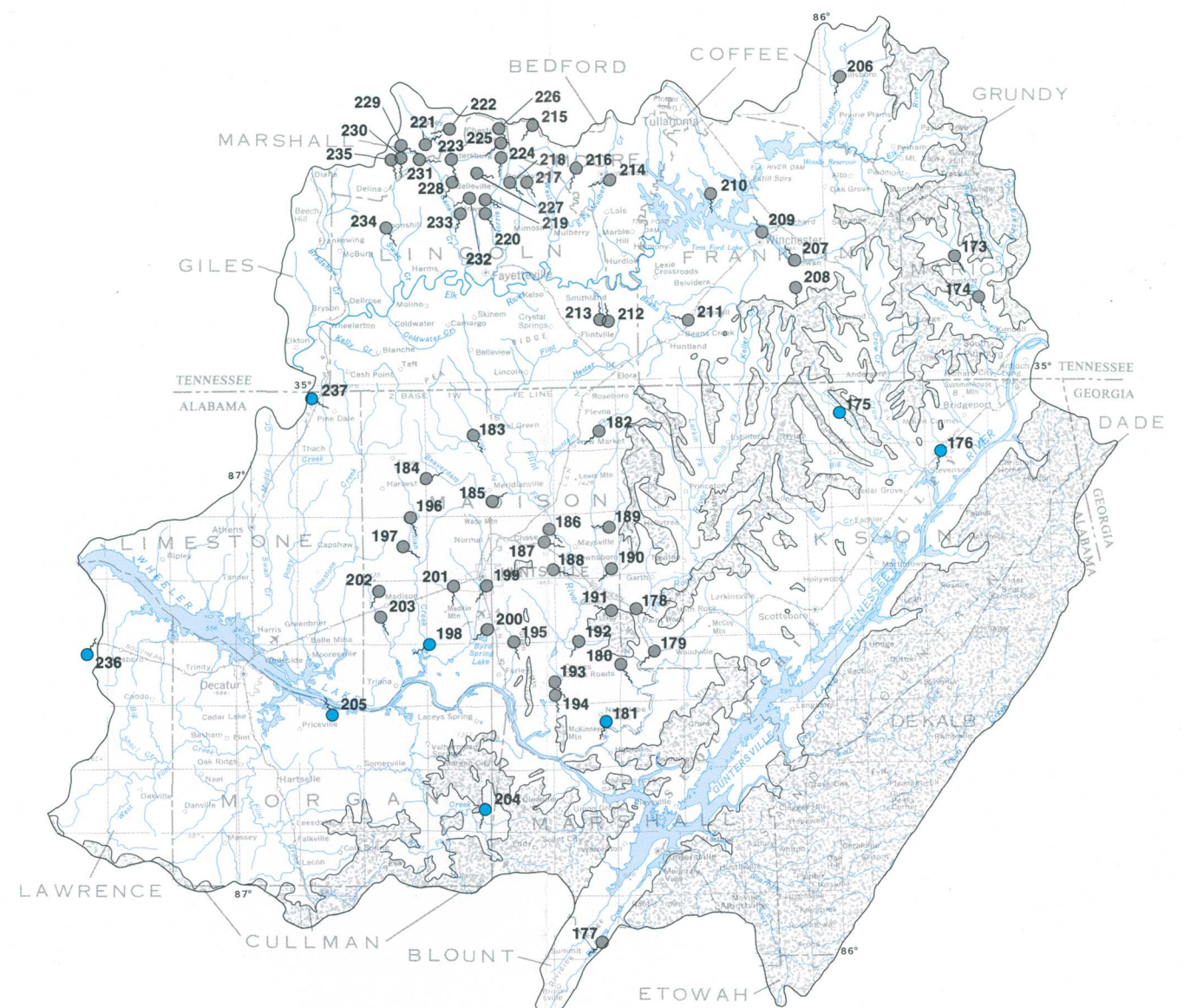
U.S. Geological Survey
Water Resources Division
520 19th Avenue
Tuscaloosa, AL 35401



EXPLANATION

- Active well
- Inactive well
- 113 Well number
See section 10.3 for detailed site description
- Coal-resources area

Figure 4.2-1 Wells.



EXPLANATION

- Active spring and direction of flow
- Inactive spring and direction of flow
- 202 Spring number
See section 10.3 for detailed site description
- Coal-resources area

Figure 4.2-2 Springs.

5.0 SURFACE-WATER QUANTITY

5.1 Streamflow Characteristics

Streamflow Varies with Time and Place

Streamflow fluctuates in a pattern similar to the seasonal variation in rainfall and evapotranspiration and varies between streams because of differences in drainage basin size and other physical characteristics.

Surface water includes the water stored in lakes, ponds, and reservoirs and that flowing in streams. The volume of stored water is relatively stable although there is some seasonal fluctuation. Streamflow, the largest component of surface water, is highly variable with time and place. It is made up of two components; direct runoff that supplies most of the volume of streamflow during flood periods, and base flow from ground-water storage during the periods of no direct runoff. The annual runoff of streams in Area 21 is equal to the average rainfall over their watersheds minus about 30 inches of evapotranspiration (Tennessee Division of Water Resources, 1961). Applying this relation to the average annual precipitation (55 inches), the average annual runoff for streams in Area 21 is approximately 25 inches.

Significant differences in topography and geology along with differences in drainage basin size, contribute to the variability of flow from stream to stream. Streamflow varies in a pattern similar to the seasonal variation in rainfall. Monthly mean discharge as a percentage of the annual mean is shown in figure 5.1-1. This figure illustrates the seasonal fluctuation of streamflow for 18 sites.

The flow variability of Town Creek near Geraldine, Ala. (site 21), during the 1980 water year is typical for the area (fig. 5.1-2). Another way of illustrating flow variability is to compare mean daily flow with the maximum and minimum daily flow for each month of a water year (fig. 5.1-3). The long-term monthly flow variability of Town Creek is illustrated in figure 5.1-4.

Table 5.1-1 Percent of mean annual discharge occurring in indicated month

Site number	Drainage area (mi ²)	Annual mean discharge (ft ³ /s)	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
21	141.0	283.0	2.66	5.96	10.20	15.9	15.3	20.1	13.50	6.50	3.28	3.94	1.13	1.55
24	91.6	187.0	0.41	8.00	10.80	22.1	18.9	17.9	8.76	3.98	2.94	2.93	1.52	1.71
30	320.0	695.0	2.26	5.02	10.70	16.4	18.6	18.9	12.70	6.80	2.73	2.78	1.22	1.87
58	342.0	567.0	3.06	5.08	9.16	15.1	17.0	18.1	11.70	7.36	4.09	4.12	2.65	2.56
74	25,610.0	43,190.0	3.58	5.97	8.98	12.0	13.1	16.0	12.4	9.37	6.06	4.81	4.18	3.56
82	49.0	75.9	8.16	6.44	7.53	12.2	14.1	23.0	13.20	7.39	3.17	2.17	1.20	1.40
106	136.0	281.0	3.19	5.21	11.40	17.0	14.6	19.3	12.50	8.47	1.71	2.51	1.67	2.52
115	119.0	196.0	1.41	4.47	10.70	16.5	20.2	17.6	12.10	6.34	3.26	3.48	2.15	1.92
116	55.8	93.7	1.13	3.17	13.80	14.2	15.2	22.1	11.90	7.97	3.41	3.47	2.52	1.16
117	86.3	147.0	1.25	4.86	10.10	14.9	19.8	18.4	16.60	6.02	2.07	2.78	1.84	1.33
126	65.6	144.0	2.69	6.73	12.00	15.3	15.4	18.0	13.30	8.36	2.79	2.28	1.51	1.60
138	41.3	64.9	0.84	5.45	10.70	15.3	21.6	14.6	13.40	6.69	4.13	4.51	1.71	1.26
139	275.0	478.0	1.62	4.26	9.39	15.3	18.2	17.7	13.20	7.69	4.41	3.50	2.77	2.02
154	55.9	87.4	1.42	3.47	9.23	10.8	15.1	22.4	16.40	11.50	3.29	3.02	2.13	1.25
179	41.2	80.4	1.78	7.20	14.70	14.3	19.6	15.1	14.10	4.40	3.23	2.59	0.44	2.60
181	827.0	1,386.0	1.53	3.58	7.25	17.9	20.4	16.9	12.50	6.59	4.14	4.22	2.75	2.26
192	897.0	1,586.0	3.04	6.77	12.50	10.6	14.4	18.1	12.10	8.84	5.16	3.39	2.95	2.20
203	36.5	58.7	2.09	7.07	13.30	11.0	22.1	20.3	13.00	4.65	2.17	2.14	0.91	1.37

Note: Sum of percentages may not equal 100 due to rounding.

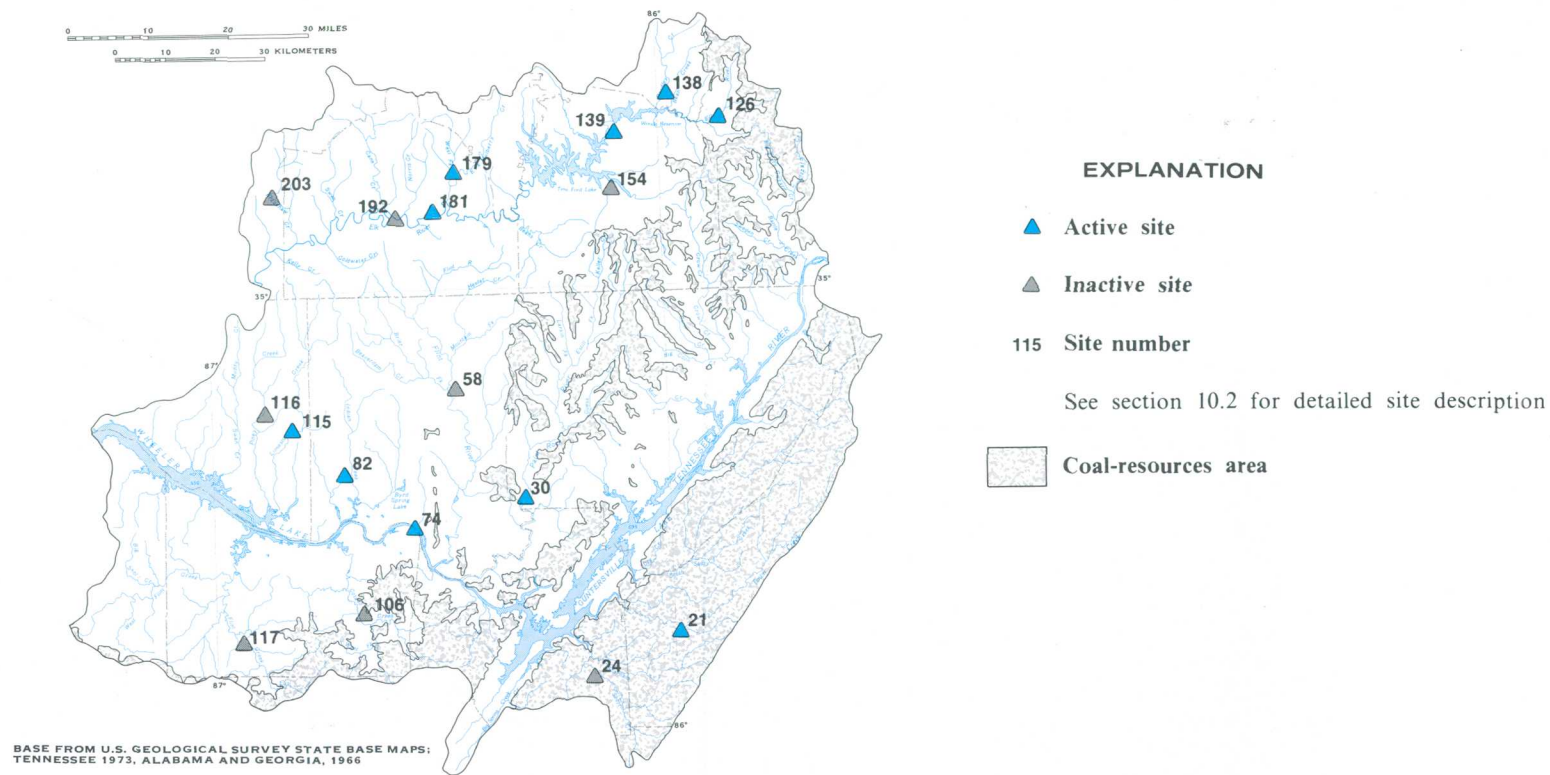


Figure 5.1-1 Location of sites in table 5.1-1.

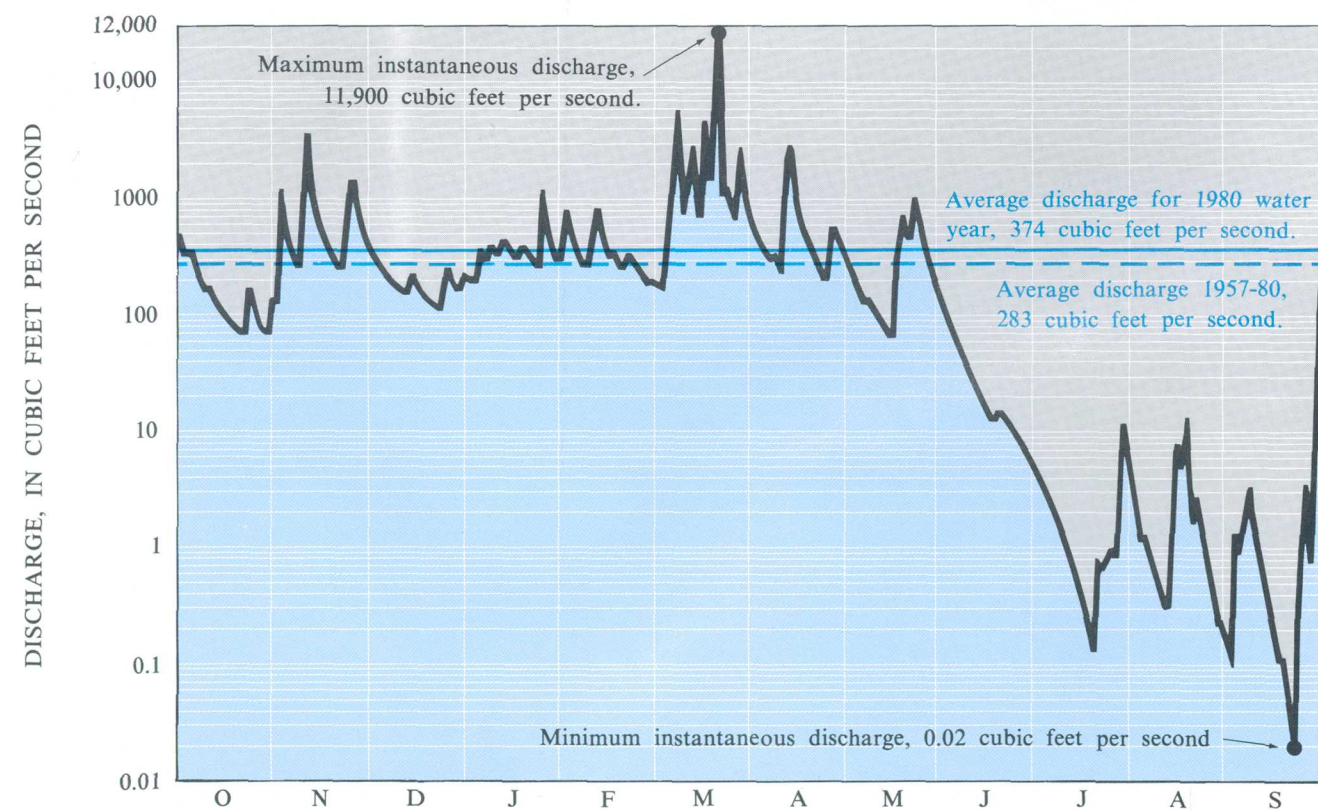


Figure 5.1-2 Discharge hydrograph for Town Creek near Geraldine, Ala. (site 21), for the 1980 water year.

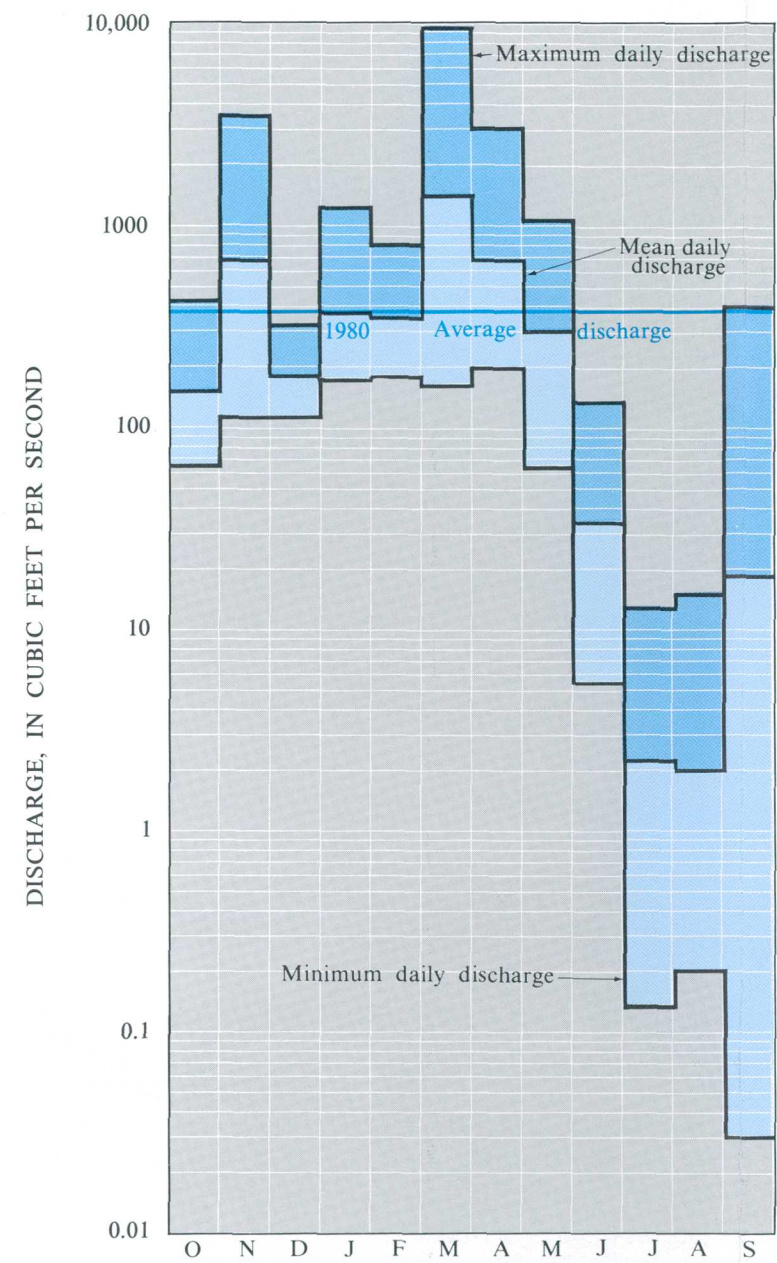


Figure 5.1-3 Range in daily discharge for the 1980 water year, Town Creek near Geraldine, Ala. (site 21).

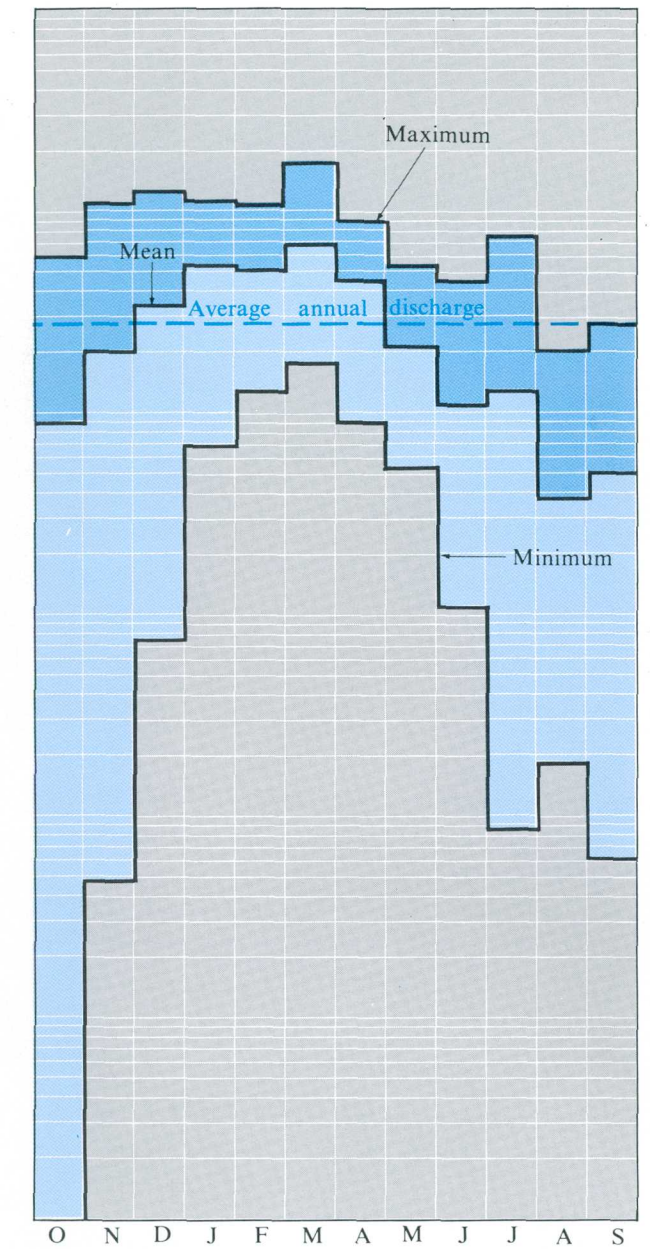


Figure 5.1-4 Range in monthly discharge for the period 1958-80, Town Creek near Geraldine, Ala. (site 21)

5.0 SURFACE-WATER QUANTITY--Continued

5.2 Average Flow

Principal Factor Affecting Average Annual Flow of Streams is Size of the Drainage Basin

Average annual flow ranges from approximately 1.6 to 2.2 cubic feet per second per square mile. The seasonal variability of the mean and maximum monthly flows per square mile is similar but minimum monthly flows per square mile are dissimilar.

The average annual flow in cubic feet per second per square mile provides a direct comparison of flow between streams (fig. 5.2-1). Assuming that differences were not caused by use of varying periods of record, the average annual flow ranges from approximately 1.6 to 2.2 (ft³/s)/mi² (section 10.4). Using a base period of 1958-80, the average flow of four sites ranged from about 1.8 to 2.4 (ft³/s)/mi² (this page). Comparison of data for these four stations shows only small variations in average flows attributable to different periods of record.

In addition to drainage basin size, seasonal variations in rainfall affect monthly flows. The seasonal variability of the mean and maximum monthly flows per square mile is similar even with the varying lengths of available record (fig. 5.2-1 and section 10.4). However, mean monthly minimum flows

indicate variations due to other factors, the most important one being that the geology affects the minimum flow. Flow is not well sustained in some streams because of the poor ability of the underground reservoirs to store and release water to streams.

Site number	Average annual flow (ft ³ /s)/mi ² (1958-80)
21	2.01
30	2.38
58	1.80
126	2.26

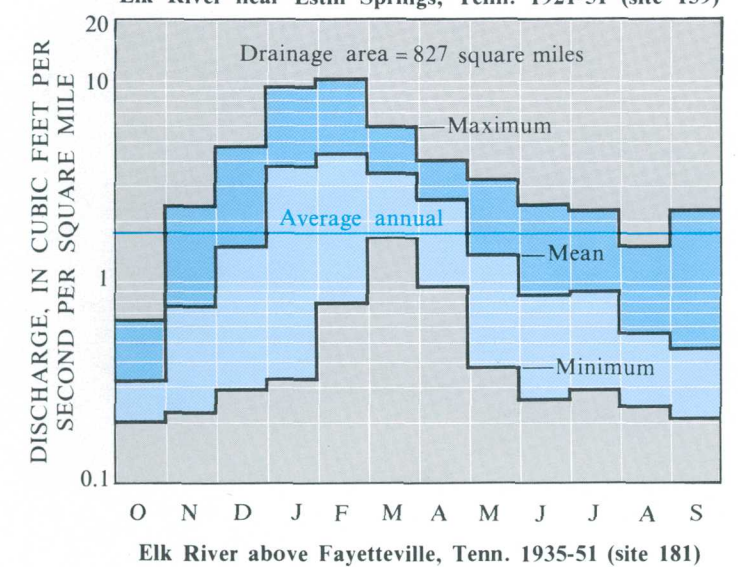
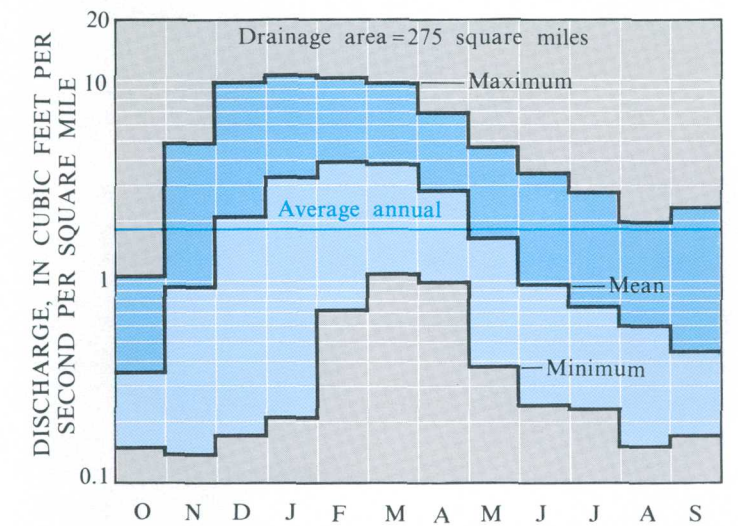
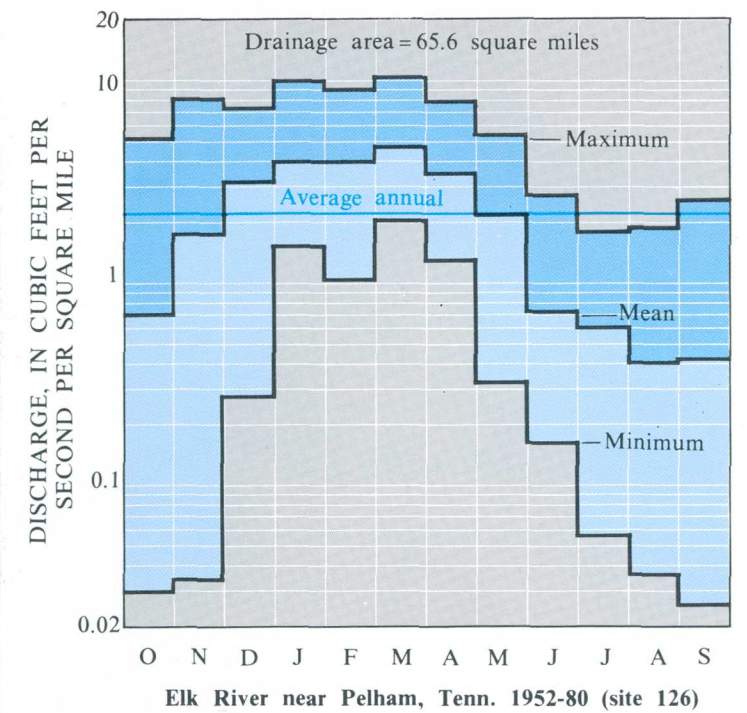
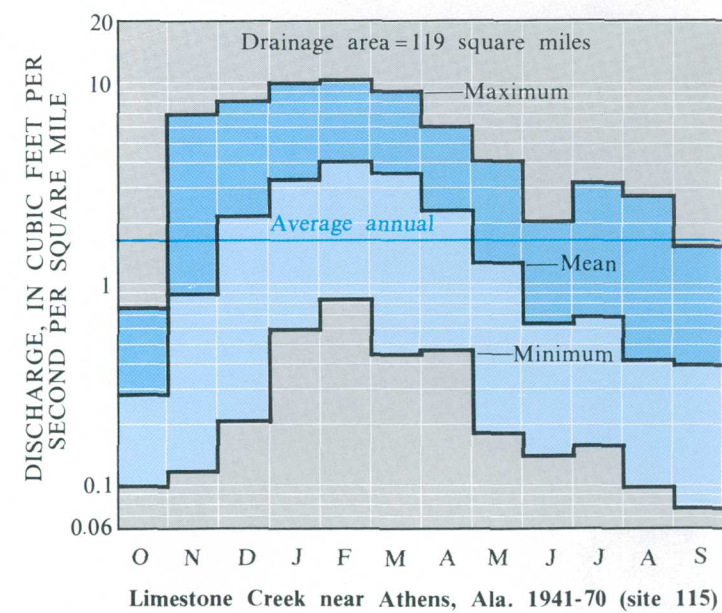
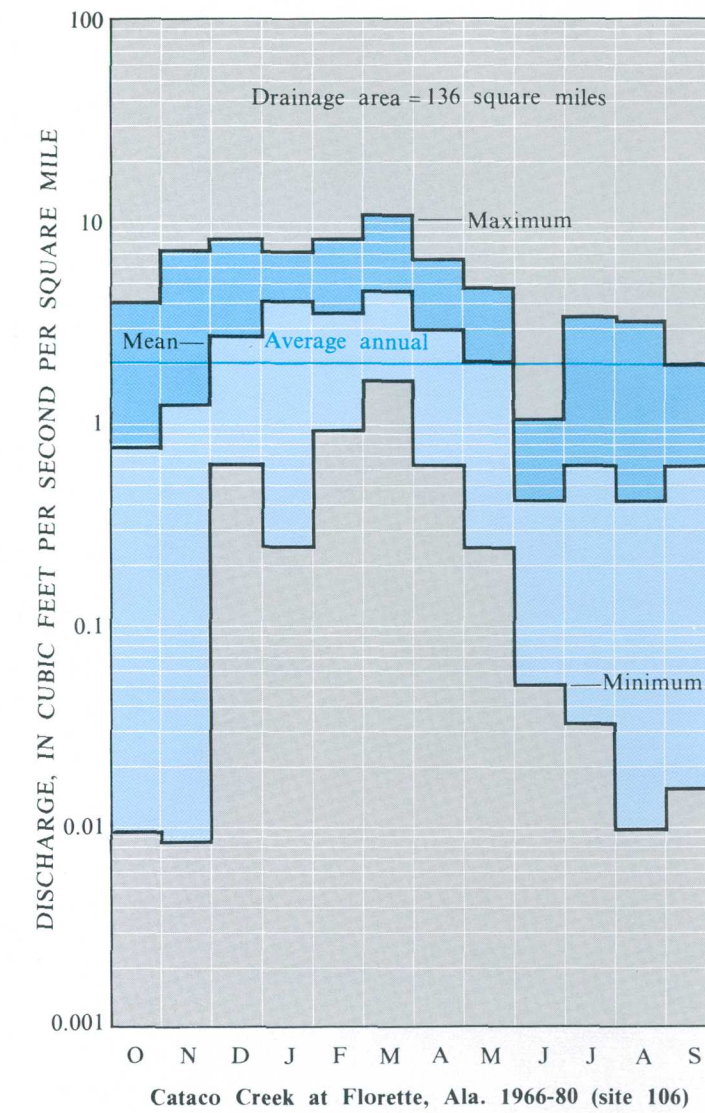
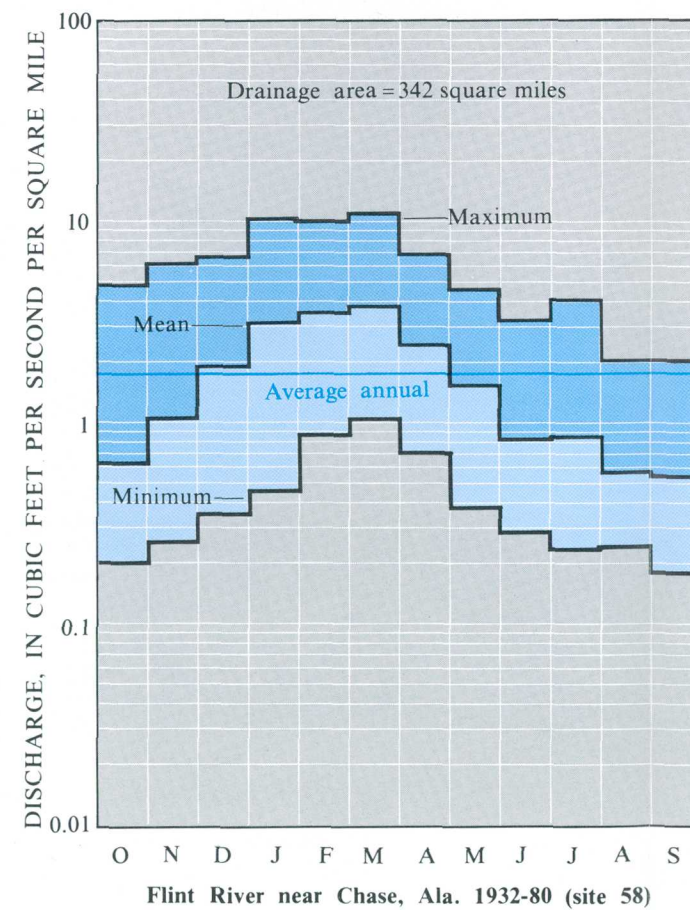
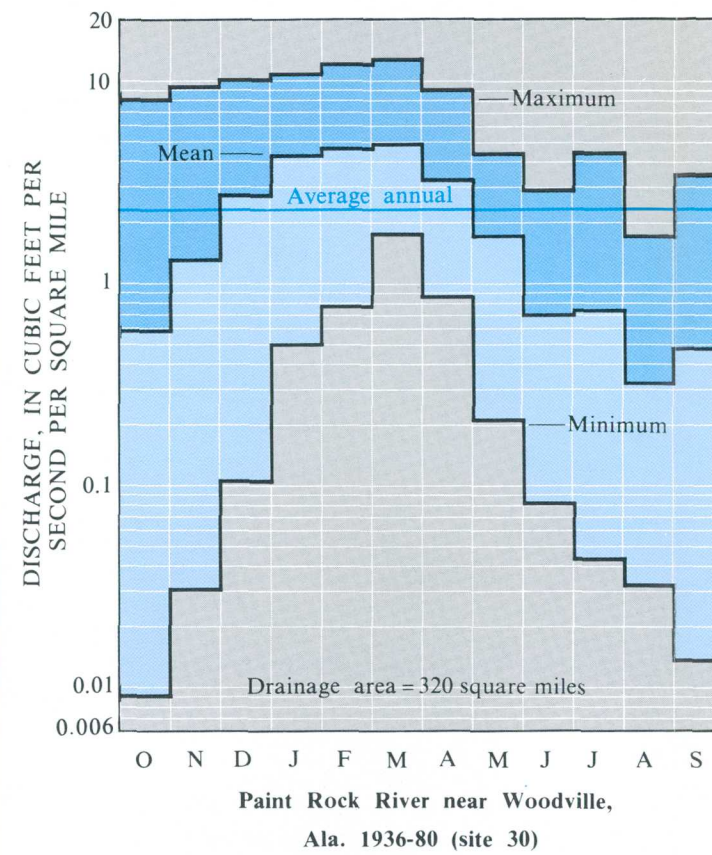
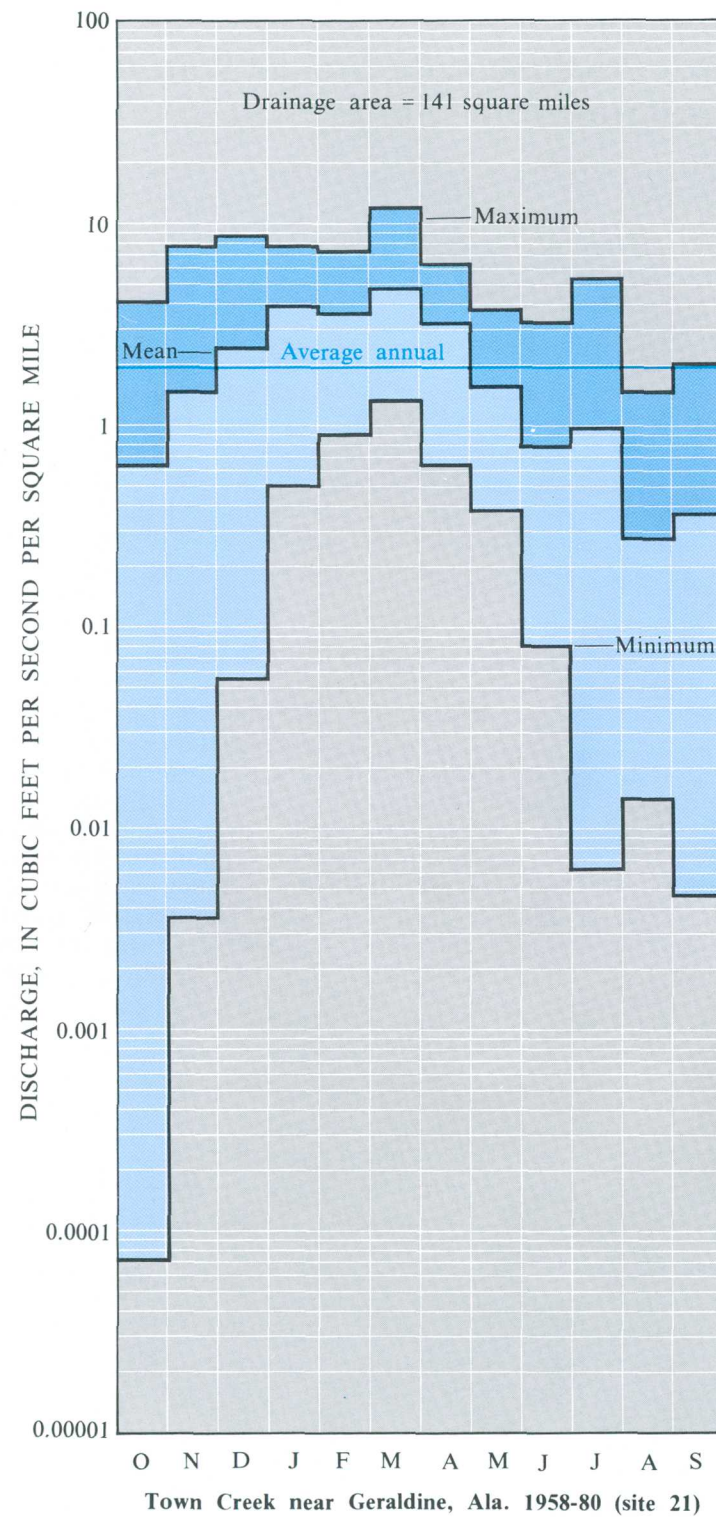


Figure 5.2-1 Average annual and range in monthly mean flow per square mile at selected sites.

5.0 SURFACE-WATER QUANTITY--Continued

5.3 Low Flow

Low Flow in a Stream is Predominantly Ground Water Released from Aquifers

Aquifers in Area 21 vary widely in their ability to provide water to streams during periods of low flow.

Low flow is affected by several factors which are difficult to measure quantitatively. Principle factors are the storage and transmissivity of the aquifers, perviousness of the soil, and the type and density of vegetation. The low flows of streams in the coal-resources area are generally less than for streams elsewhere in Area 21 (table 5.3-1).

Low-flow frequency curves can be derived from continuous-record streamflow data. Low-flow frequency is expressed as the lowest average flow for a given number of consecutive days for a given recurrence interval. The 3-day 20-year low flows are commonly used in Tennessee. Data for selected Tennessee streams are shown in figure 5.3-1. There are many small streams in Area 21 for which the 3-day 20-year low flow is less than one cubic foot per second.

The 7-day 10-year and 7-day 2-year low flows are commonly used in Alabama and are defined using a streamflow recession index, drainage area, and average annual precipitation (Bingham, 1982). The

streamflow-recession index is a measure of the rate of streamflow decline (fig. 5.3-1). The average annual precipitation for Area 21 ranges from 52 to 56 inches and averages about 55 inches. The low flows for ungaged Alabama streams in Area 21 can be estimated from figure 5.3-2 for drainage basins larger than 5 mi² and discharges larger than 0.3 ft³/s for the 7-day 2-year low flow and discharges larger than 0.1 ft³/s for the 7-day 10-year low flow. In the example illustrated for a drainage basin with a streamflow recession index of 140, drainage area of 23 mi², and average annual precipitation of 54 inches, the 7-day 2-year low flow is 8.5 ft³/s and the 7-day 10-year low flow is 4.2 ft³/s. The low flow for sites where parts of the basin have different streamflow-recession indexes should be estimated by applying the entire basin to each streamflow-recession index graph. A weighted average low-flow estimate is computed based on the percentage of the basin draining each area. The graphs in figure 5.3-2 should not be used beyond the ranges shown nor should they be used for streams where activities of man have significantly affected low flow.

Table 5.3-1 Low flows for selected sites

Site number	Station name	Drainage area (mi ²)	Period of record	Recurrence interval		
				3-day 20-year low flow (ft ³ /s)	7-day 10-year low flow (ft ³ /s)	7-day 2-year low flow (ft ³ /s)
21	Town Creek near Geraldine, Ala.	141	1959-80	0.0	0.0	0.8
30	Paint Rock River near Woodville, Ala.	320	1937-80	4.0	5.9	14.9
58	Flint River near Chase, Ala.	342	1932-80	62.5	68.0	85.4
82	Indian Creek near Madison, Ala.	49.0	1961-80	2.8	3.3	5.7
115	Limestone Creek near Athens, Ala.	119	1941-68	9.3	10.8	14.8
126	Elk River near Pelham, Tenn.	65.6	1953-80	1.1	1.5	3.5
138	Bradley Creek near Prairie Plains, Tenn.	41.3	1953-59	3.1	3.3	3.9
154	Boiling Fork Creek above Winchester, Tenn.	55.9	1965-70	2.8	3.3	4.6
179	West Fork Mulberry Creek at Mulberry, Tenn.	41.2	1955-62, 1967-68	0.0	0.0	0.2
203	Bradshaw Creek at Frankewing, Tenn.	36.5	1956-61, 1967-68	0.0	0.0	0.1

(Low-flow discharges computed from Geological Survey data)

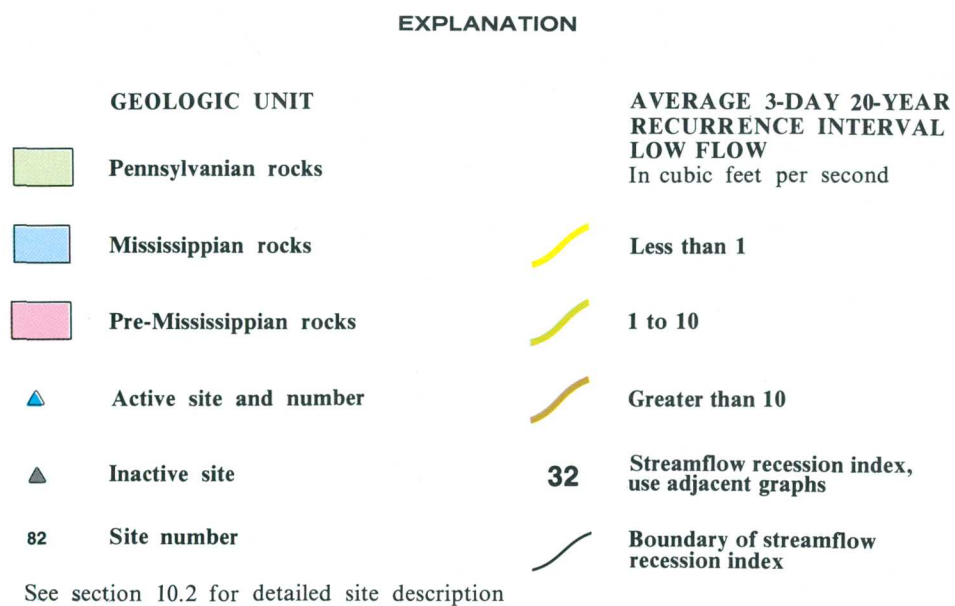
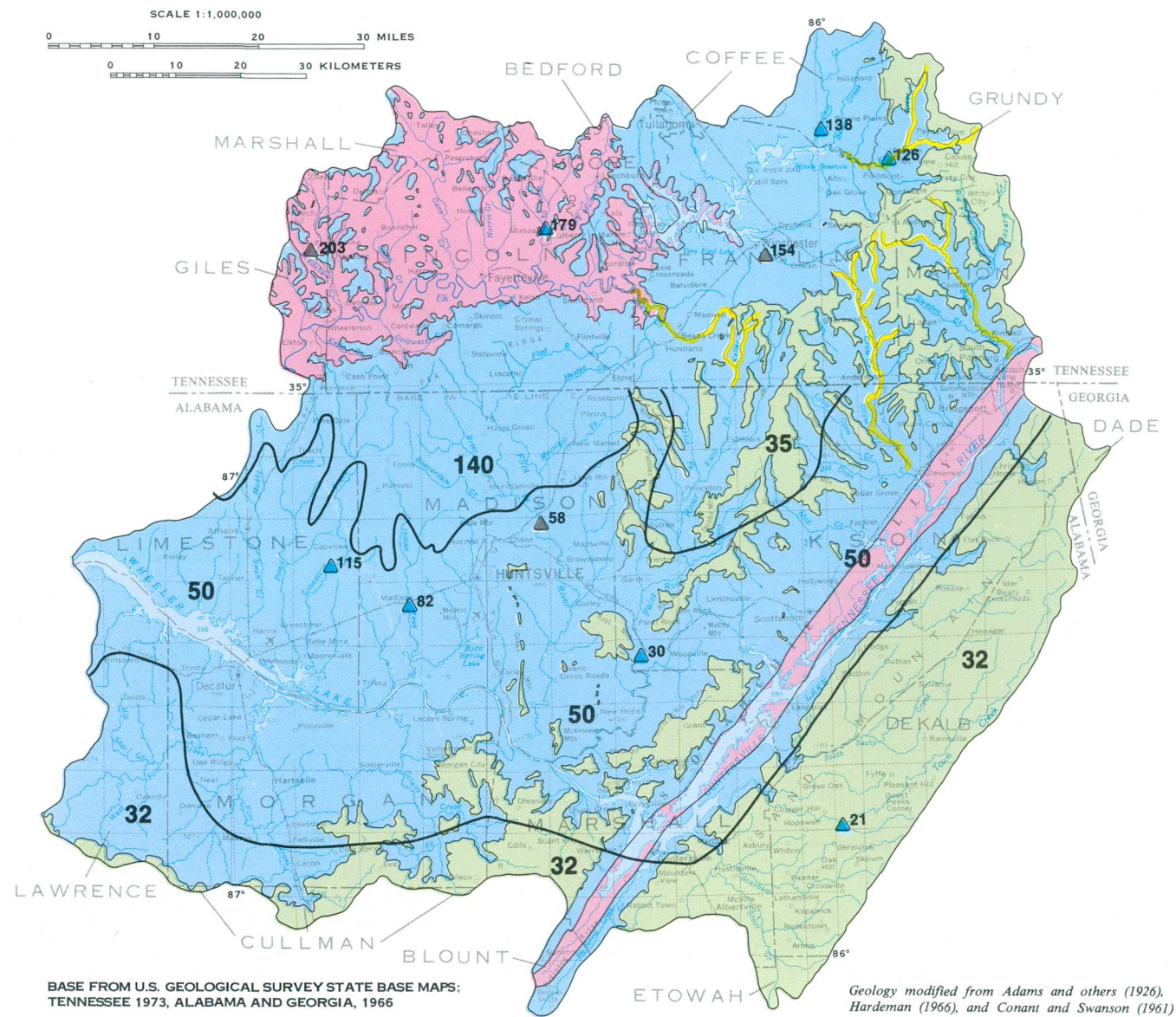


Figure 5.3-1 Generalized low flow of streams in Tennessee, and streamflow recession indexes for Alabama streams.

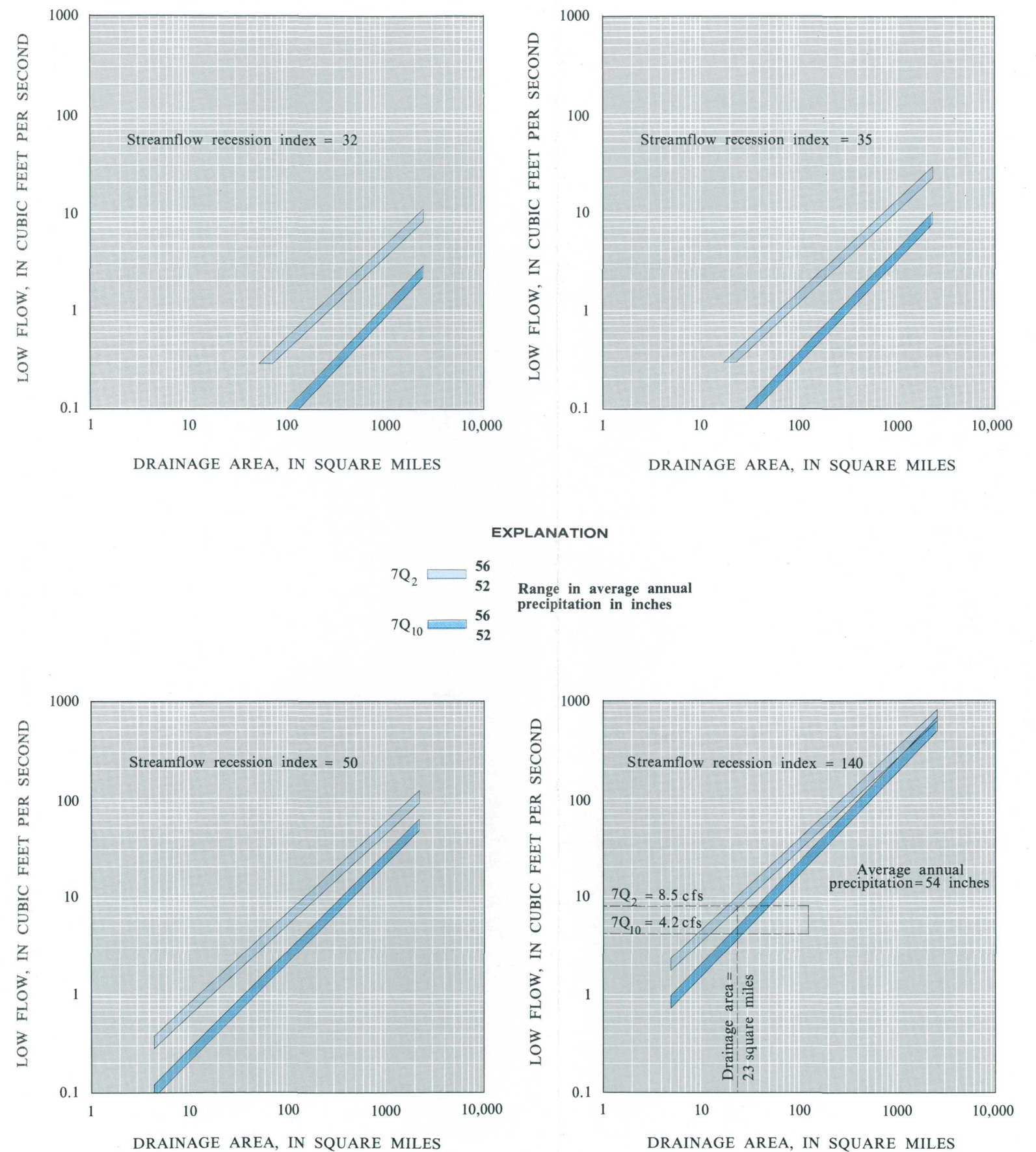


Figure 5.3-2 Graphs for estimating low flow in Alabama streams.

5.0 SURFACE-WATER QUANTITY--Continued

5.4 Floods

5.4.1 Magnitude, Frequency and Seasonal Distribution of Floods

Most Floods Occur During Winter and Spring

About 73 percent of the annual maximum floods occur from December through March. Techniques have been developed for estimating flood magnitude and frequency.

Maximum known floods observed in Area 21 range in magnitude of discharge for a given drainage basin size from about one half to one order of magnitude (fig. 5.4.1-1). For example, for a drainage basin of 3 mi² the range in discharge is from about 800 to about 4,000 ft³/s and for a drainage basin of 100 mi² the range is from about 5,000 to about 45,000 ft³/s. The occurrence of floods is a natural, random phenomenon, and larger floods than those observed can occur at any time.

Floods occur in Area 21 in any month of the year, however, most of the annual peaks occur during the winter and spring months. About 47 percent of the annual peaks occur during February and March and about 73 percent occur during the longer period December through March (fig. 5.4.1-2). Almost 30 percent of the annual peaks occur in March. Only about 4 percent of the annual peaks occur during August through October.

Methods for estimating the flood-frequency characteristics of natural streams in Area 21 are contained in reports for Alabama by Hains (1973)

and Olin and Bingham (1977), and for Tennessee by Randolph and Gamble (1976). Methods and results vary somewhat between these reports. In general, all gaging station records of 10 or more years in length and not significantly affected by manmade changes were analyzed. The results of the analysis generally take the form of equations relating discharge for a given recurrence interval to significant basin characteristics. Recurrence interval is defined as the average interval of time, in years, within which the given flood magnitude will be equaled or exceeded once. For example, a 50-year flood could be expected, on the average, once in 50 years or, stated another way, has a 2-percent chance of occurring in any given year. A 5-year flood is one that has a 20-percent chance of occurring in any given year.

The discharge-frequency relation for ungaged sites where parts of the basin are in different states should be estimated by computing the desired discharge as if the total drainage area lies in each state and weight the discharge on the percentage of drainage area in each state. Various other refinements and adjustments are given in the individual reports.

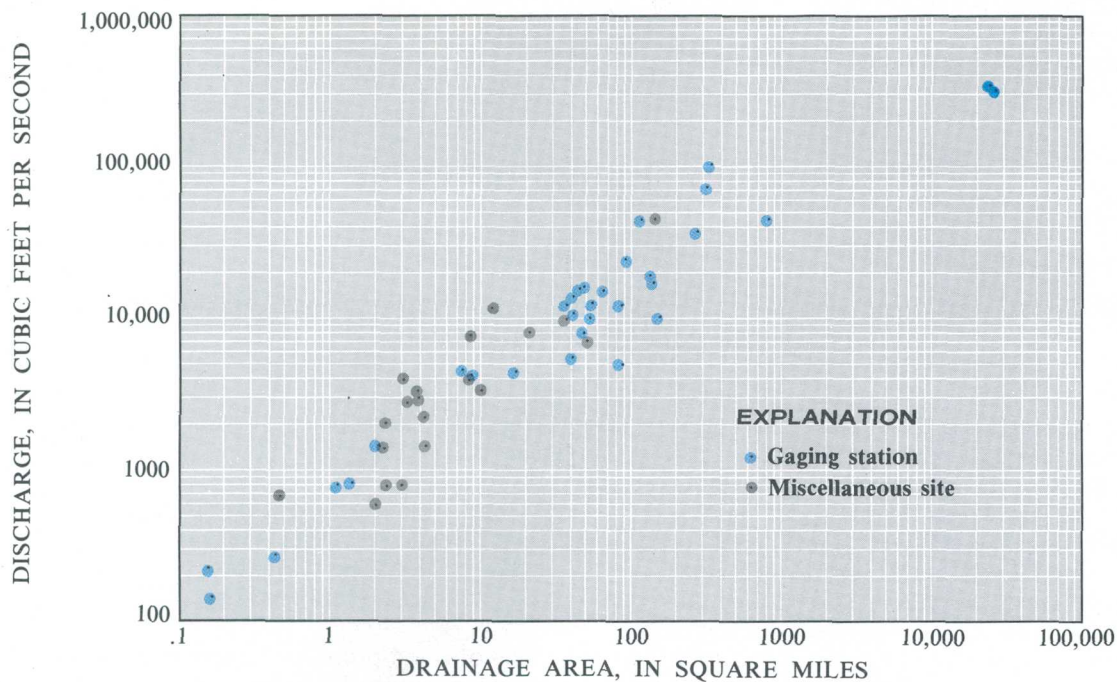


Figure 5.4.1-1 Relation of maximum known floods to drainage basin size.

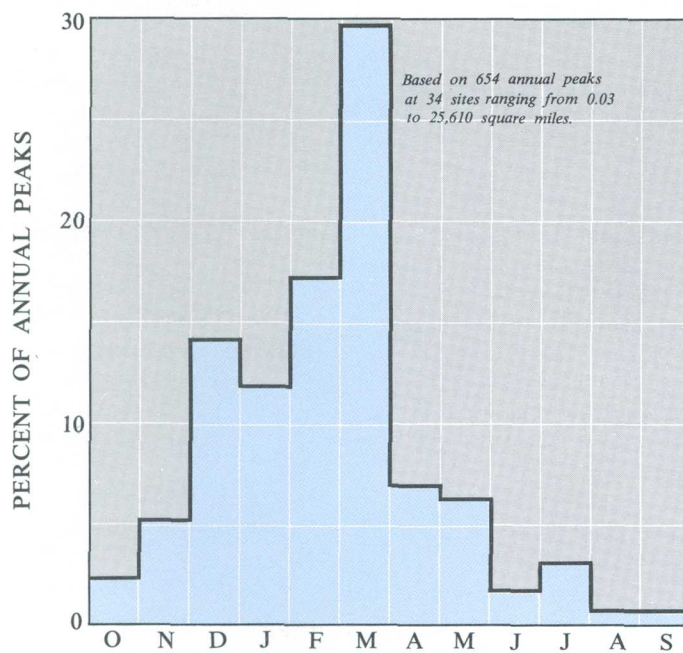


Figure 5.4.1-2 Seasonal distribution of floods.

5.0 SURFACE-WATER QUANTITY--Continued

5.4 Floods

5.4.1 Magnitude, Frequency, and Seasonal Distribution of Floods

5.0 SURFACE-WATER QUANTITY--Continued

5.4 Floods--Continued

5.4.2 Flood Depths and Flood-Prone Areas

100-Year Flood Depths Predictable

Methods for predicting 100-year flood depths are available. Flood-prone area maps are available for selected areas.

Methods were developed by Gamble and Lewis (1977) for Tennessee and by Hains (1976) for Alabama to estimate depth of the 100-year flood on natural streams unaffected by works of man. Equations were derived which relate 100-year flood depth to drainage basin size. Each State was divided into several hydrologic areas. Area 21 is in parts of four of these areas (fig. 5.4.2-1). The equation for computing flood depth for each area is shown along with the basin size limits of application.

The National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973 established programs for identifying towns and streams subject to flood problems and for outlining approximate flood-prone areas on topographic maps using existing information. In 1968, the U.S. Geological Survey began delineating flood-prone areas for the maximum known flood on 7½-minute topographic quadrangle maps. In 1970 it was decided that uniformity of the delineated flood would be preferable, so the 100-year flood was selected for mapping.

The relation between flood depth and drainage area was used in the flood-prone area mapping program to determine 100-year flood depths, where no other data were available. This relation can be used to estimate the depth of the 100-year flood for any purpose where extreme accuracy is not necessary. The location of maps within Area 21 depicting the flood-prone area of the maximum known flood or the 100-year flood is given in figure 5.4.2-2.

The Tennessee Valley Authority also mapped some flood-prone areas in 1973 using the 100-year

flood (fig. 5.4.2-2). Copies of these maps may be obtained from:

Chief, Flood Hazard Analysis Branch
Tennessee Valley Authority
100 Liberty Building
Knoxville, TN 37901

Copies of flood-prone area maps prepared by the Geological Survey may be obtained from:

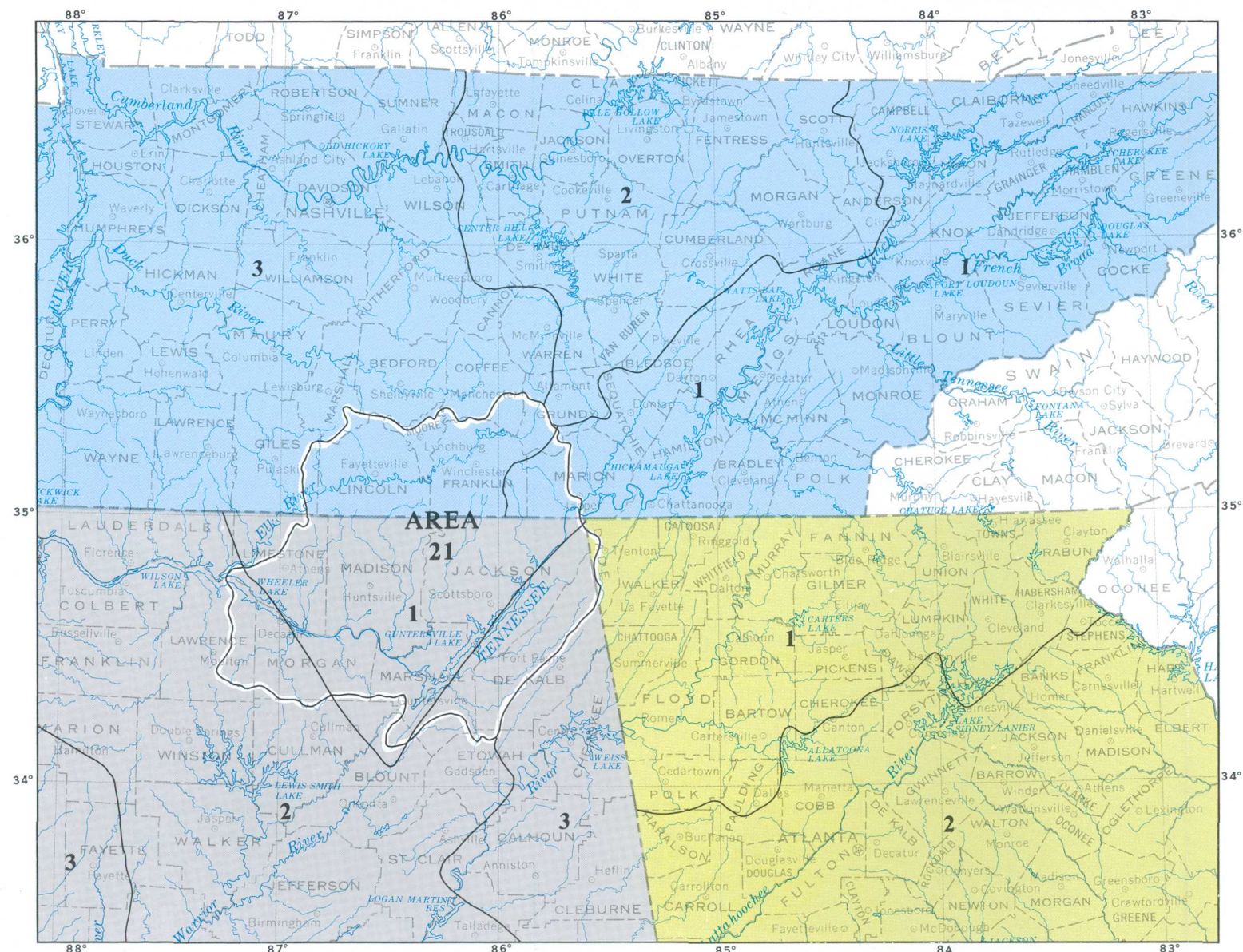
(TENNESSEE MAPS)
U.S. Geological Survey
Water Resources Division
A-413 Federal Building - U.S. Courthouse
Nashville, TN 37203

(ALABAMA MAPS)
U.S. Geological Survey
Water Resources Division
520 19th Avenue
Tuscaloosa, AL 35401

Copies of 7½-minute topographic maps may be purchased from:

(TENNESSEE MAPS)
Tennessee Department of Conservation
Division of Geology
701 Broadway
Nashville, TN 37203

(ALABAMA MAPS)
Geological Survey of Alabama
P.O. Drawer O
University, AL 35486



BASE FROM U.S. GEOLOGICAL SURVEY
UNITED STATES BASE MAP, 1980

EXPLANATION DEPTH OF 100-YEAR FLOOD

TENNESSEE Hydrologic areas, from Gamble and Lewis, 1977

- 1 $5.3(A)^{0.20}$ for drainage areas of 0.36 to 428 square miles
- 2 $7.1(A)^{0.23}$ for drainage areas of 0.49 to 382 square miles
- 3 $6.1(A)^{0.23}$ for drainage areas of 0.17 to 666 square miles

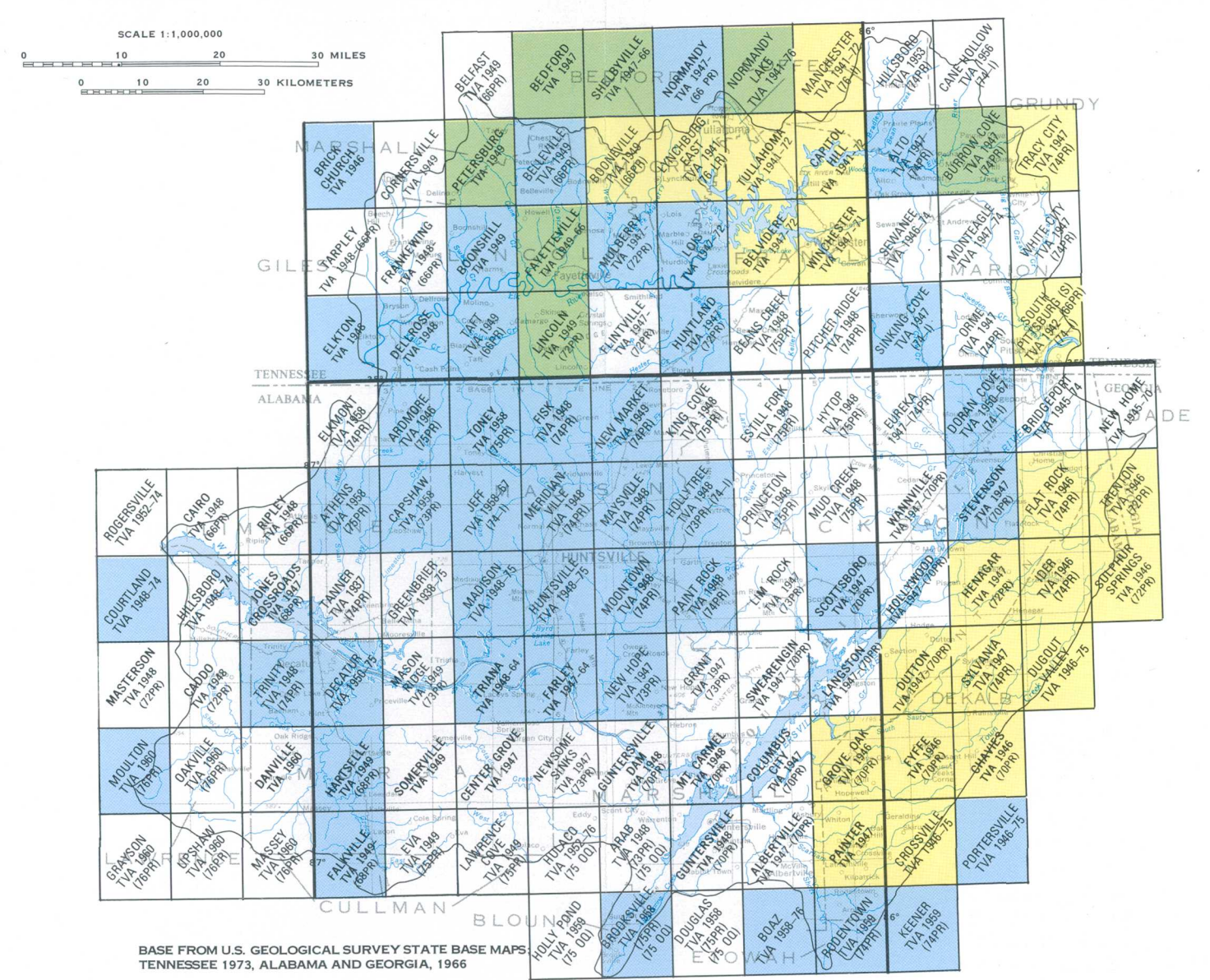
GEORGIA Hydrologic areas, from Price, 1977

- 1 $3.79(A)^{0.32}$ for drainage areas of 1 to 740 square miles
- 2 $6.38(A)^{0.22}$ for drainage areas of 0.39 to 990 square miles

ALABAMA Hydrologic areas, from Hains, 1976

- 1,3 $6.3(A)^{0.20}$ for drainage areas of 1 to 800 square miles
- 2 $9.6(A)^{0.20}$ for drainage areas of 1 to 800 square miles

Figure 5.4.2-1 Hydrologic areas and equations for computing 100-year flood depths.



BASE FROM U.S. GEOLOGICAL SURVEY STATE BASE MAPS
TENNESSEE 1973, ALABAMA AND GEORGIA, 1966

EXPLANATION



7 1/2 minute quadrangle map and name



Mapped by U.S. Geological Survey



Mapped by Tennessee Valley Authority



Mapped by U.S. Geological Survey and
Tennessee Valley Authority

Figure 5.4.2-2 Location and availability of flood-prone area maps.

5.0 SURFACE-WATER QUANTITY--Continued

5.5 Flow Duration

Flow of Some Streams is Poorly Sustained

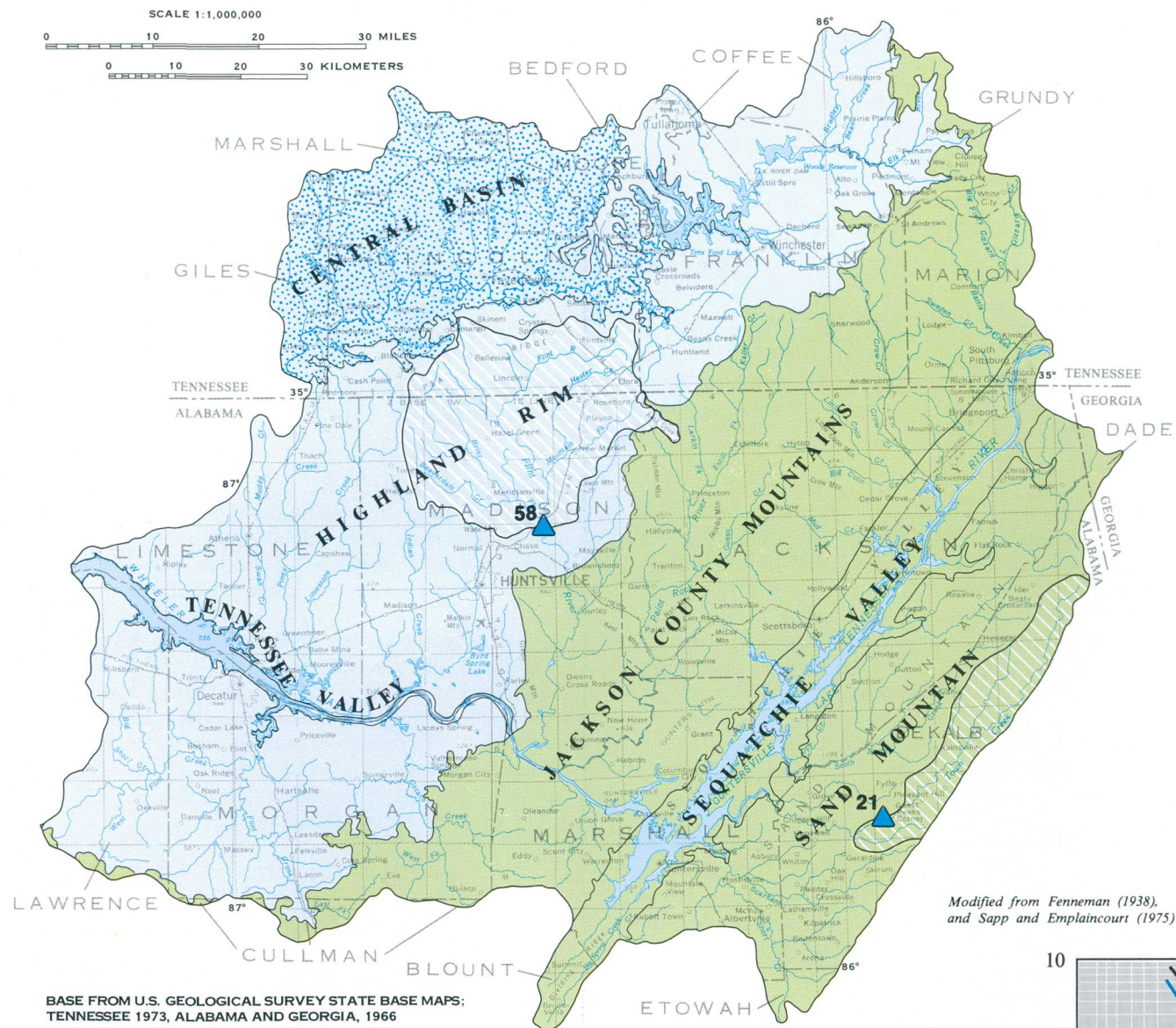
The flow of streams in Area 21 varies with differing water-bearing characteristics of the underlying geologic formations and physiography of the basins.

The streamflow at a given point represents the surface outflow of the drainage basin upstream. Thus, the streamflow record is an integration of the effects of climate, topography, and geology, and gives a distribution of flow both in time and in magnitude. Flows can be arranged according to frequency of occurrence and plotted as a flow-duration curve. The resulting curve shows the effect of the various factors affecting streamflow from that basin and provides a convenient means of comparing the flow of streams. Flow duration data for Alabama streams may be found in Hayes (1978) and for Tennessee in Gold (1980).

The slope of the flow-duration curve for an unregulated stream is a measure of that stream's variability of flow and is indicative of the underground storage and yield capabilities of the drainage basin. A steep slope indicates highly variable flow and poor storage and yield capabilities whereas a flat

slope indicates more uniform flow caused by large underground storage and uniform yield capability.

Differences in streamflow at two sites are illustrated by flow-duration curves (fig. 5.5-1). These curves are based on the same period of record (1958-80) and are plotted in unit discharge so that more direct comparison can be made. The streams shown represent basins of different geologic and physiographic characteristics (figs. 5.5-2 and 5.5-3). The low, poorly sustained discharge of Town Creek near Geraldine, Ala. (site 21), during dry periods is shown by the steep slope of the curve. The curve for Flint River near Chase, Ala. (site 58), has a flatter slope on the lower end indicating better yield and well sustained discharge from the ground-water system of that basin. The upper ends of both curves have similar slopes and are relatively close together indicating that the high-flow runoff per square mile from the two basins is much less affected by geologic and physiographic differences.



- EXPLANATION**
- Central Basin section**
Interior Low Plateaus province
 - Highland Rim section**
Interior Low Plateaus province
 - Cumberland Plateau section**
Appalachian Plateaus province
 - 21** **Site and number**
See section 10.2 for detailed site description

Figure 5.5-2 Location of selected basins in relation to physiography.

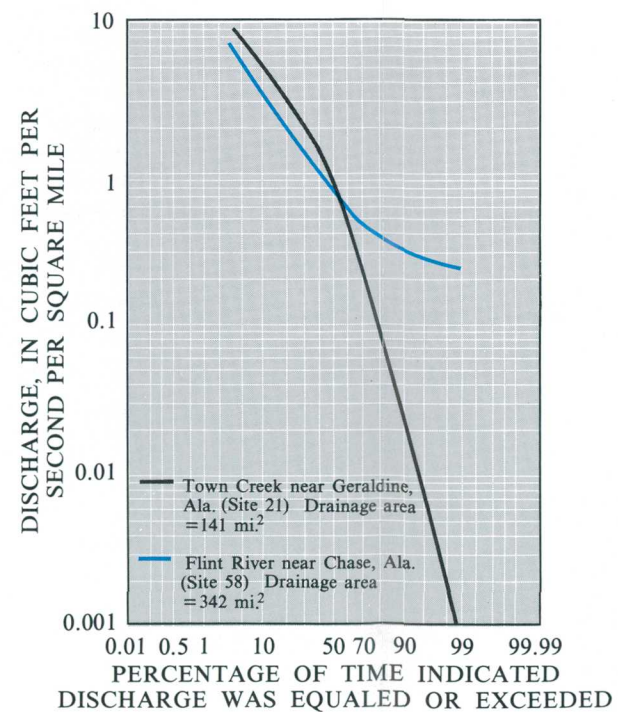
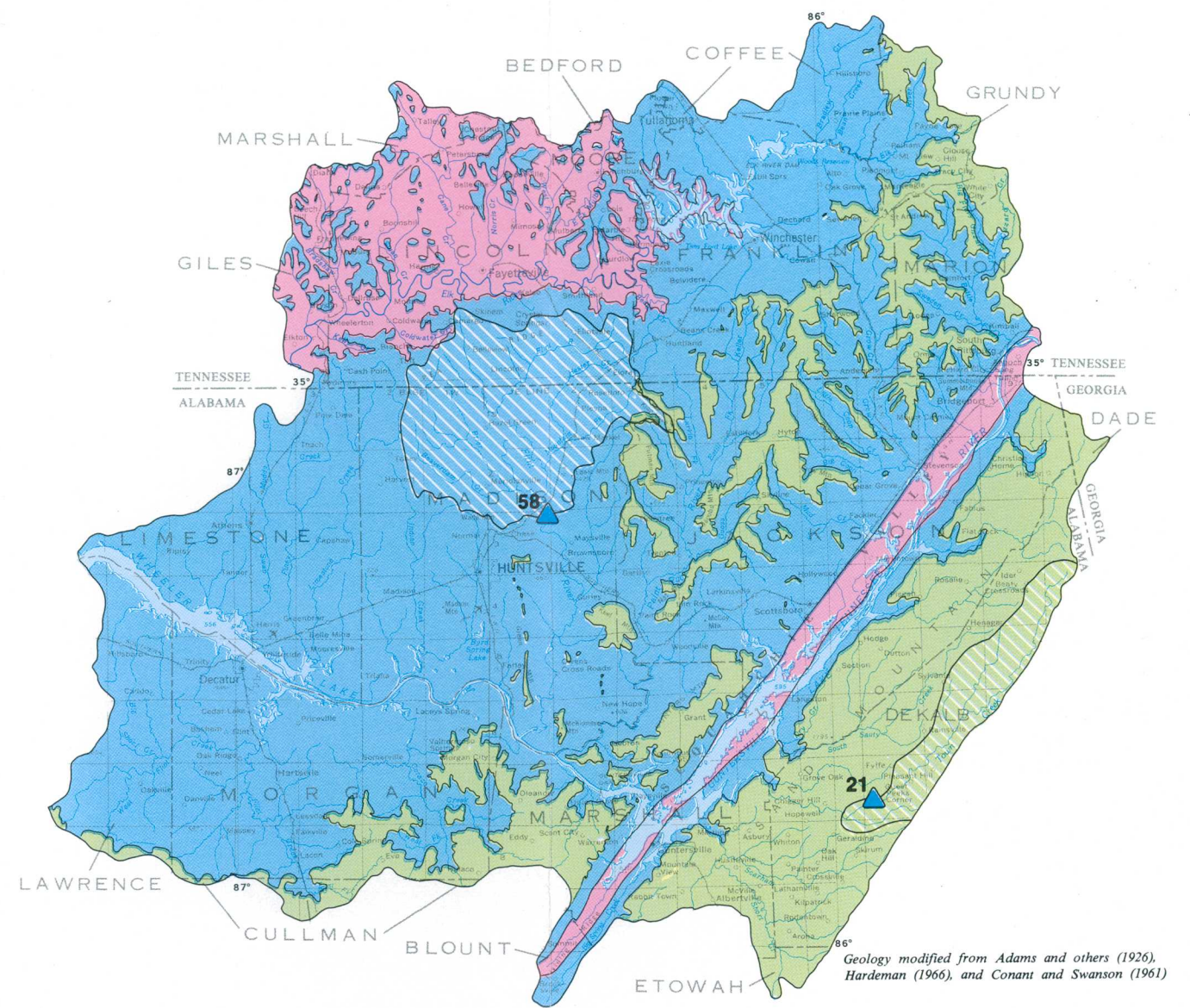


Figure 5.5-1 Selected flow-duration curves for base period 1958-80.



- EXPLANATION**
- Pennsylvanian rocks (Pottsville Formation)**
Sandstone, conglomerate, shale, siltstone, underclay, and coal
 - Mississippian rocks**
Limestone, siltstone, shale, and chert
 - Pre-Mississippian rocks**
Limestone, mudstone, and dolomite
 - 21** **Site and number**
See section 10.2 for detailed site description

Figure 5.5-3 Location of selected basins in relation to geology.

6.0 QUALITY OF SURFACE WATER

6.1 Introduction

Impacts on the Environment May Be Indicated by Water-Quality Data

Effects of surface coal-mining activities on the hydrologic environment often can be evaluated by using water-quality data.

Beginning in 1979 in response to the Surface Mining Control and Reclamation Act of 1977, the U.S. Geological Survey established a network of 17 data-collection sites in Area 21. Water-quality data were being collected at 11 other sites in the area in 1979. The water-quality data collected at the 28 sites, as well as data previously collected at 34 sites through other programs, are presented in this report (fig. 6.1-1). Miscellaneous data, usually only one analysis per site, are available for 53 additional sites (section 10.2), but these data were not used in this report. Several important points regarding all data presented should be considered:

- The term "quality" is not precise. The quality of water from any source cannot be defined unless the intended use is considered. The use itself, in fact, probably has the greatest effect on the determination of the suitability of water. For example, water unsuitable for drinking may be adequate for use in mining operations.

- Locally severe water-quality problems may exist and not be detected, because no mine drainage or seepage or other point source of possible water pollution was purposely sampled.

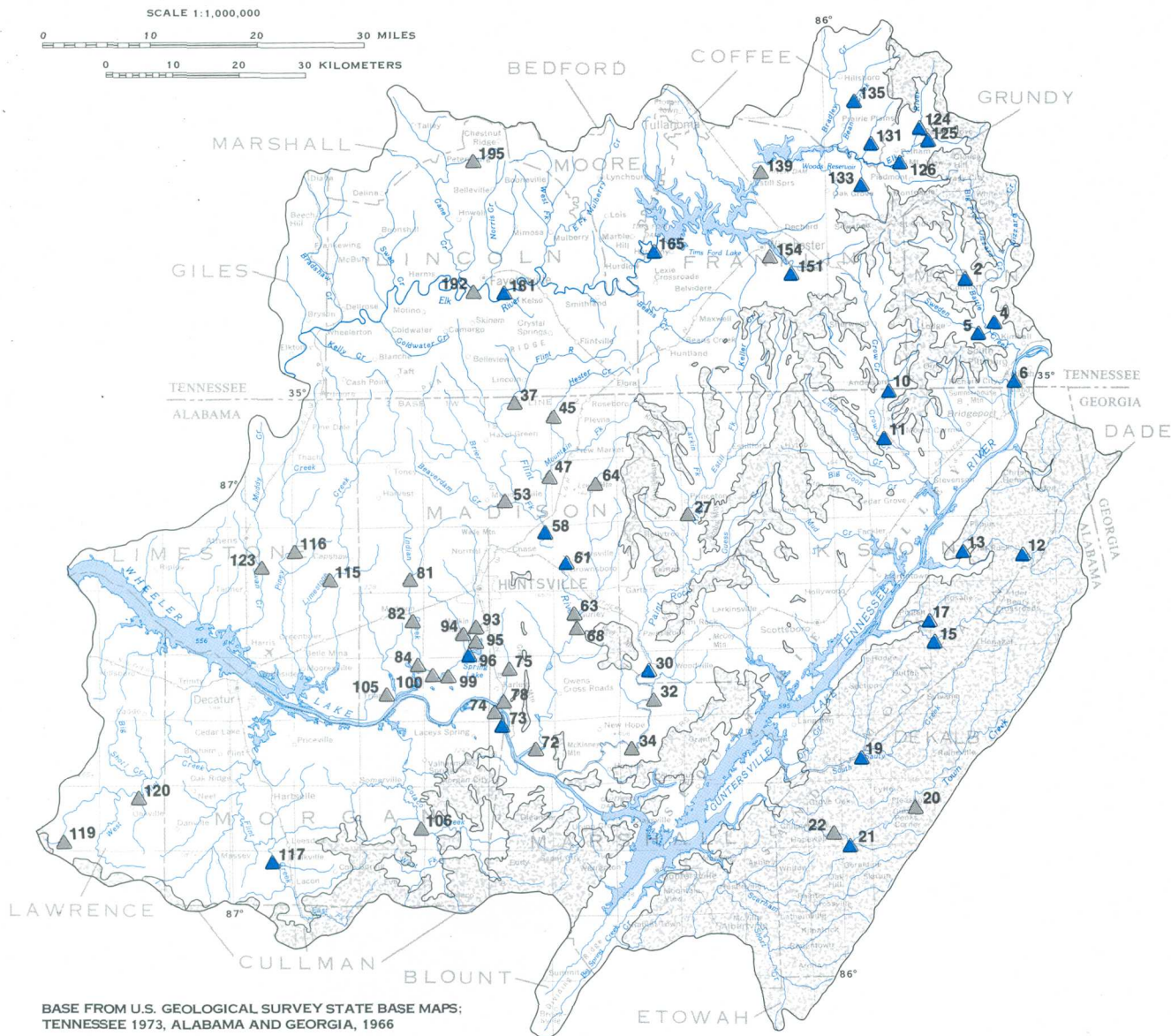
- Methodology and instrumentation affecting the determination of water-quality parameters have

changed significantly over the years. Some of the most important changes involve parameters such as iron, manganese, and trace constituents. For this reason, water-quality data collected at sites active during 1979-80 have been emphasized.

- The water-quality data collected at the 17 sites established or reactivated in 1979 include those parameters specified in the Act. Although additional factors concerning the limitations are specified, the basic allowable ranges or maximums in mine effluents are as follows:

- pH range from 6.0 to 9.0
- total manganese concentration, 4,000 $\mu\text{g/L}$
- total iron concentration, 7,000 $\mu\text{g/L}$
- total suspended-solids concentration, 70 mg/L .

Sufficient data to define seasonal water-quality variations are required by various sections of the Act. Therefore, additional chemical, physical, and biological data were collected at selected sites. Samples were collected over a range of streamflows. Samples for trace constituents in bottom material from stream channels were collected at low flow.



EXPLANATION

▲ Active site

▲ Inactive site

120 Site number

See section 10.2 for detailed site description



Coal-resources area

Figure 6.1-1 Sites for which water-quality data are available.

6.0 QUALITY OF SURFACE WATER--Continued

6.2 Specific Conductance and Dissolved Solids

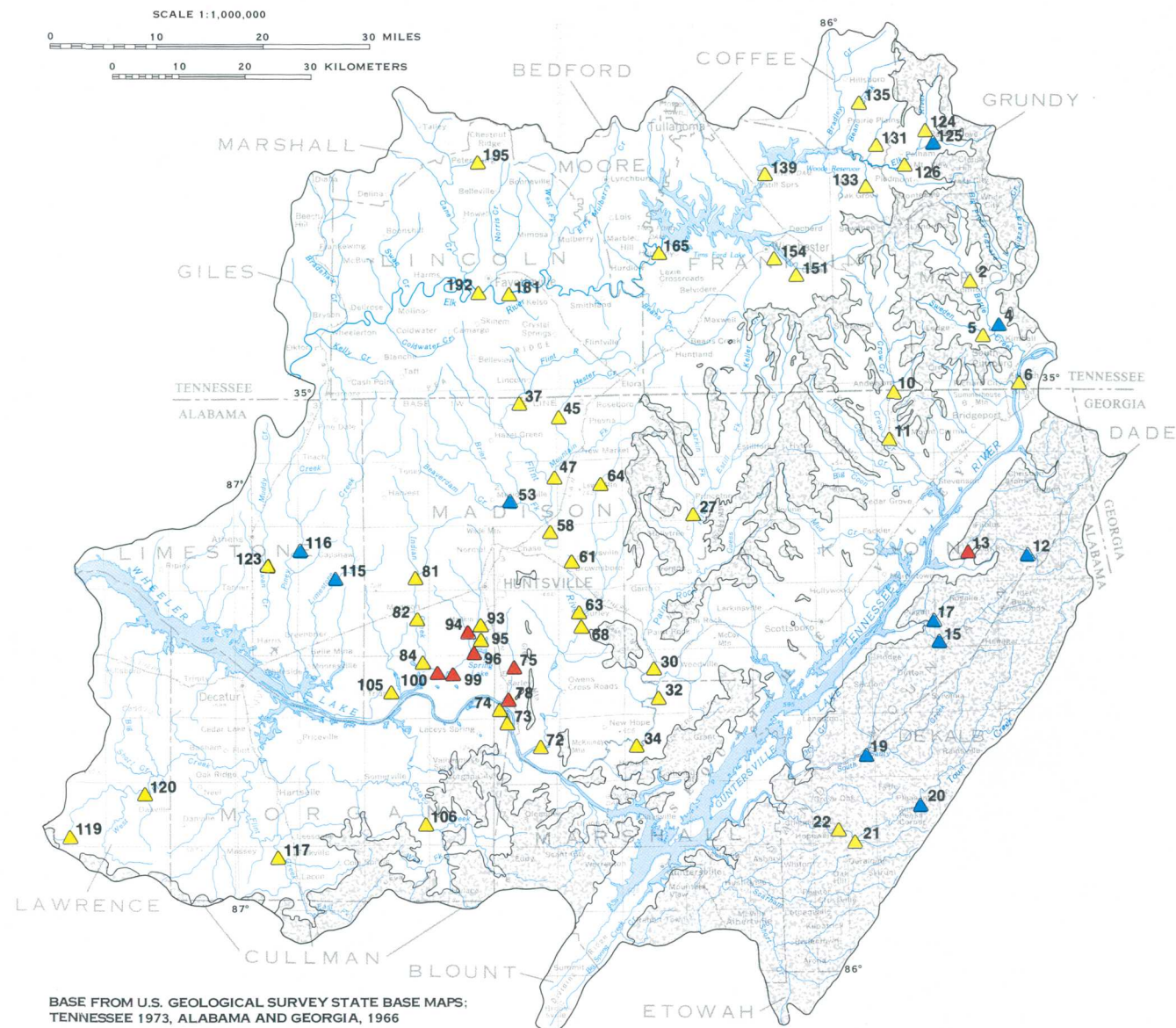
Specific Conductance and Dissolved Solids Were Generally Low

Specific conductance of water at most sites was less than 400 micromhos; dissolved-solids concentrations were generally less than 250 milligrams per liter.

Specific conductance values are not included in any of the commonly used water-quality criteria, but can be used to estimate dissolved-solids and individual constituent concentrations which have specific limits. An estimate of dissolved solids concentrations can be obtained by multiplying specific conductance values by a factor. The factor can range from about 0.54 to 0.96 depending on the relative concentrations of major constituents, but for most waters it is between 0.55 and 0.75 (Hem, 1970). For most streams in Area 21, the average ratio of dissolved solids concentrations to specific conductance is 0.54 as determined by a comparison of dissolved solids and specific conductance data for 62 sites (figs. 6.2-1

and 6.2-2). Thus, based on currently available surface-water data, dissolved-solids concentrations are generally less than 250 mg/L which is low by most criteria.

Specific conductance ranged from 28 to 5,850 $\mu\text{mho/cm}$ (table 6.2-1) with the maximum occurring in a drainage ditch from a landfill near Huntsville, Ala. (site 94). The maximum specific conductance in the coal-resources area, 880 $\mu\text{mho/cm}$, occurred in Dry Creek near Fabius, Ala. (site 13). The maximum values at most sites active in 1979-81 were less than 400 $\mu\text{mho/cm}$.



EXPLANATION

Maximum specific conductance

- ▲ Less than 100 micromhos
- ▲ 100 to 400 micromhos
- ▲ Greater than 400 micromhos

15 Site number

See section 10.2 for detailed site description

Coal-resources area

Figure 6.2-2 Specific conductance.

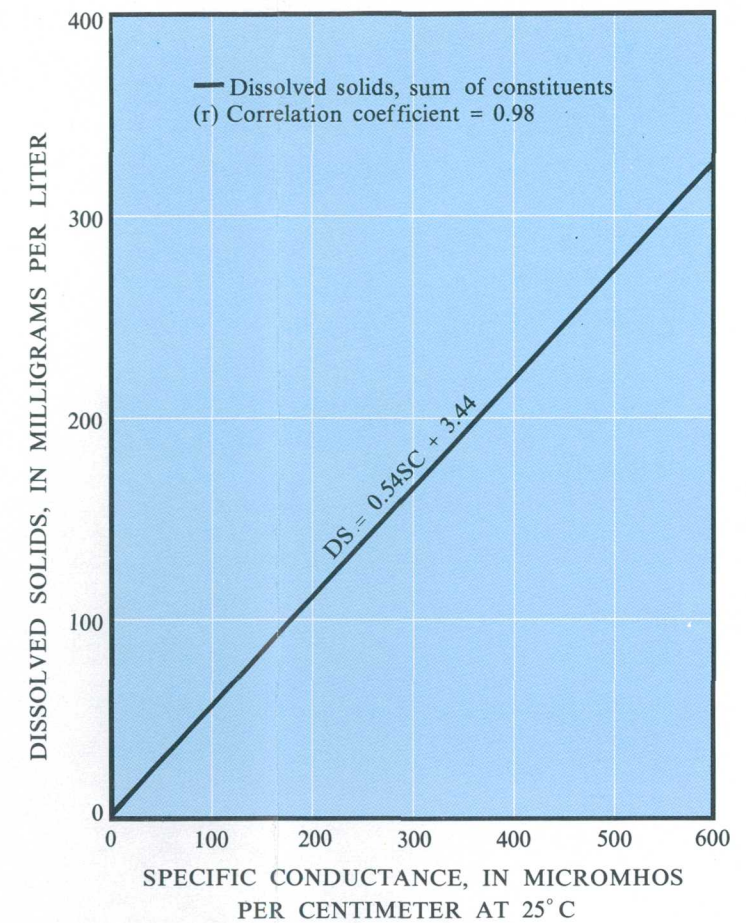


Figure 6.2-1 Specific conductance and dissolved solids are related.

See section 10.2 for detailed site description

Table 6.2-1 Specific conductance, in micromhos per centimeter at 25°C

Sites active in 1979-81									
Site no.	Minimum	Maximum	Median	No. of determinations	Site no.	Minimum	Maximum	Median	No. of determinations
2	122	270	145	6	73	130	212	164	34
4	---	---	---	1	96	127	680	367	58
5	123	240	165	8	106	80	385	155	128
6	110	225	160	82	117	70	306	150	60
10	155	250	201	6	124	58	158	96	24
11	170	315	216	36	125	74	88	---	2
12	38	60	42	6	126	90	320	176	58
13	270	880	446	6	131	177	384	202	6
15	34	67	44	9	133	170	232	188	6
17	---	---	---	1	135	190	300	240	5
19	41	77	61	5	151	220	370	300	6
21	31	135	50	144	165	110	260	160	49
30	120	385	246	120	181	120	360	200	52
58	55	172	122	152					
61	100	188	136	74					

Other sites									
Site no.	Minimum	Maximum	Median	No. of determinations	Site no.	Minimum	Maximum	Median	No. of determinations
20	40	62	50	11	82	38	195	150	84
22	45	100	51	9	84	86	231	210	4
27	220	303	250	7	93	138	315	263	34
32	182	335	263	13	94	300	5,850	2,660	12
34	263	310	274	4	95	128	325	252	28
37	55	103	74	9	99	232	459	387	10
45	41	124	49	10	100	212	408	329	8
47	152	229	184	10	105	126	235	172	10
53	56	92	70	10	115	29	95	75	45
63	131	174	138	8	116	58	85	62	50
64	383	387	---	2	119	150	350	242	16
68	125	170	137	6	120	152	349	280	25
72	128	200	144	6	123	62	392	115	17
74	141	240	180	20	139	89	200	150	77
75	132	468	383	33	154	188	300	265	11
78	475	550	519	4	192	150	240	200	12
81	154	166	---	2	195	310	372	342	8

6.0 QUALITY OF SURFACE WATER--Continued

6.3 Dissolved Sulfate

Dissolved Sulfate Concentrations Generally Low

Maximum dissolved sulfate concentrations were less than 20 milligrams per liter in water at 75 percent of the sites.

High dissolved sulfate concentrations often occur in streams adversely affected by acid-mine drainage due to the weathering of sulfur minerals in coal-mine spoil piles. To some extent, the chemical composition of the spoil piles determines the magnitude of the effect. Dissolved sulfate concentrations ranged from 0.0 to 450 mg/L in water from streams in Area 21 (fig. 6.3-1 and table 6.3-1). Concentrations ranged from 110 mg/L to 450 mg/L in Dry Creek near Fabius, Ala. (site 13), a site located in the coal-resources area. No other site in Area 21 had water with any dissolved sulfate concentration greater than 53 mg/L. The maximum dissolved sulfate

concentration was less than 20 mg/L at about 75 percent of the sites.

Dissolved sulfate concentrations in most streams were generally higher during low flow. However, differences caused by variations in flow were generally small. An estimate of dissolved sulfate concentrations frequently can be obtained using specific conductance data, but in Area 21 no statistically significant relation between sulfate and conductance has been established.

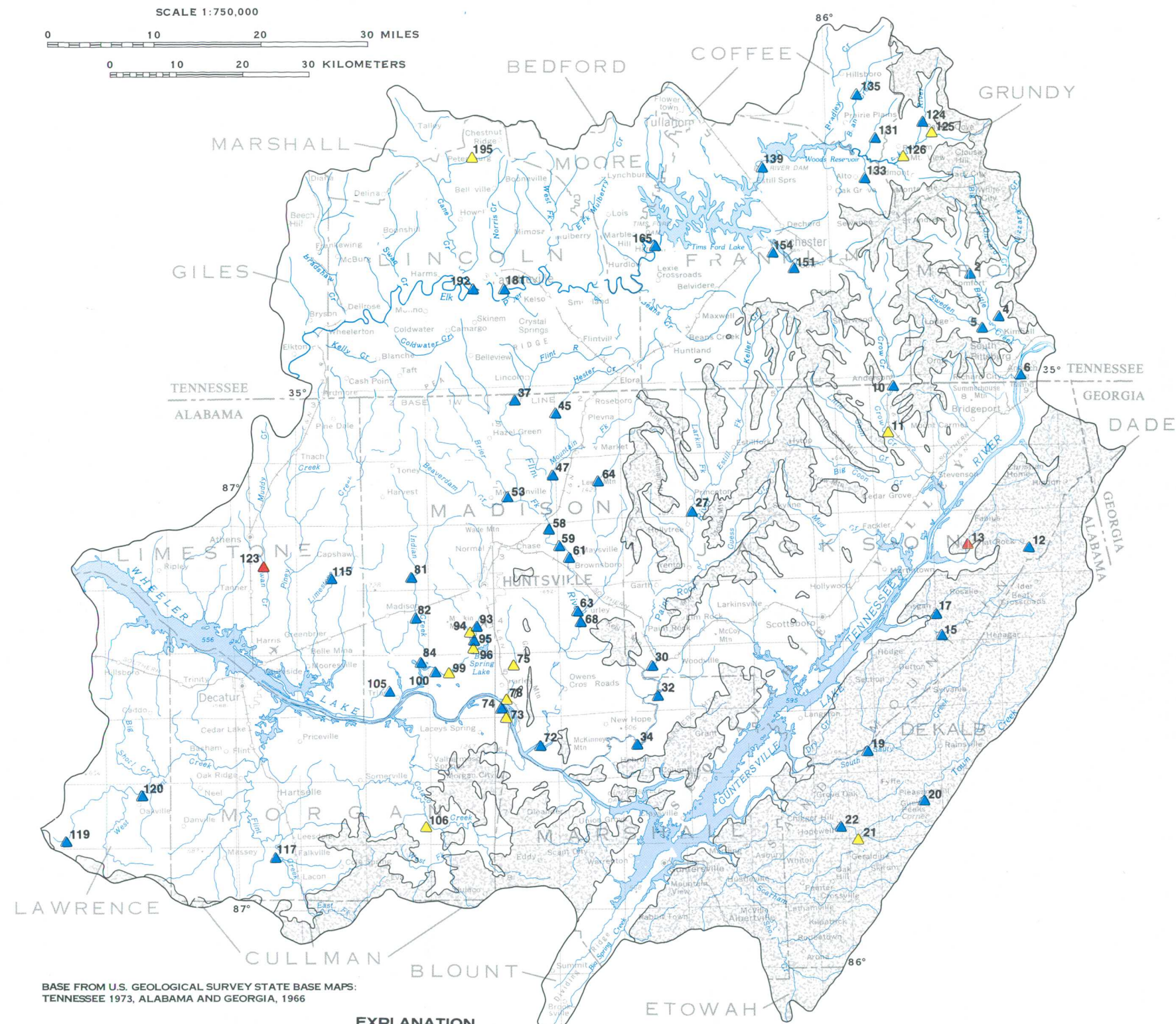


Table 6.3-1 Dissolved sulfate concentrations, in milligrams per liter

Sites active in 1979-81									
Site no.	Minimum	Maximum	Median	No. of determinations	Site no.	Minimum	Maximum	Median	No. of determinations
2	6.3	15	8.1	6	73	7.2	20	12	35
4	---	---	---	1	96	4.8	43	19	62
5	6.5	15	7.2	9	106	0.2	23	5.3	43
6	8.0	19	13	83	117	2.0	7.7	4.9	4
10	8.0	15	10	6	124	3.5	8.1	5.0	10
11	1.4	24	10	42	125	17	21	---	2
12	5.6	8.3	6.7	5	126	7.8	25	14	23
13	110	450	220	5	131	4.5	15	8.2	6
15	0.2	7.6	5.7	9	133	7.9	13	10	6
17	---	---	---	1	135	6.1	7.7	7.1	5
19	3.2	12	7.4	5	151	7.7	14	10	6
21	1.2	23	5.8	62	165	1.0	11	7.0	42
30	4.5	19	8.8	42	181	4.0	13	7.5	30
58	0.4	8.4	3.8	74					
61	0.4	10	3.9	68					

Other sites									
Site no.	Minimum	Maximum	Median	No. of determinations	Site no.	Minimum	Maximum	Median	No. of determinations
20	3.1	7.0	5.0	11	82	0.0	4.0	0.2	3
22	4.2	7.2	6.0	9	84	9.1	18	11	84
27	8.4	16	12	7	93	4.4	13	7.7	30
32	4.6	15	8.0	11	94	0.2	33	3.4	10
34	4.4	14	9.4	5	95	5.1	8.6	7.8	30
37	1.2	5.0	3.9	12	99	7.4	32	16	13
45	1.2	6.6	2.8	12	100	6.6	7.9	7.1	12
47	3.2	6.2	4.6	13	105	1.6	7.6	3.2	12
53	1.0	6.2	2.0	12	115	6.7	7.5	7.1	14
63	2.4	8.0	3.9	12	119	---	---	---	1
64	13	15	---	2	120	---	---	---	1
68	3.4	7.4	4.6	6	123	3.1	53	5.6	15
72	3.2	7.8	4.4	10	139	3.0	7.0	12	49
74	6.9	7.8	7.3	13	154	3.6	7.8	12	11
75	8.0	20	12	33	192	1.0	10	6.0	13
78	21	48	44	4	195	14	26	16	8
81	---	---	---	1					

Figure 6.3-1 Dissolved sulfate.

6.0 QUALITY OF SURFACE WATER--Continued

6.4 pH

The pH of Streams Usually in Near-Neutral Range

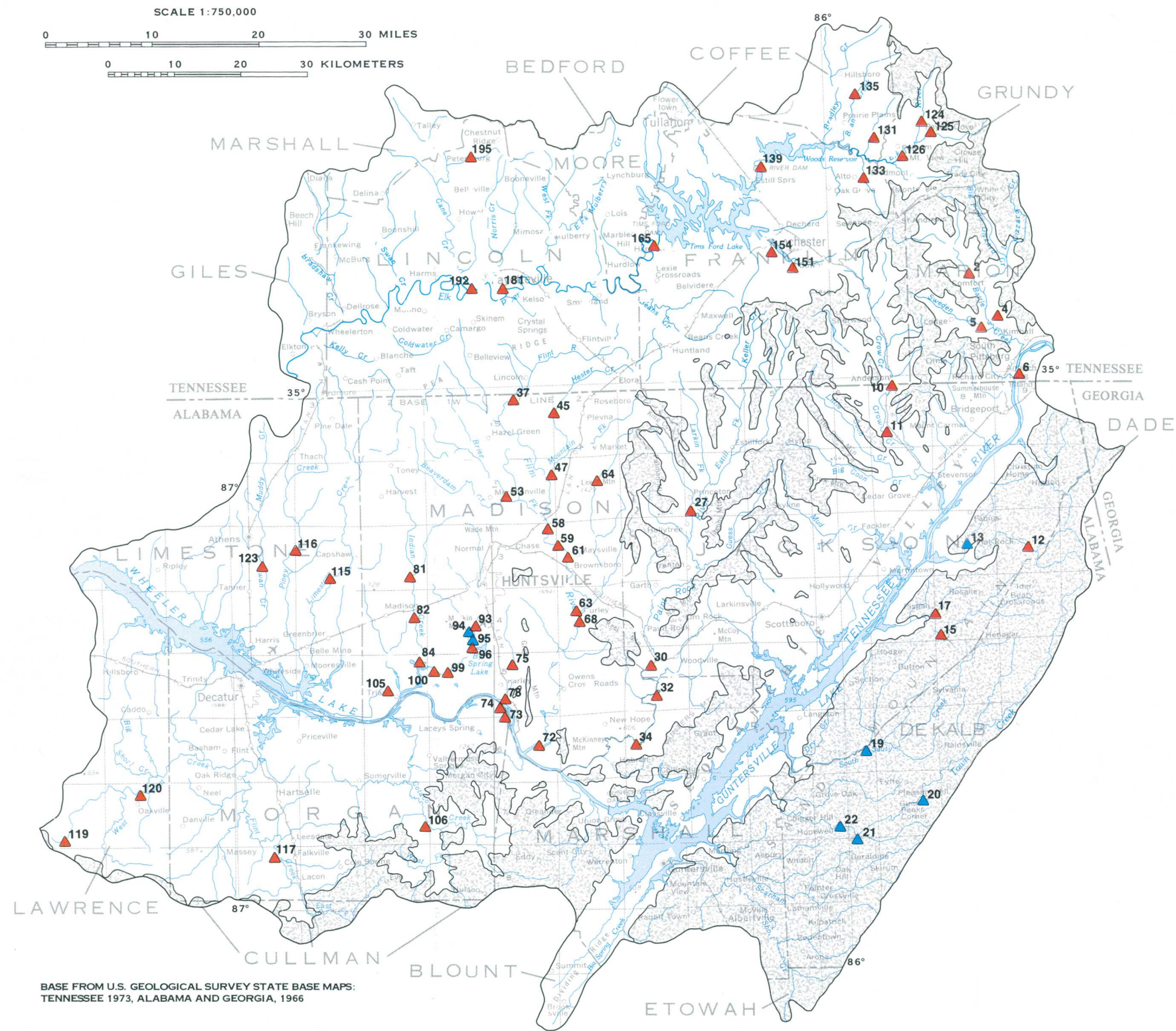
The pH of most streams was in the range 6.0 to 9.0 indicating acid mine drainage is not a widespread problem in Area 21.

The pH scale, ranging from 0 to 14, is an indicator of the relative acidity or alkalinity of a solution. A pH of 7.0 indicates a neutral solution. Progressively lower pH values indicate increasingly acidic solutions. Similarly, progressively higher pH values indicate increasingly alkaline solutions.

The pH of water affects its suitability for industrial, municipal, and recreational purposes. Acidic water adversely affects most substances; consequently, for most purposes, guidelines specify an acceptable pH range. The Surface Mining Control and Reclamation Act specifies that mine effluents must have a pH between 6.0 and 9.0. Acidity in streams has several important sources other than mine drain-

age, including rainfall, reaction of rainfall with organic matter in soils, and weathering of geologic strata.

Although the pH of water in Area 21 streams ranged from 4.2 to 9.0, the pH in most streams was between 6.0 and 9.0 (fig. 6.4-1 and table 6.4-1). Only eight sites had water with pH values less than 6.0, the low end of the range specified in the Act. The lowest pH (4.2) occurred in water in Town Creek at Elrod Bridge, Ala. (site 22), but no data have been collected at this site since 1972. The stream drains part of the coal-resources area.



- EXPLANATION**
- ▲ All pH values within the range 6.0 to 9.0 units
 - ▲ Minimum pH less than 6.0 units
 - 10 Site number
 - See section 10.2 for detailed site description
 - Coal-resources area

Figure 6.4-1 pH.

Table 6.4-1 pH, in standard units

Sites active in 1979-81									
Site no.	Minimum	Maximum	Median	No. of determinations	Site no.	Minimum	Maximum	Median	No. of determinations
2	7.5	8.2	8.2	6	73	6.8	8.1	7.4	33
4	---	6.6	---	1	96	6.8	8.6	7.4	60
5	7.4	7.8	7.6	9	106	6.5	8.1	7.4	66
6	6.3	8.4	7.4	82	117	6.6	7.9	7.3	17
10	7.9	8.7	8.1	6	124	7.1	8.3	7.6	20
11	6.9	8.6	7.8	41	125	7.1	7.1	---	2
12	6.6	7.1	6.8	6	126	7.0	8.1	7.7	24
13	5.4	6.6	6.1	6	131	7.4	8.2	8.0	6
15	6.1	7.8	7.2	9	133	7.6	8.2	8.0	6
17	---	---	---	1	135	7.7	8.3	8.0	5
19	5.5	7.5	6.8	5	151	7.5	8.0	7.8	6
21	5.7	8.2	6.6	79	165	4.6	8.1	7.4	49
30	6.8	8.3	7.6	56	181	6.8	8.6	7.8	29
58	6.3	8.8	7.3	87					
61	6.6	8.0	7.3	61					

Other sites									
Site no.	Minimum	Maximum	Median	No. of determinations	Site no.	Minimum	Maximum	Median	No. of determinations
20	5.6	6.6	6.0	11	82	6.9	7.8	7.5	10
22	4.2	6.6	6.0	9	84	7.3	7.7	7.4	4
27	7.2	8.2	7.7	7	93	7.1	8.5	7.9	32
32	6.5	8.1	7.6	11	94	5.5	8.2	7.0	12
34	7.2	8.3	7.8	5	95	5.1	8.6	7.8	30
37	6.6	7.6	6.9	12	99	6.6	7.9	7.5	13
45	6.1	8.2	6.9	11	100	6.6	7.9	7.1	12
47	6.4	8.1	7.4	13	105	6.7	7.7	7.0	11
53	6.1	8.3	7.0	12	115	6.7	7.5	7.0	14
63	6.7	8.7	7.4	12	116	6.5	7.3	7.0	11
64	7.5	7.9	---	2	119	6.7	7.5	---	2
68	6.9	7.7	7.1	6	120	6.8	8.2	7.6	6
72	6.5	7.7	7.6	10	123	6.4	7.6	6.8	17
74	6.9	7.8	7.3	13	139	6.4	9.0	7.5	49
75	7.2	8.3	7.8	32	154	7.5	8.2	7.9	11
78	6.8	8.6	7.6	4	192	6.7	8.2	7.5	12
81	7.6	7.8	---	2	195	7.6	8.2	7.9	8

6.0 QUALITY OF SURFACE WATER--Continued

6.5 Iron

Iron Concentrations Generally Low

The maximum concentrations of total recoverable iron at all but two sites meet the mandatory limits specified for effluents from mining areas.

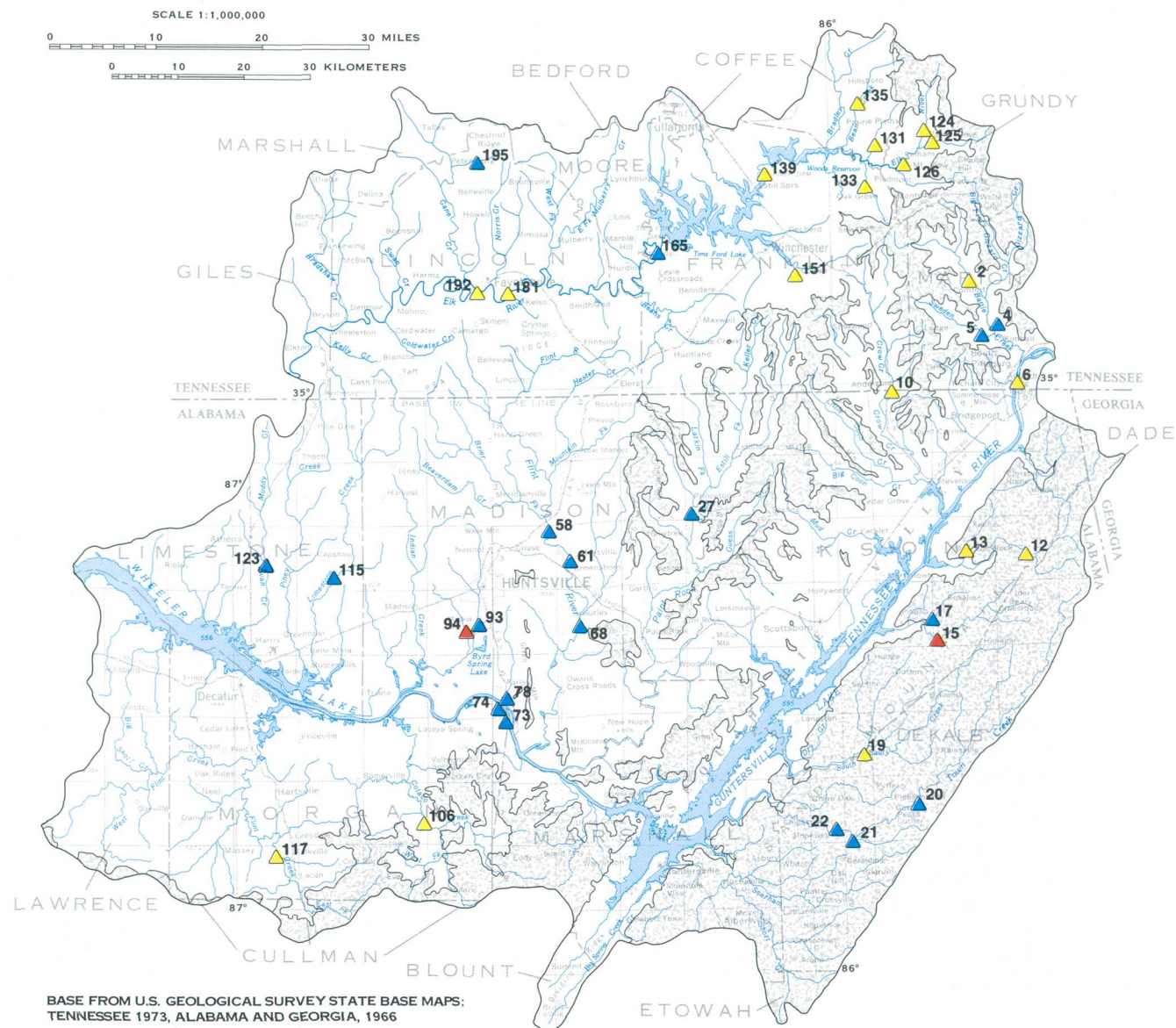
Iron in excessive concentrations can severely limit the use of water for public supply, domestic, and recreational purposes. Consequently, most water-supply standards contain recommended maximum limits for dissolved iron. The recommended maximum concentration of iron in drinking water is 300 $\mu\text{g/L}$ (U.S. Environmental Protection Agency, 1976). The Act specifies 7,000 $\mu\text{g/L}$ as the maximum allowable concentrations of total iron in effluents from mining operations. In Area 21, total recoverable (dissolved plus suspended) and dissolved iron concentrations in water have been determined for 38 and 50 sites, respectively (figs. 6.5-1 and 6.5-2).

Total recoverable iron concentrations in water in streams in the area ranged from 0 to at least 62,000 $\mu\text{g/L}$. (A dissolved iron concentration of 62,000 $\mu\text{g/L}$ occurred in water in a drainage ditch from a landfill near Huntsville, Ala. (site 94). Although the corresponding total recoverable iron concentration was not determined, it necessarily would have been at least equal to 62,000 $\mu\text{g/L}$. Only one concentration in a stream in the coal-resource area exceeded the 7,000 $\mu\text{g/L}$ limit. This concentration, 30,000 $\mu\text{g/L}$,

occurred in Bryant Creek near Pisgah, Ala. (site 15). The median total recoverable iron concentration at most sites active in 1979-81 was less than 500 $\mu\text{g/L}$ (table 6.5-1).

Dissolved iron is only a small part of the total recoverable iron transported by most streams in Area 21. Concentrations generally were less than 300 $\mu\text{g/L}$. Dissolved iron concentrations ranged from 0 to 62,000 $\mu\text{g/L}$, the maximum occurring at site 94 (table 6.5-2). Median dissolved iron concentrations were less than 100 $\mu\text{g/L}$ at about 75 percent of the sites.

Dissolved iron concentrations did not vary widely with fluctuations in streamflow. In contrast, the maximum total recoverable iron concentrations occurred during high flows because larger amounts of suspended iron were transported with suspended sediment. Because of this relation, and because most of the suspended sediment in a particular stream is transported during storms, total recoverable iron loads can be defined with data obtained only by comprehensive sampling.



EXPLANATION

Maximum total recoverable iron

- ▲ Less than 1,000 micrograms per liter
- ▲ 1,000 to 7,000 micrograms per liter
- ▲ Greater than 7,000 micrograms per liter

133 Site number

See section 10.2 for detailed site description

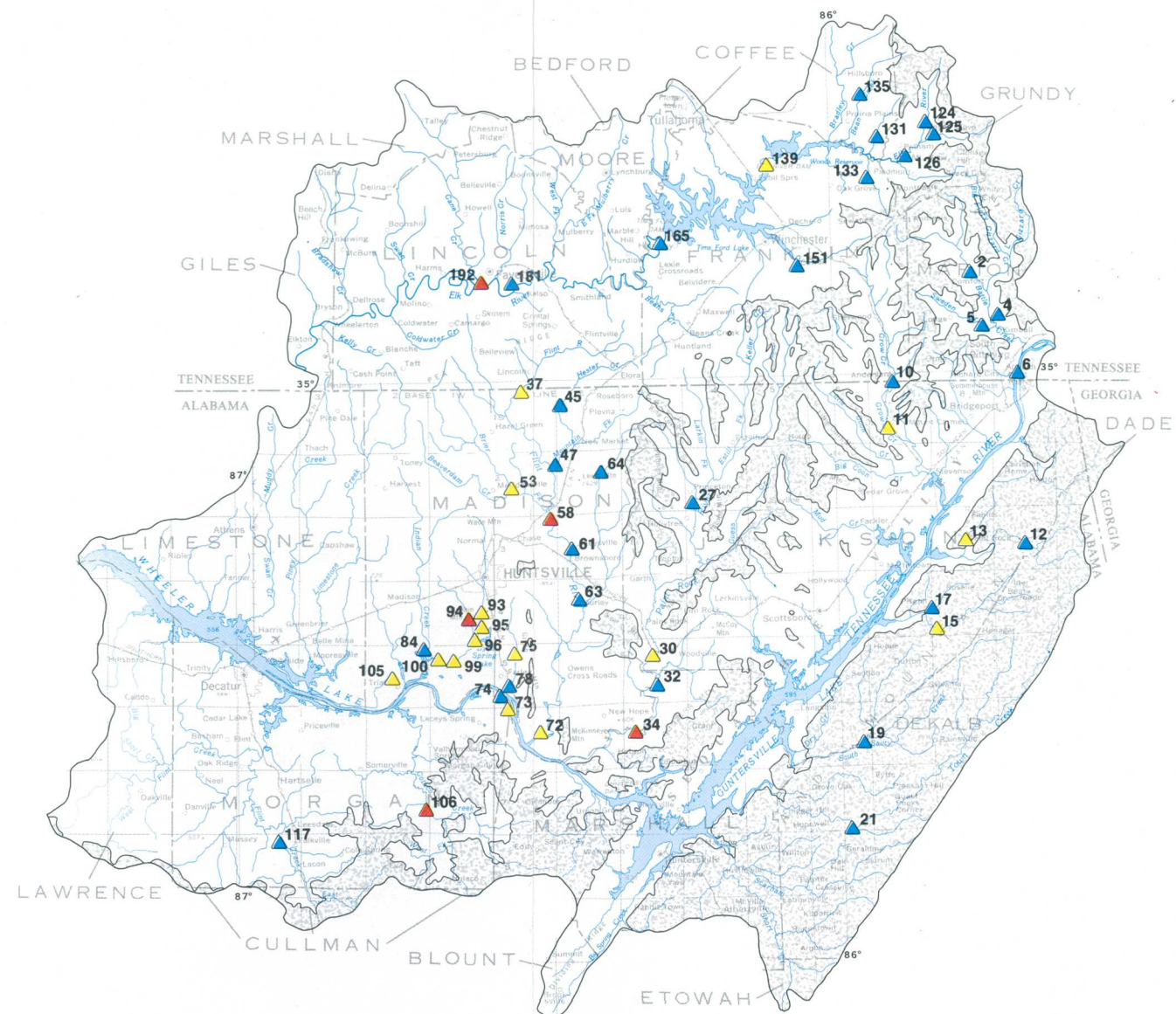
Coal-resources area

Table 6.5-1 Total recoverable iron concentrations, in micrograms per liter

Sites active in 1979-81									
Site no.	Minimum	Maximum	Median	No. of determinations	Site no.	Minimum	Maximum	Median	No. of determinations
2	190	1,000	280	6	73	---	---	---	1
4	---	---	---	1	106	580	2,600	1,400	5
5	190	890	450	8	117	410	1,200	720	5
6	20	1,200	360	26	124	90	1,400	180	10
10	220	1,000	420	6	125	210	1,000	---	2
12	290	2,200	530	6	126	140	1,500	290	23
13	200	1,100	970	5	131	160	2,200	450	6
15	280	30,000	2,400	8	133	270	1,700	360	6
17	---	---	---	1	135	70	2,200	310	5
19	230	2,500	600	4	151	130	3,700	260	6
21	0	350	30	14	165	10	860	120	35
58	48	440	140	8	181	120	1,700	520	23
61	0	300	180	8					

Sites sampled prior to 1979									
Site no.	Minimum	Maximum	Median	No. of determinations	Site no.	Minimum	Maximum	Median	No. of determinations
20	11	230	40	11	94	---	---	---	1
22	8	230	30	9	115	60	320	75	8
27	40	123	60	6	123	0	600	140	14
68	0	190	8	5	139	50	1,600	400	48
74	30	240	115	6	192	410	2,600	1,000	13
78	20	50	50	3	195	10	460	40	8
93	0	580	0	3					

Figure 6.5-1 Total recoverable iron.



EXPLANATION

Maximum dissolved iron

- ▲ Less than 300 micrograms per liter
- ▲ 300 to 1,000 micrograms per liter
- ▲ Greater than 1,000 micrograms per liter

133 Site number

See section 10.2 for detailed site description

Coal-resources area

Table 6.5-2 Dissolved iron concentrations, in micrograms per liter

Sites active in 1979-81									
Site no.	Minimum	Maximum	Median	No. of determinations	Site no.	Minimum	Maximum	Median	No. of determinations
2	10	70	35	6	61	0	250	60	69
4	---	---	---	1	73	0	640	20	33
5	20	80	50	9	96	0	310	50	60
6	0	240	25	32	106	5	1,300	60	43
10	10	60	30	6	117	130	190	160	4
11	0	1,000	20	42	124	0	60	25	10
12	40	150	80	5	125	10	40	---	2
13	160	510	360	5	126	0	90	35	22
15	90	370	110	7	131	10	110	70	6
17	---	---	---	1	133	20	70	30	6
19	80	180	110	3	135	10	70	30	5
21	10	270	75	40	151	10	80	35	6
30	5	310	20	41	165	0	210	10	14
58	10	1,600	60	65	181	10	160	50	17

Other sites									
Site no.	Minimum	Maximum	Median	No. of determinations	Site no.	Minimum	Maximum	Median	No. of determinations
27	40	130	90	4	75	0	630	50	32
32	0	80	40	11	78	20	50	50	3
34	10	1,800	30	5	84	10	90	40	3
37	30	330	125	10	93	0	570	30	28
45	5	290	110	12	94	10	62,000	3,250	10
47	10	140	40	12	95	0	890	50	28
53	20	760	220	11	99	10	340	75	12
63	5	250	80	11	100	10	390	85	12
64	30	50	---	2	105	0	730	120	11
72	20	340	50	9	139	16	900	65	42
74	20	25	20	3	192	50	2,600	90	12

Figure 6.5-2 Dissolved iron.

6.0 QUALITY OF SURFACE WATER--Continued

6.6 Manganese

Manganese Concentrations Low in Most Streams

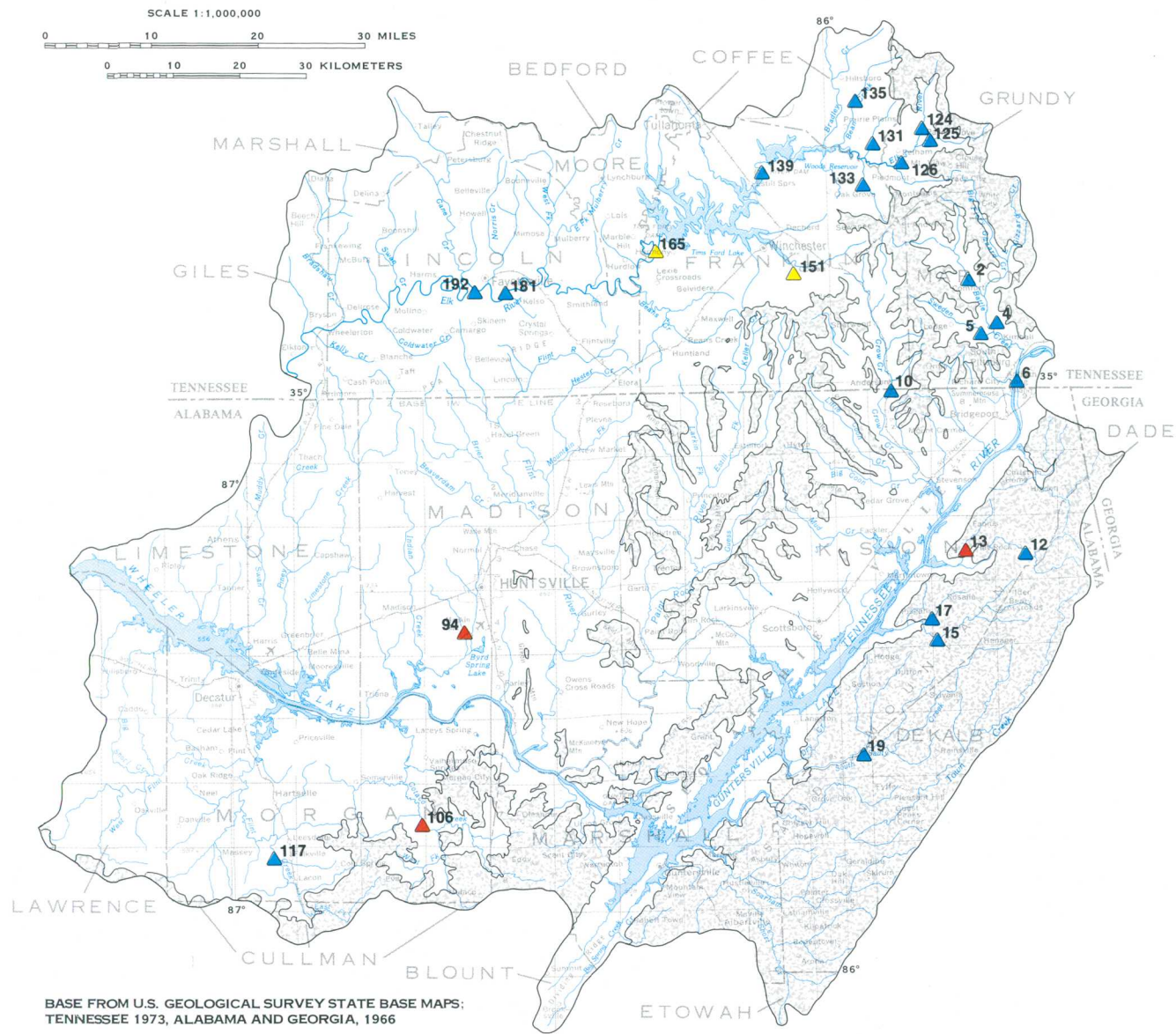
Maximum concentrations of total recoverable manganese in most streams were less than the mandatory limits specified for effluents from mining areas.

Excessive concentrations of manganese can severely limit the use of water for public supply, domestic, and recreational purposes. As a result, most water-supply standards contain recommended maximum limits for dissolved manganese. The recommended maximum limit for drinking water is 50 $\mu\text{g/L}$ (U.S. Environmental Protection Agency, 1976). As specified in the Act, the maximum allowable concentrations of total manganese in effluents from mined areas is 4,000 $\mu\text{g/L}$. In Area 21, total recoverable (dissolved plus suspended) and dissolved manganese concentrations in water have been determined for 24 and 50 sites, respectively (figs. 6.6-1 and 6.6-2).

The total recoverable manganese concentrations in streams in the area ranged from 10 to 25,000 $\mu\text{g/L}$, with the maximum occurring in Dry Creek near Fabius, Ala. (site 13). The 4,000 $\mu\text{g/L}$ limit was also exceeded at two other sites. (Although total recoverable manganese concentrations exceeding the limit

were not determined for these sites, dissolved manganese of 9,000 and 4,400 $\mu\text{g/L}$ were determined for sites 94 and 106, respectively. Total concentrations necessarily would have been at least equal to those dissolved concentrations.) The median total recoverable manganese concentration at most sites was less than 100 $\mu\text{g/L}$ (table 6.6-1). Generally, higher concentrations of total recoverable manganese occurred during high flows because larger amounts of suspended manganese were transported with suspended sediment.

Dissolved manganese concentrations ranged from 0 to 19,000 $\mu\text{g/L}$, but the maximum concentration at most sites was less than 200 $\mu\text{g/L}$ (table 6.6-2). The maximum concentration at about 65 percent of the sites for which at least three determinations were obtained was less than 50 $\mu\text{g/L}$. Dissolved manganese concentrations did not vary widely with fluctuations in streamflow.



EXPLANATION

Maximum total recoverable manganese

- ▲ Less than 1,000 micrograms per liter
- ▲ 1,000 to 4,000 micrograms per liter
- ▲ Greater than 4,000 micrograms per liter

133 Site number

See section 10.2 for detailed site description

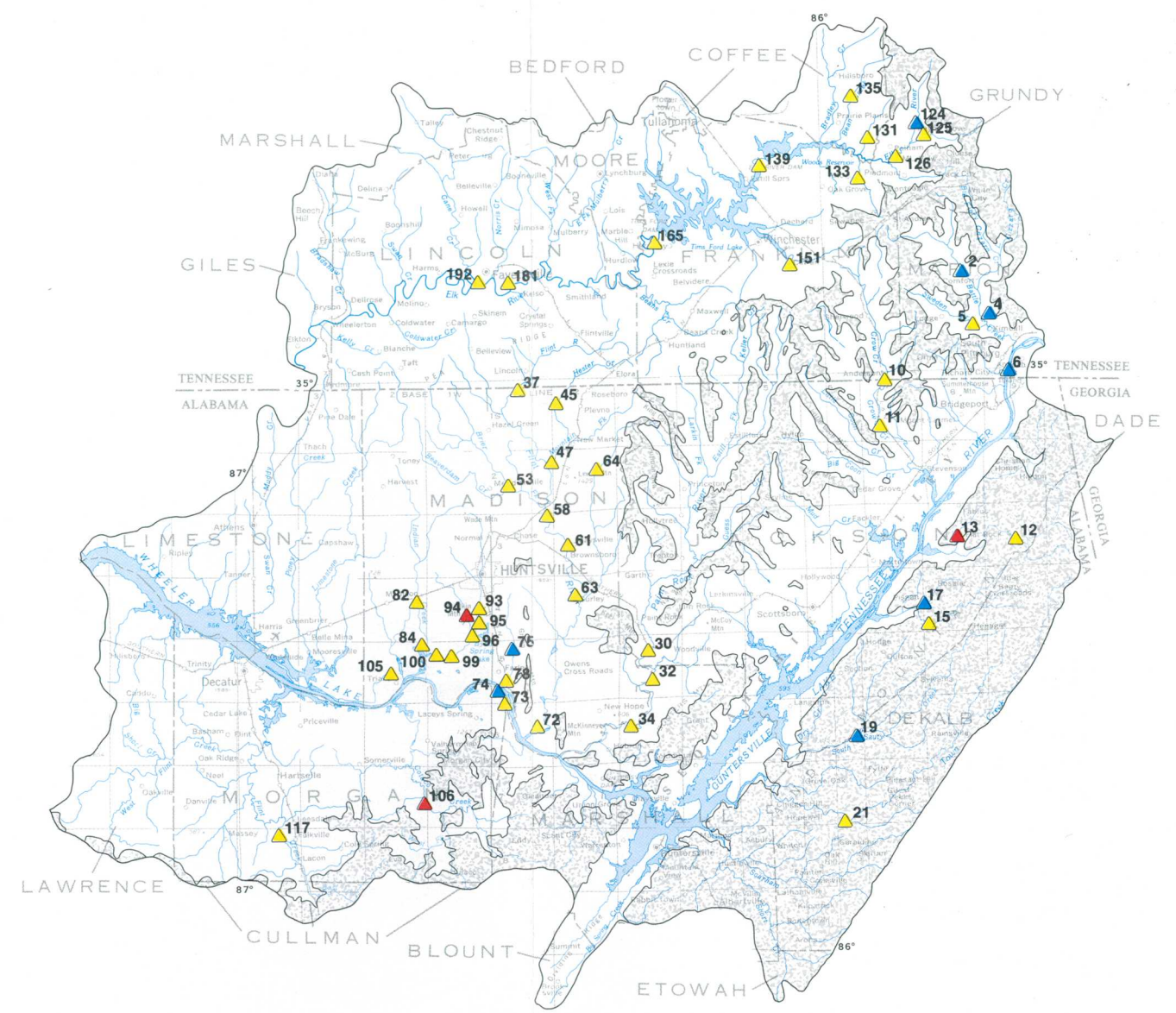
Coal-resources area

Table 6.6-1 Total recoverable manganese concentrations, in micrograms per liter

Sites active in 1979-81									
Site no.	Minimum	Maximum	Median	No. of determinations	Site no.	Minimum	Maximum	Median	No. of determinations
2	10	50	20	6	106	30	280	160	4
4	---	---	---	1	117	30	410	130	5
5	30	70	50	7	124	10	120	10	10
6	20	100	60	27	125	120	400	---	2
10	20	90	40	6	126	20	140	50	22
12	60	160	90	5	131	20	310	70	5
13	4,700	25,000	9,400	6	133	20	200	70	6
15	40	200	140	7	135	40	150	60	4
17	---	---	---	1	151	20	2,100	40	6
19	40	300	100	4	165	20	1,500	240	29
94	---	---	---	1	181	30	450	80	23

Other sites									
Site no.	Minimum	Maximum	Median	No. of determinations	Site no.	Minimum	Maximum	Median	No. of determinations
139	10	3,700	50	48	192	90	680	135	12

Figure 6.6-1 Total recoverable manganese.



EXPLANATION

Maximum dissolved manganese

- ▲ Less than 50 micrograms per liter
- ▲ 50 to 4,000 micrograms per liter
- ▲ Greater than 4,000 micrograms per liter

133 Site number

See section 10.2 for detailed site description

Coal-resources area

Table 6.6-2 Dissolved manganese concentrations, in micrograms per liter

Sites active in 1979-81									
Site no.	Minimum	Maximum	Median	No. of determinations	Site no.	Minimum	Maximum	Median	No. of determinations
2	10	30	10	6	61	0	76	26	67
4	---	---	---	1	73	0	120	10	33
5	10	120	40	9	96	5	570	72	62
6	0	40	20	28	106	0	4,400	61	43
10	10	50	30	6	117	20	190	75	4
11	0	100	22	40	124	10	10	10	10
12	60	130	100	4	125	110	320	---	2
13	840	19,000	7,600	4	126	0	120	40	22
15	20	90	60	7	131	10	200	30	6
17	---	---	---	1	133	10	60	30	6
19	30	30	---	2	135	20	80	40	5
21	4	180	35	40	151	10	1,900	20	6
30	0	260	39	41	165	20	1,100	70	5
58	0	430	21	69	181	10	370	30	17

Other sites									
Site no.	Minimum	Maximum	Median	No. of determinations	Site no.	Minimum	Maximum	Median	No. of determinations
32	5	69	29	11	78	70	90	80	3
34	15	68	32	5	82	40	100	---	2
37	24	76	36	11	84	10	64	35	4
45	5	40	34	11	93	0	60	20	28
47	23	120	40	12	94	290	9,000	2,200	9
53	37	100	74	11	95	10	92	30	27
63	23	96	31	11	99	140	430	230	13
64	90	130	---	2	100	130	430	220	11
72	19	88	29	9	105	74	1,500	275	10
74	2	20	10	33	139	10	2,400	30	42
75	2	20	10	5	192	10	280	70	12

Figure 6.6-2 Dissolved manganese.

6.0 QUALITY OF SURFACE WATER--Continued
6.7 Trace Constituents

Most Concentrations of Trace Constituents in Water and Bottom Materials Were Low

Low concentrations of trace constituents were found in water in streams and in bottom material in stream channels in Area 21.

Trace constituents are predominantly metals of low solubility, but also include inorganic and organic compounds. Trace constituents normally occur in low concentrations in water in most streams. Although high concentrations of some constituents can be toxic, low concentrations generally are essential for a balanced environment. Most high concentrations are a result of urban, industrial, and domestic effluents, and do not occur naturally.

Selected trace constituent concentrations in water for 30 sites and in stream bottom material for 17 sites in Area 21 were determined (fig. 6.7-1 and tables 6.7-1 and 6.7-2). No widespread occurrence of any of the constituents in potentially troublesome quantities was evident either in water or in bottom material. Although total recoverable cadmium, lead, and mercury concentrations in water have exceeded recommended criteria at sites in Area 21, there is no indication of a chronic trace-constituent problem at any site. The limit for lead was exceeded once at each of two sites, 7 and 99. The cadmium and mercury limits were exceeded once each at sites 7 and 165, respectively.

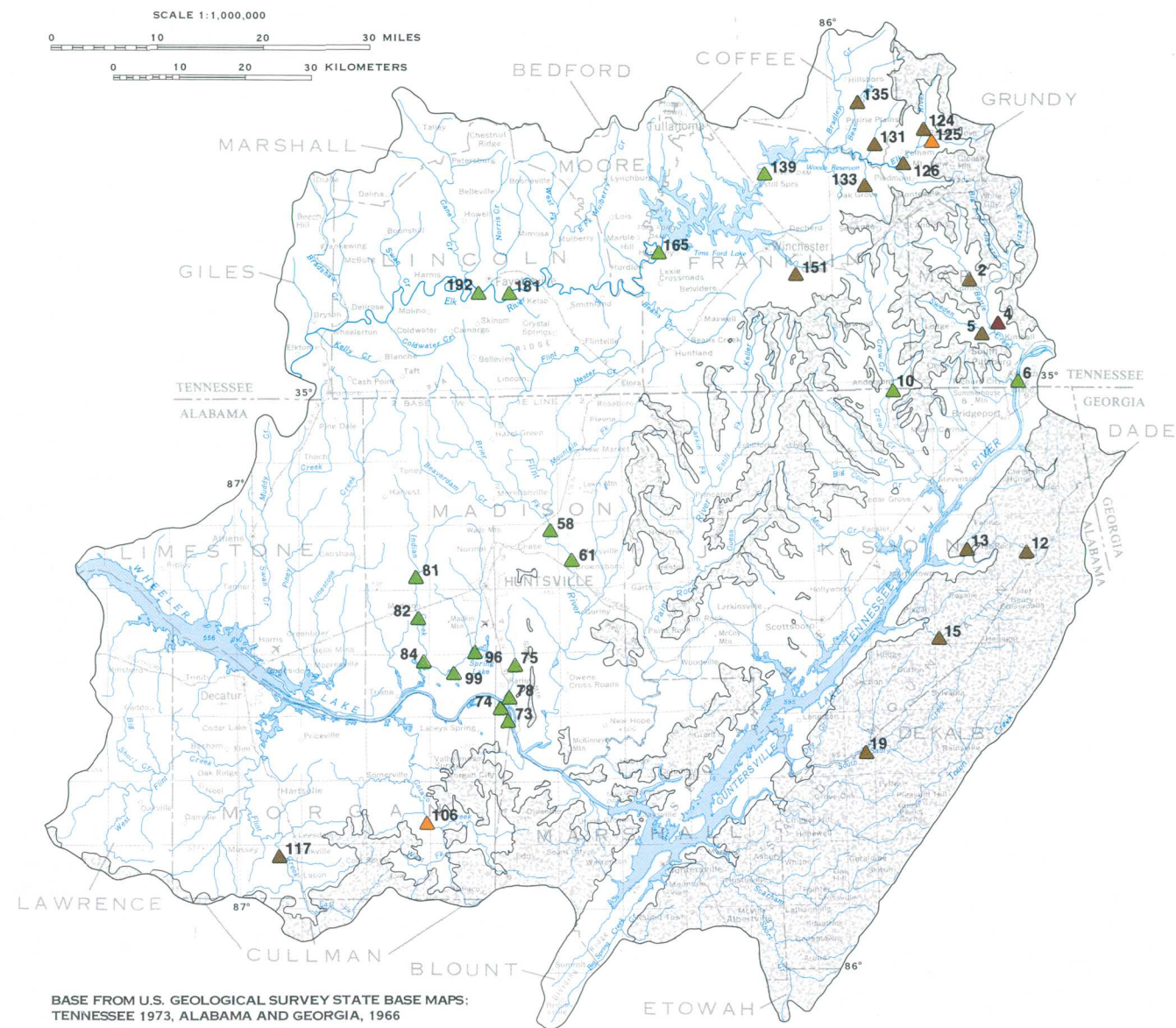
Several important facts should be considered in any interpretation of concentrations of trace constituents in water or in bottom material. These include:

- Mandatory or recommended standards have been established for concentrations in water of several dissolved or total recoverable (dissolved plus suspended) trace constituents such as arsenic, cadmium, chromium, copper, lead, mercury, selenium, and zinc. The States of Tennessee and Alabama have adopted most of the drinking-water regulations issued by the U.S. Environmental Protection Agency, although State criteria in Tennessee are more stringent for physical properties such as turbidity.

- Limits for concentrations of trace constituents in bottom material have not been established.

- Concentrations of constituents exceeding recommended or mandatory limits in raw water in streams do not necessarily violate those standards because drinking-water regulations apply only to water delivered to a consumer.

- High concentrations of constituents in bottom material are potentially troublesome because the constituents can be transported downstream or can be dissolved or suspended by natural geochemical or biological processes. The presence of any constituent in bottom material at a particular site does not indicate a source in the immediate area.



EXPLANATION

▲ Both water and bottom-material trace-constituent site

▲ Water trace-constituent site

▲ Bottom-material trace-constituent site

74 Site number

See section 10.2 for detailed site description

Coal-resources area

Figure 6.7-1 Trace constituents.

Table 6.7-1 Total recoverable trace-constituent concentrations, in micrograms per liter (water)

Constituent	Minimum	Maximum	Median	Number of determinations	Maximum* contaminant levels
Arsenic	0	10	1	89	50
Cadmium	0	33	1	118	10
Chromium	1	40	10	81	50
Copper	0	120	80	91	1,000
Lead	0	130	10	116	50
Mercury	<0.1	2.1	0.3	114	2
Selenium	0	2	1	58	10
Zinc	0	290	20	117	5,000

Note: Arsenic and selenium values are total concentrations.

* U.S. Environmental Protection Agency primary or secondary drinking water regulations, 1976.

Table 6.7-2 Trace-constituent concentrations, in micrograms per gram (bottom material)

Constituent	Minimum	Maximum	Median	Number of determinations
Arsenic	0	1	0	34
Cadmium	1	10	10	34
Chromium	<10	30	10	34
Copper	2	10	10	34
Lead	<10	50	10	34
Mercury	0	.02	0	34
Selenium	0	1	0	34
Zinc	4.7	140	16	34

Note: Arsenic and selenium values are total concentrations.

6.0 QUALITY OF SURFACE WATER--Continued

6.8 Sediment

Suspended-Sediment Discharge Higher in Mined Basins

Suspended-sediment concentrations are highly variable; highest concentrations occur during high flows.

The production and transport of suspended sediment depends on the interaction of sensitive and complex relations between basin characteristics such as land use, and external factors, such as climate. Any land-use activity that strips the surface of its vegetative cover may greatly increase erosion and sediment yields. Suspended sediment in large quantities can have far-reaching effects on the aquatic environment as well as channel capacity and channel morphology. The amount of sediment supplied to a stream reflects upstream activities.

Suspended-sediment data were collected at 31 sites in Area 21 (fig. 6.8-1 and section 10.5). The table in section 10.5 summarizes suspended-sediment concentrations for all sites. The number of samples collected, drainage area, and the availability of storm-period sampling are also included in the table. Significant quantities of material are transported during storms making data collection at these times most important for accurately assessing trends in suspended-sediment transport. Sufficient data to determine the differences in suspended-sediment transport as a function of land use are available for several sites.

One of the difficulties in constructing the relation between water discharge and suspended-sediment discharge (known as a suspended-sediment transport curve) is shown in fig. 6.8-2. The variability in both water and suspended-sediment discharge at site 124 during a storm in the basin is illustrated. Suspended-sediment concentration peaked approximately 5 hours prior to the peak in water discharge. Substantial differences in sediment concentration at a given discharge at different times during a storm are apparent. For example, at discharges of 400 ft³/s, the concentration was 92 mg/L before the peak water discharge and 24 mg/L after it. This variability in suspended-sediment concentrations along with other factors such as basin area, source area, precipitation duration and intensity, type of bed and bank

material, season of the year and antecedent conditions must be considered prior to estimating sediment yields.

The suspended-sediment transport curves in figure 6.8-3 are based on a minimal amount of data but illustrate the effect of land use on suspended-sediment transport in the coal-resources area. Bryant Creek near Pisgah, Ala. (site 15) transported significantly more material per unit of water discharge than Elk River near Mt. View, Tenn. (site 124). This is because the Bryant Creek drainage basin upstream from site 15 has been disrupted by surface-mining activities that may have made more material available for transport. Although orphan-mines may exist near the headwaters of Dry Creek (an ephemeral, upstream tributary to the Elk River), their effects at site 124 are not evident from available data. Transport curves for South Sauty Creek near Macedonia, Ala. (site 19) and Sweden Creek near South Pittsburg, Tenn. (site 5) show a similar relation between an actively mined and an unmined basin.

These suspended-sediment transport curves, including sites in both mined and unmined areas, also illustrate the differences in estimated yields as a function of sampling schedules. Note the lower calculated yields for the two sites where no samples were taken during storm periods. These particular curves (sites 5 and 19) tend to reflect recession (lower) concentrations which may lead to underestimates of suspended-sediment loads.

The detrimental effects of increased sediment yield are not restricted to stream segments adjacent to disturbed slopes but may extend downstream. The fine, constituent-transporting fraction of the sediment load may travel relatively long distances from its source area. Thus, materials may be delivered to areas where no mining occurs and, consequently, have an adverse effect on water quality.

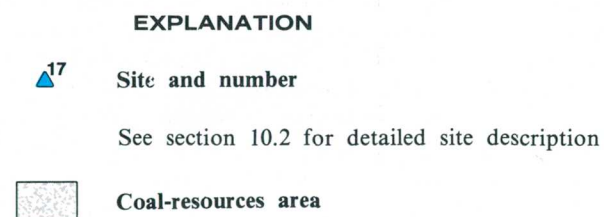
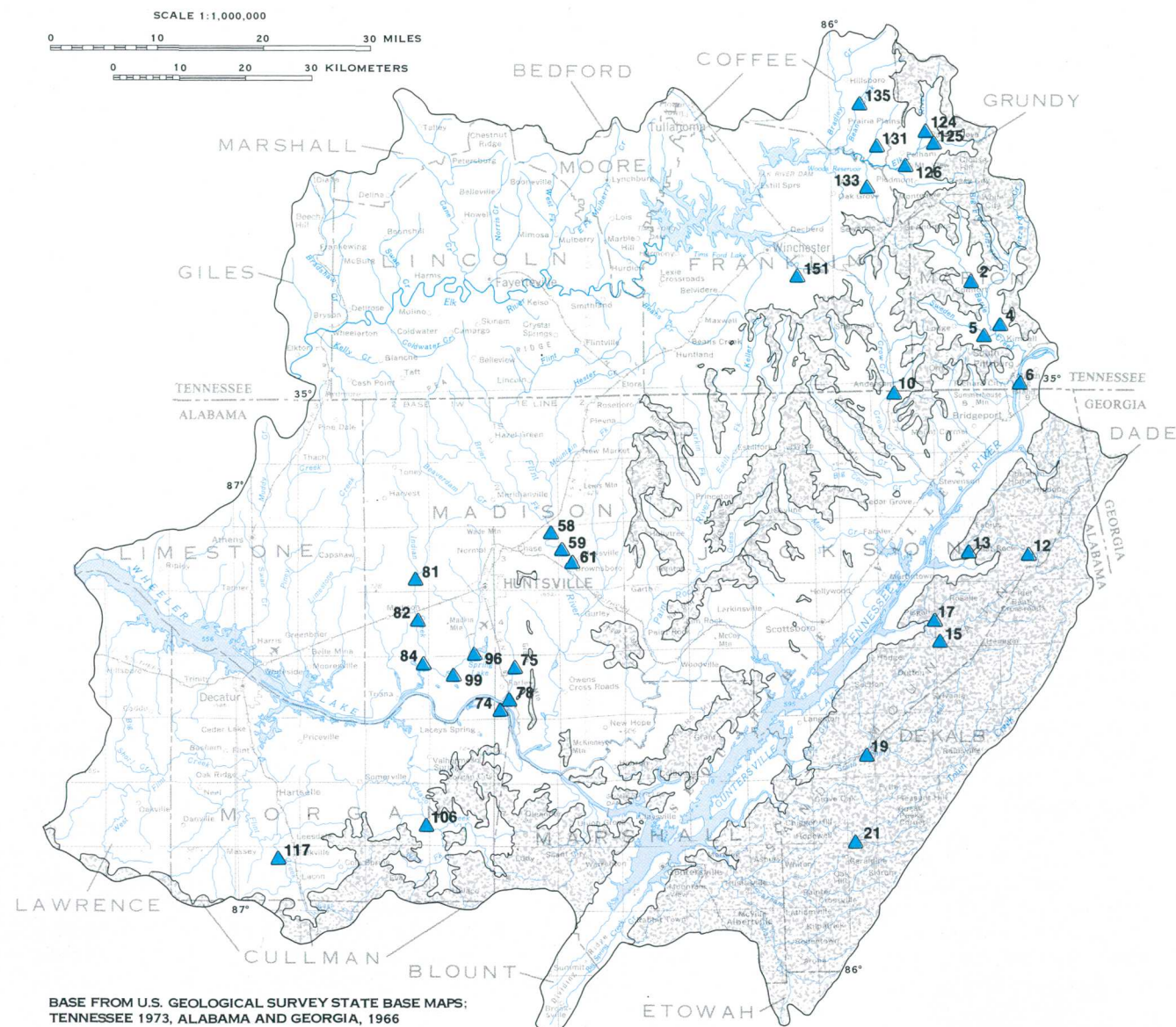


Figure 6.8-1 Suspended-sediment.

- A Discharge = 400 cubic feet per second
Suspended-sediment concentration = 24 milligrams per liter
- A' Discharge = 400 cubic feet per second
Suspended-sediment concentration = 92 milligrams per liter

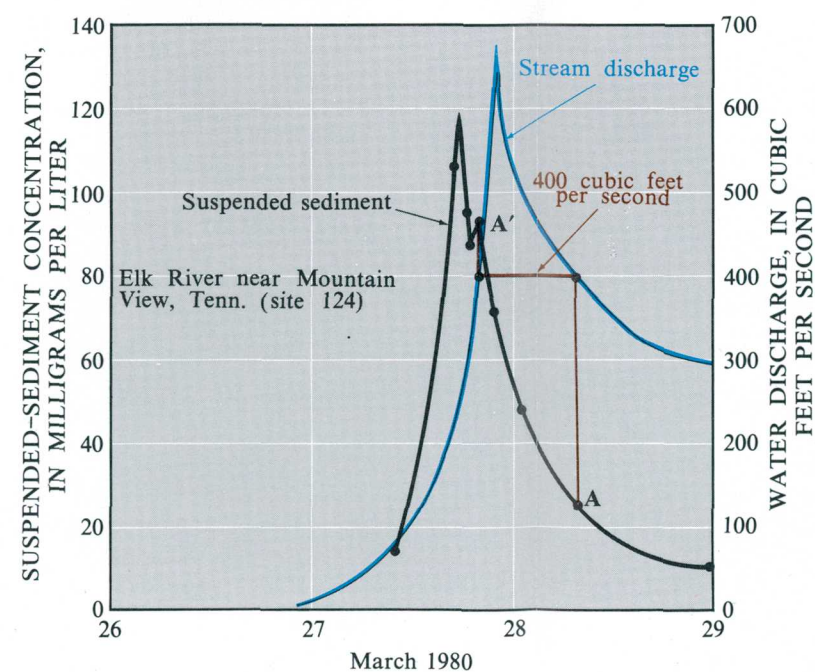
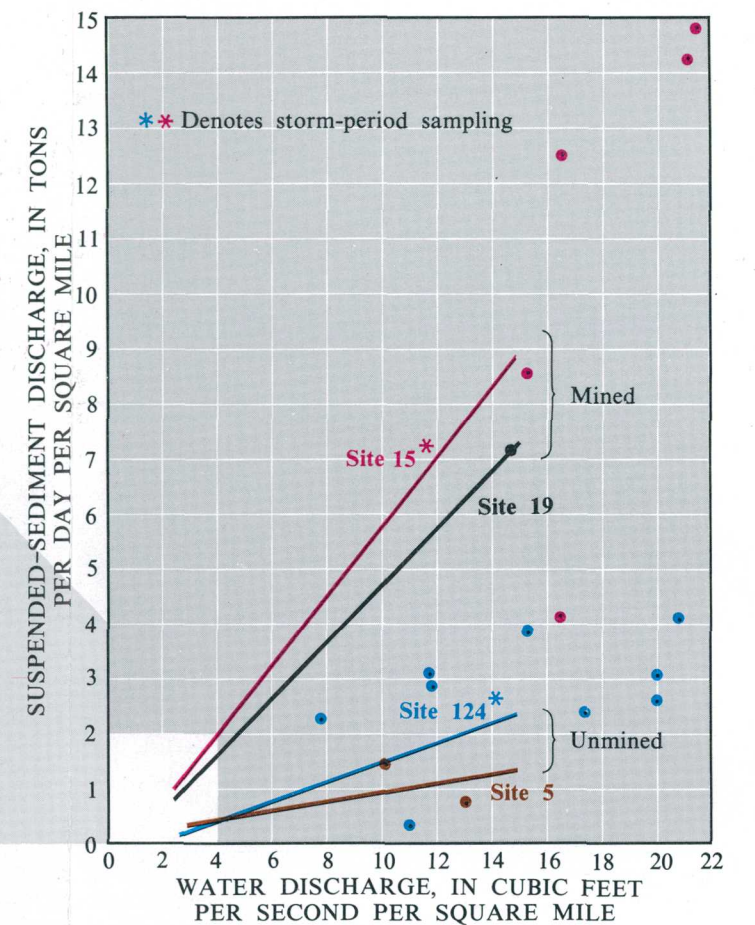
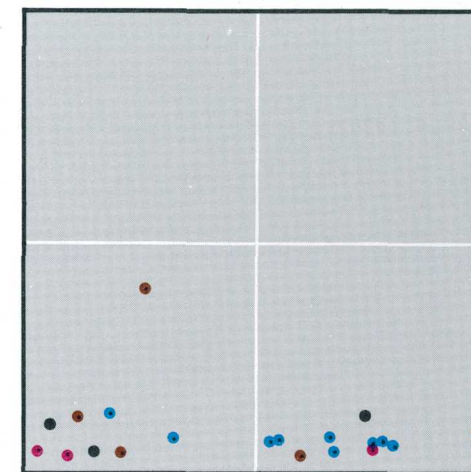


Figure 6.8-2 The variability of suspended-sediment concentrations during a storm event.



Stream	Site	Drainage area in square miles	Regression* equation	Data symbol	Number of samples
Bryant Creek	15	41.8	$SS = 0.64(Q) - 0.80$	●	8
South Sauty Creek	19	102	$SS = 0.51(Q) - 0.39$	●	4
Elk River	124	25.7	$SS = 0.18(Q) - 0.32$	●	20
Sweden Creek	5	28.2	$SS = 0.086(Q) - 0.17$	●	6

*SS = Suspended-sediment discharge (Q) = Water discharge

Figure 6.8-3 Suspended-sediment discharge higher in surface-mined areas.

6.0 Quality of Surface Water--Continued
6.9 Benthic Invertebrates

Benthic Invertebrate Populations Indicate Water Quality

Indices computed for benthic samples collected at three sites indicate all sites relatively free of pollution.

Benthic invertebrates, organisms found in the substrate of aquatic environments, are useful indicators of water quality. Like all living creatures, invertebrates have ranges of tolerance to environmental changes. When water quality is altered by increases in sediment or other pollutants, the population structure of these bottom dwellers responds with changes in the number and kinds of organisms found. A high community diversity is associated with clean water whereas lower diversity is common in polluted water. The effect of heavy pollution on most invertebrate populations is so marked that whole taxonomic groups may be reduced or eliminated while more tolerant organisms may flourish (Hynes, 1960).

The type and number of invertebrates present depend upon a variety of physical factors as well as water quality. Biological data are particularly useful to monitor changes in environmental conditions when collected along with other water-quality data over a period of time.

Benthic invertebrate samples were collected at three sites during May 1980 (fig. 6.9-1). The Elk River basin has some mining activity in the headwater areas. While there is no known mining in the Crow Creek basin above the site, there is a concrete plant located just upstream of the sampled area.

Several sampling techniques were used, but the data shown in table 6.9-1 were computed for kick

samples. In this method the stream bottom was disturbed, and dislodged organisms were collected in a dip net (210 micron) held downstream. After collection, organisms were separated from the debris and identified to genus level.

A biotic index (J. Gore, Tennessee Technological University, written commun., 1980; modified from Hilsenhoff, 1977) and a diversity index (Shannon and Weaver, 1949) were computed for each of the three sites. Because each index has its own limitations, it is often useful to evaluate samples by more than one index. The biotic index considers the pollution tolerance of the organisms in a sample. However, it is subjective since each genus is given a water quality "rating" and there is some variation in tolerance among species of the same genus. The biotic index used here is based on experience with organic pollutants. The Shannon-Weaver diversity index takes into account the distribution of individuals among the various taxa, but it does so without regard to the pollution tolerance of the organisms or to the sample size.

The results for the two indices are given in table 6.9-1. The scales for each index are different and are given in table 6.9-2. While the potential for water-quality problems exists in regard to present population densities and land-use practices in the basins, no serious problems were evident at the three sites sampled for benthic invertebrates.

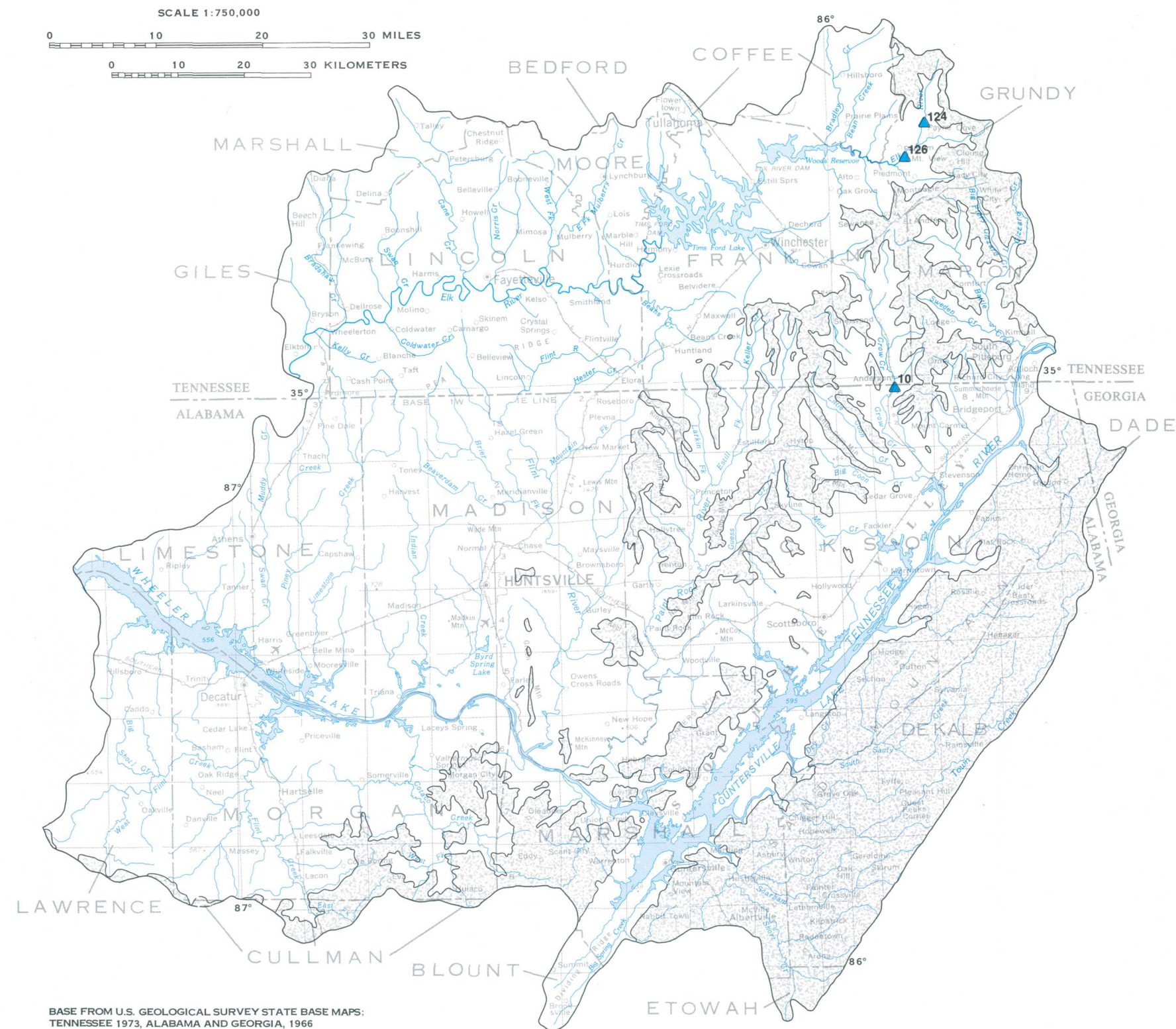


Table 6.9-1 Results of kick samples at sites in Area 21

Site no.	Station name	Drainage area (mi ²)	Indices		Sample count	Dominant order	Composition (percent)
			Biotic	Diversity			
10	Crow Creek near Anderson, Tenn.	78.4	2.59	3.62	223	Ephemeroptera	55
124	Elk River near Mt. View, Tenn.	25.7	2.48	3.52	333	Ephemeroptera	40
126	Elk River near Pelham, Tenn.	65.6	2.48	3.82	1,035	Diptera	43

Table 6.9-2 Scales for biotic and diversity indices

Biotic index	Diversity index	Water quality rating
<1.75	>4	excellent
1.75-2.25	3-4	good
2.25-3.00	2-3	fair
3.00-3.75	1-2	poor
>3.75	<1	very poor

Figure 6.9-1 Benthic invertebrates.

7.0 GROUND-WATER QUANTITY

7.1 Occurrence

Distinct Aquifer Systems Correspond to the Three Physiographic Sections

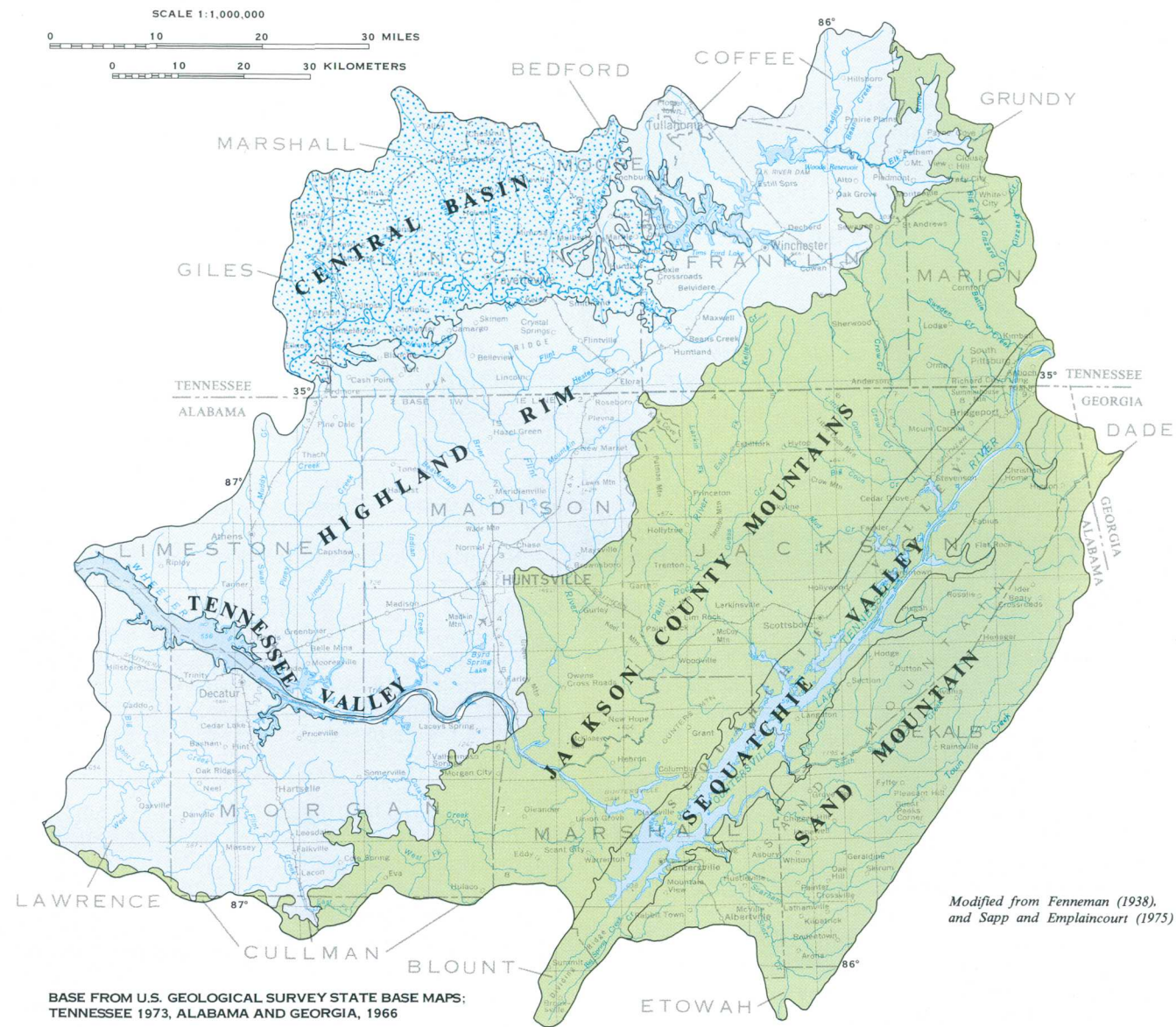
The aquifer systems include the fractured sandstone, shale, and conglomerate beneath the Cumberland Plateau; the limestone and dolomite overlain by thick regolith (weathered rock and soil) beneath the Highland Rim; and the limestone beneath the Central Basin.

Ground water in the coal-resources area of the Cumberland Plateau primarily occurs in fractures in sandstone, shale, and conglomerate (fig. 7.1-1). These rocks have a low intergranular permeability, but fractures provide secondary openings for storage and movement of ground water. Water-bearing openings generally occur within 100 feet of land surface. Although water-bearing openings are numerous, the yields are generally low. Large springs commonly occur at the base of the steep escarpments bordering the upland coal-resources area of the Cumberland Plateau (Hollyday and others, 1982).

Ground water in the Highland Rim and in the lowlands of the Jackson County Mountains occurs in solution-prone carbonate rocks which have weathered to form a deep regolith (fig. 7.1-2). Both the regolith and the carbonate rocks are water bearing and form a single aquifer, but their hydrologic properties are different (Burchett and Hollyday, 1974). The regolith contains openings in the form of intergranular spaces much like those in sand or gravel. In contrast, the underlying bedrock transmits water almost exclusively through a network of solution openings. The regolith serves as a storage reservoir that slowly provides water to the network of solution

openings in the bedrock part of the aquifer. The aquifer is generally unconfined, but in some areas clay in the upper part of the regolith creates local artesian conditions. Springs are common along the Highland Rim escarpment bordering the Central Basin.

In the Central Basin (fig. 7.1-3) and the Sequatchie Valley (fig. 7.1-1) parts of Area 21, ground water occurs in solution enlarged openings along joints, fractures, and bedding planes in the limestone. These limestones have only a small content of insoluble material and weather to form a thin residual soil; average thickness is about 4 feet. This thin residual soil is ineffective as a storage reservoir for ground water. The occurrence and movement of ground water, therefore, is entirely dependent on the presence of solution openings, which are most likely to occur within 100 feet below the land surface. Solution openings are less abundant at greater depths, although reports from drillers indicate some openings have been penetrated in the Central Basin at depths of several hundred feet (May and others, 1981).



- EXPLANATION**
- Central Basin section**
Interior Low Plateaus province
 - Highland Rim section**
Interior Low Plateaus province
 - Cumberland Plateau section**
Appalachian Plateaus province

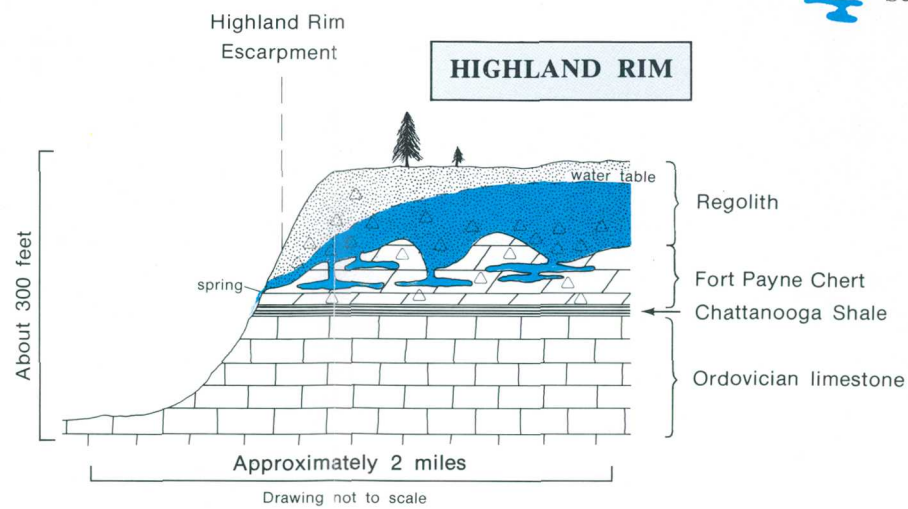
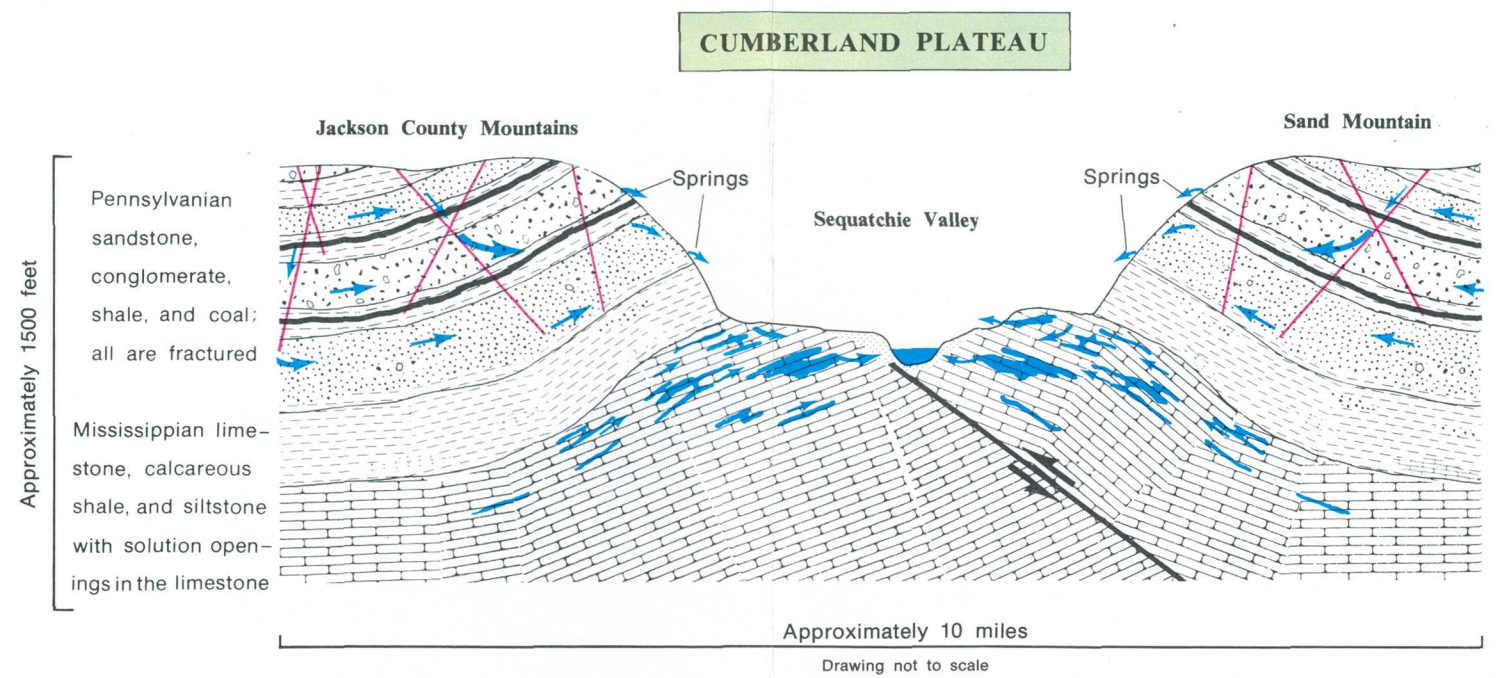


Figure 7.1-2 Ground-water occurrence and flow in the Highland Rim section.

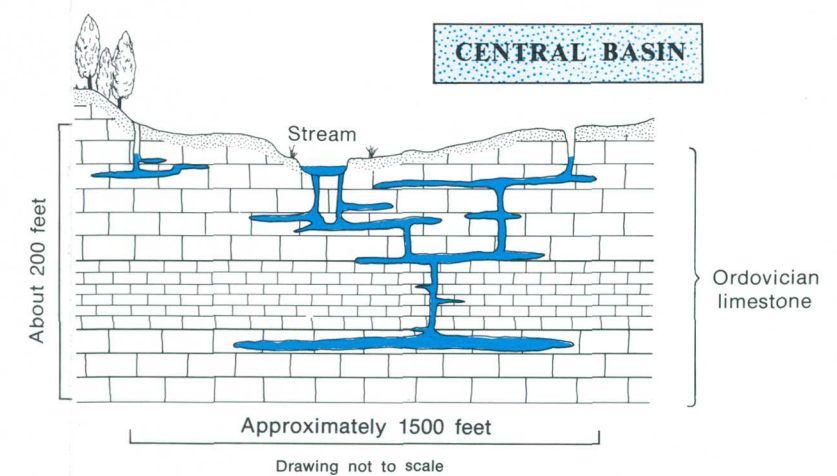
Geology from Zurawski (1978)



Geology from Zurawski (1978) and Milici (1979)

Figure 7.1-1 Ground-water occurrence and flow in the Cumberland Plateau section.

- Ground-water movement
- Fracture
- Solution Opening



Geology from Zurawski (1978)

Figure 7.1-3 Ground-water occurrence and flow in the Central Basin section.

7.0 GROUND-WATER QUANTITY

7.1 Occurrence

7.0 GROUND-WATER QUANTITY--Continued

7.2 Yield and Transmissivity

Yields and Transmissivities are Highly Variable

Yields to wells range from less than 1 to more than 3,000 gallons per minute; variations in yield and transmissivity are related to the size of fractures and solution openings.

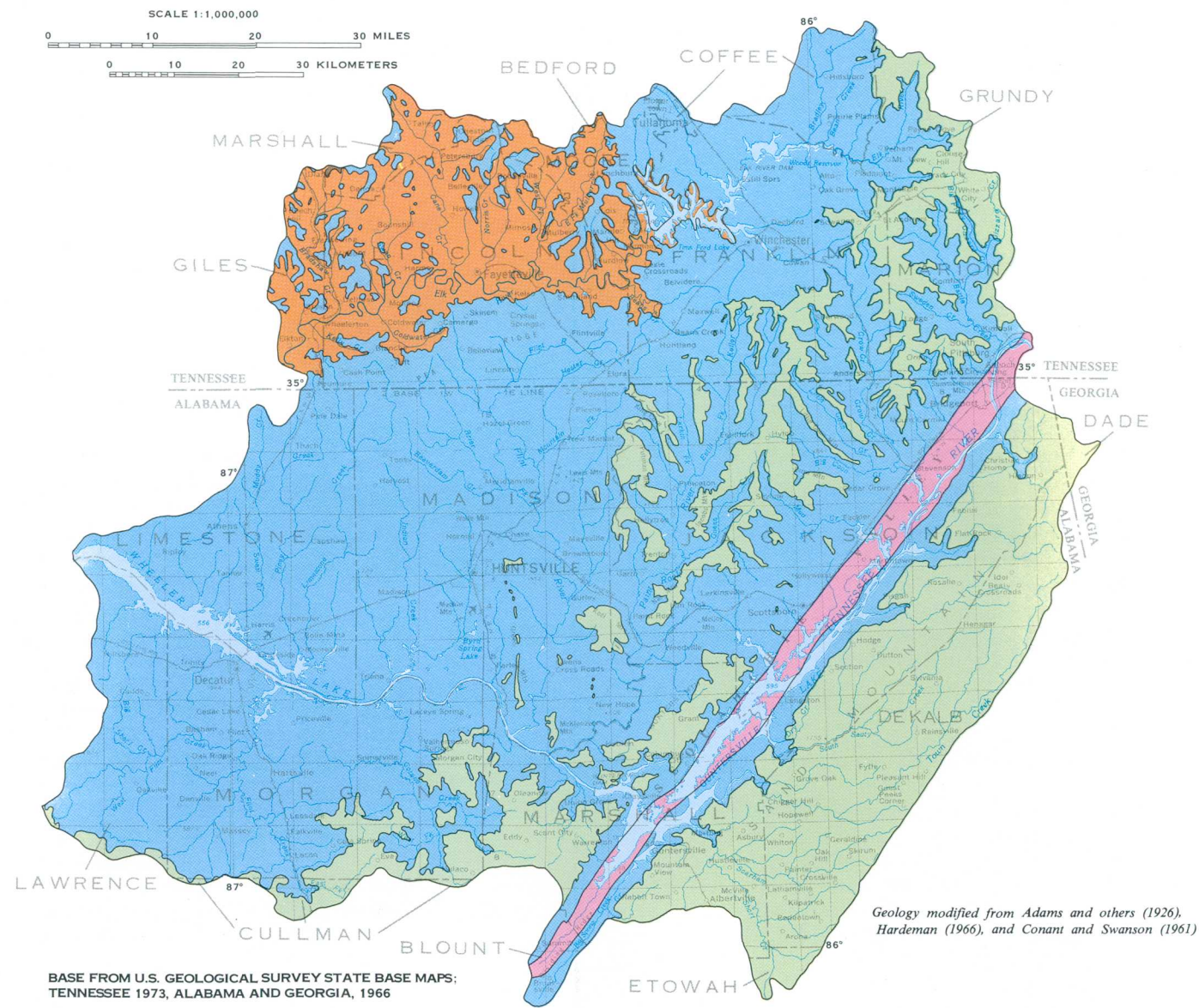
Fractured Pennsylvanian sandstone and shale yield most of the ground water to wells in the coal-resources area of the Cumberland Plateau section (fig. 7.2-1). Reported yields to more than 500 wells in the Pennsylvanian rocks range from less than 1 to about 1,000 gal/min with yields to 75 percent of the wells less than 25 gal/min. Specific capacity (yield per foot of drawdown in a well) can be used to estimate transmissivity, a measure of the ability of an aquifer to transmit water (Walton, 1962). Estimated transmissivities at 20 sites range from 50 to 13,000 ft^2/d (fig. 7.2-2) with 68 percent between 120 and 6,700 ft^2/d . This wide range is due to the variation in size and extent of the fractures.

Reported yields to more than 2,400 wells in the Mississippian carbonate rocks of the Highland Rim and Cumberland Plateau lowlands (fig. 7.2-1) range from less than 1 to more than 3,000 gal/min, but yields to 73 percent of the wells are less than 25 gal/min. Based on specific capacity data at 71 sites, transmissivities are estimated to range from 100 to 27,000 ft^2/d (fig. 7.2-2) with 68 percent between 370

and 7,100 ft^2/d . The wide range is due to differences in size of solution openings in the carbonate rocks.

Reported yields to more than 500 wells in the pre-Mississippian carbonate rocks of the Central Basin (fig. 7.2-1) range from less than 1 to more than 500 gal/min. Ninety-three percent of these wells yield less than 25 gal/min. Specific capacity data from 11 wells were used to estimate transmissivity. The estimated transmissivities range from 20 to 2,700 ft^2/d (fig. 7.2-2) with 68 percent between 30 and 1,100 ft^2/d .

Reported yields to wells in the pre-Mississippian carbonate rocks of the Sequatchie Valley of the Cumberland Plateau section (fig. 7.2-1) range from about 5 to more than 1,000 gal/min. Forty-two percent of the wells yield less than 25 gal/min. Estimated transmissivities at 16 sites range from 30 to 4,000 ft^2/d (fig. 7.2-2) with 68 percent between 40 and 2,900 ft^2/d .



REPORTED YIELDS, IN GALLONS PER MINUTE

Less than 1 to 1000

Less than 1 to greater than 3000

Less than 1 to greater than 500

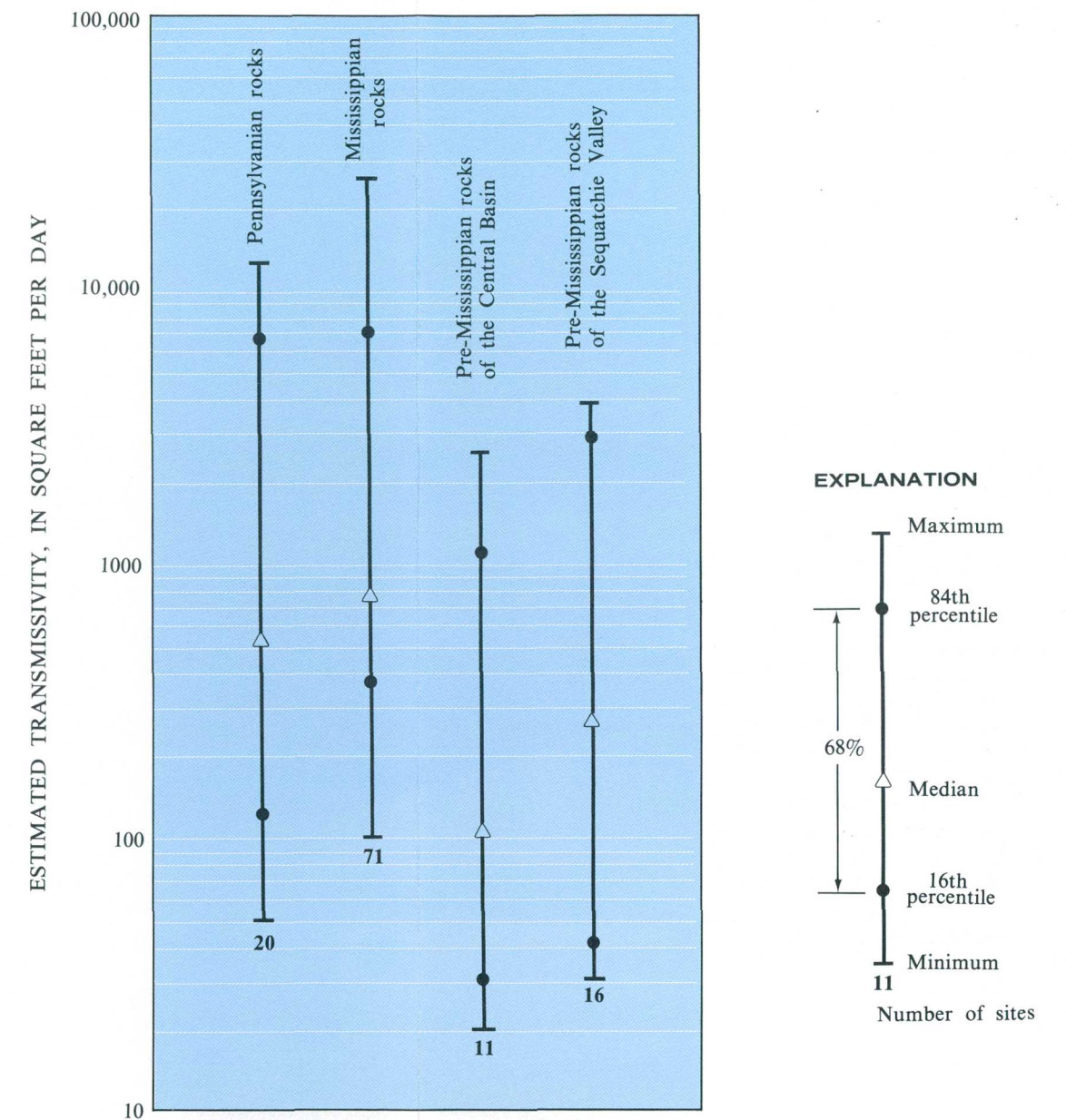
5 to greater than 1000

EXPLANATION

GEOLOGIC UNIT

- Pennsylvanian rocks:** Sandstones and shales of the coal-resources area of the Cumberland Plateau
- Mississippian rocks:** Carbonate rocks in the Highland Rim and the Cumberland Plateau lowlands
- Pre-Mississippian rocks:** Carbonate rocks of the Central Basin
- Pre-Mississippian rocks:** Carbonate rocks of the Sequatchie Valley

Figure 7.2-1 Yields and water-bearing rocks.



Transmissivity values estimated from specific capacity data in Dodson and Harris (1961), Harris and McMaster (1965), Malmberg and Downing (1957), McMaster (1963), McMaster and Harris (1963), Sanford (1966), and unpublished well records on file with the Tennessee Division of Water Resources.

Figure 7.2-2 Range of estimated transmissivities.

7.0 GROUND-WATER QUANTITY--Continued

7.3 Water Levels

Water Levels Fluctuate Seasonally

Water levels reflect seasonal variations in recharge to, and discharge from, ground-water reservoirs.

Ground-water levels in Area 21 fluctuate seasonally. Highest levels usually occur in the spring in response to intermittent recharge from precipitation. During the growing season, precipitation that would otherwise become recharge is instead transpired by growing plants or evaporated from the land surface. Lowest water levels usually occur in the fall as a result of continuing discharge and little or no recharge from precipitation. Drought in winter or unusually heavy precipitation in summer can noticeably alter this normal pattern of water-level fluctuations.

Water levels in the well at site 81 show the usual pattern of fluctuations in response to natural recharge and discharge (figs. 7.3-1 and 7.3-2). With few exceptions, water levels were highest in spring and lowest in fall. One exception was the occurrence of the annual maximum water level in July 1967 in response to a 15-inch rainfall. Water levels in this well, which taps Mississippian carbonate rocks, ranged from about 25 to 45 feet below land surface during the period of record. This large, natural fluctuation is typical in Mississippian rocks due to faster recharge and discharge through solution cavities as compared to movement through either granular or fractured rocks.

Water levels in the well at site 12, tapping Penn-

sylvanian sandstone and shale, ranged from about 50 to 75 feet below land surface. This well is affected by nearby pumping as well as by natural recharge and discharge. Seasonal pumping increased the magnitude of fluctuation during several periods (fig. 7.3-3). Natural water-level fluctuations during periods without pumping generally were less than 2 feet, characteristic of Pennsylvanian rocks.

Natural water-level fluctuations in these two wells are fairly representative of those in similar formations in Area 21 (fig. 7.3-1). Additional data may be obtained from the annual data reports "Water Resources Data for Tennessee" and "Water Resources Data for Alabama" available from:

U.S. Geological Survey
A-413 Federal Bldg. - U.S. Courthouse
Water Resources Division
Nashville, TN 37203

or

U.S. Geological Survey
Water Resources Division
520 19th Avenue
Tuscaloosa, AL 35401

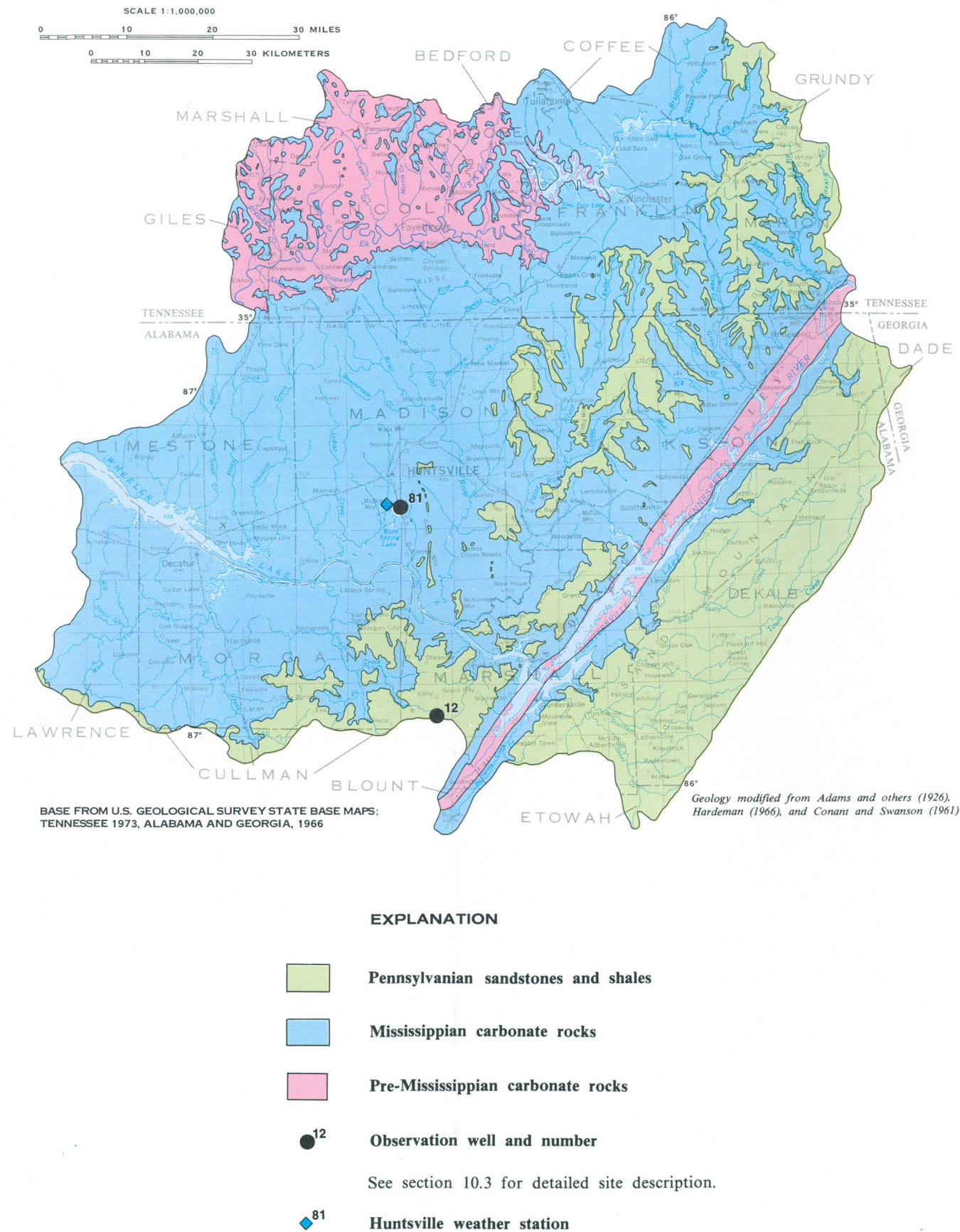


Figure 7.3-1 Geology and observation wells.

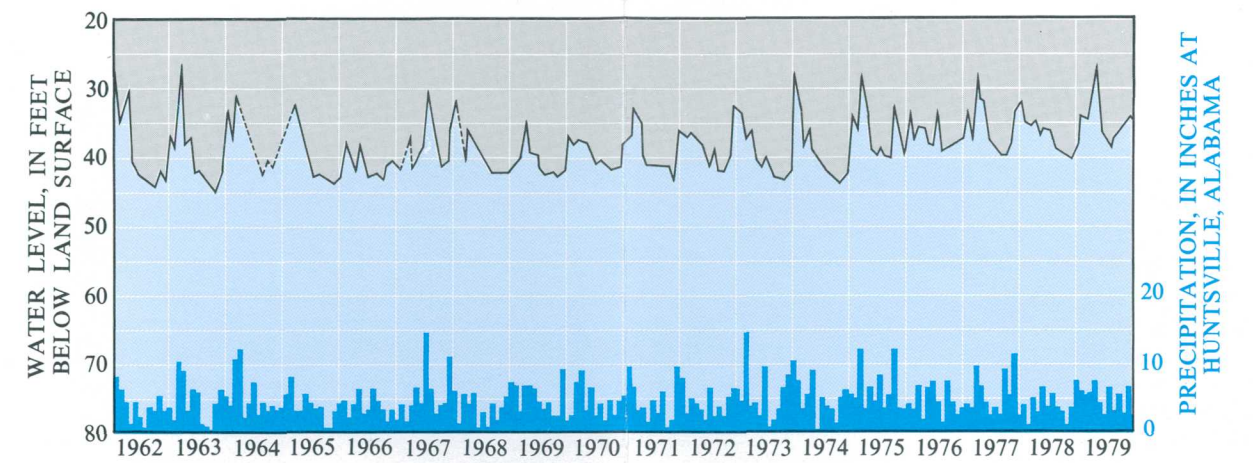


Figure 7.3-2 Water levels for well tapping the Mississippian carbonate rocks.

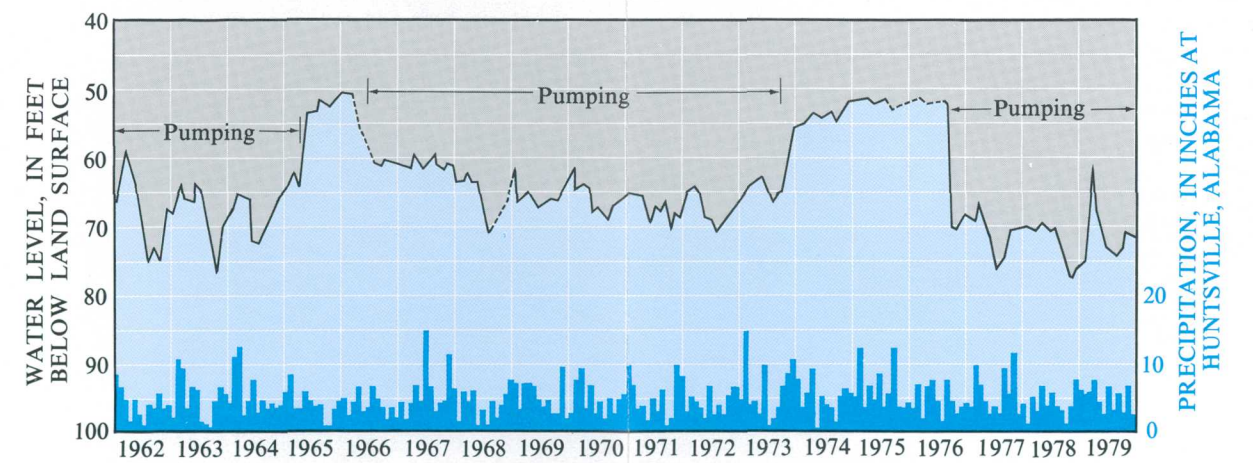


Figure 7.3-3 Water levels for well tapping the Pennsylvanian sandstone and shale.

8.0 QUALITY OF GROUND WATER

Quality of Ground Water is Variable

Dissolved solids ranged from 44 to 6,000 milligrams per liter depending upon several environmental factors.

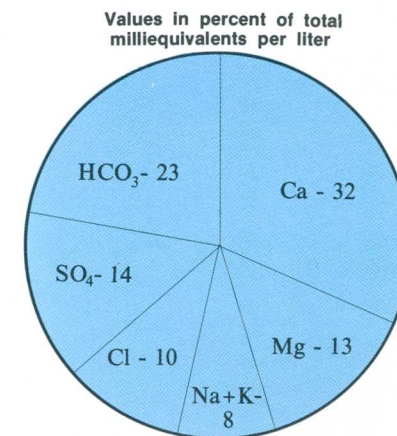
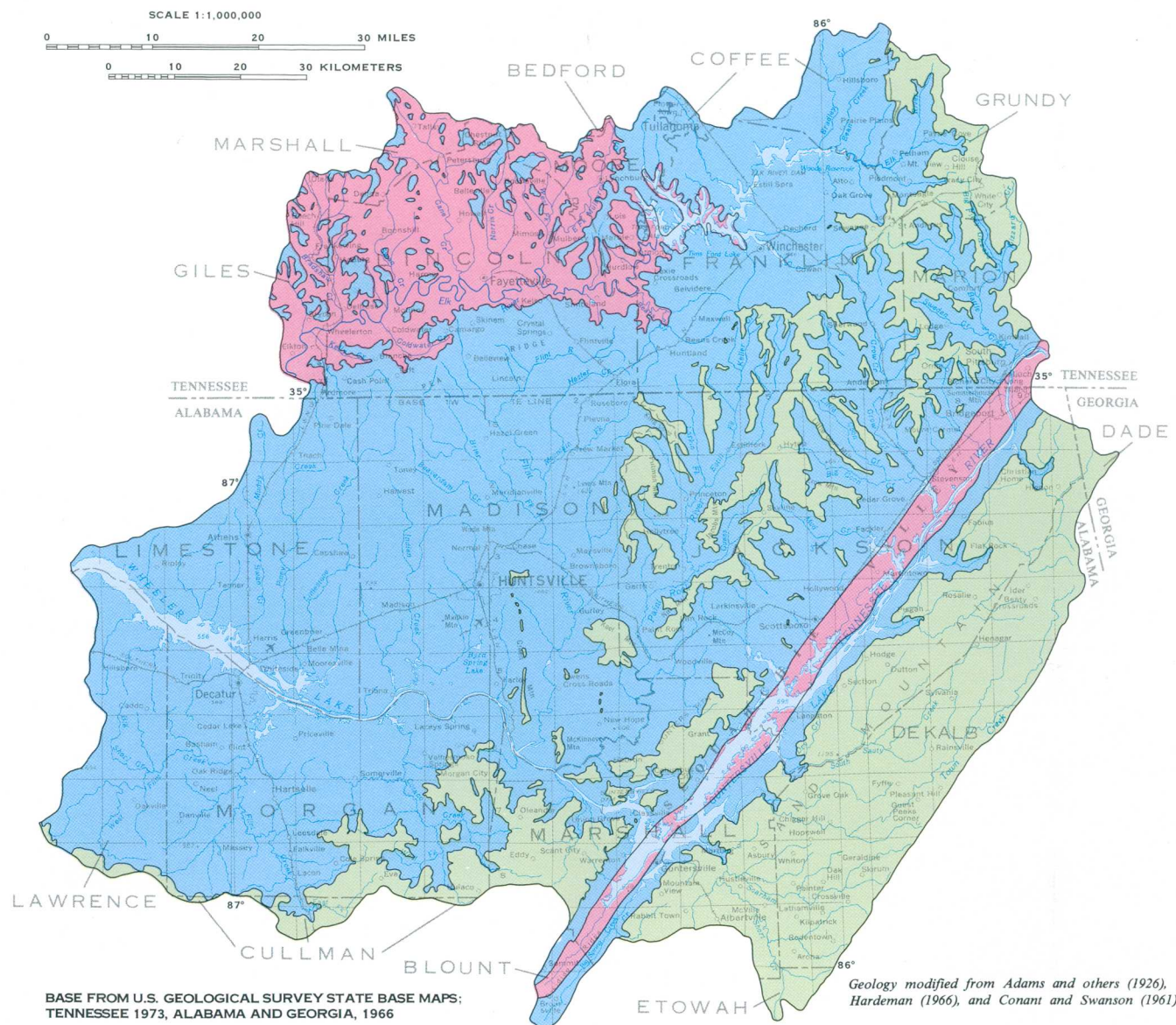
The quality of ground water depends on properties of the rocks, distance from recharge areas, time the water has been in contact with the rocks, and the overall pattern of ground-water circulation. Because of the variety of rock types, distances, contact times, and circulation patterns in Area 21, the quality of ground water is highly variable.

Minimum, maximum, and median values of selected constituents and physical properties of water from the Pennsylvanian, Mississippian, and pre-Mississippian rocks and from regolith overlying Mississippian rocks are shown on figure 8.0-1. The dissolved solids in water collected from the four units ranged from 44 to 6,000 mg/L. Water from Pennsylvanian rocks was generally of the calcium-magnesium-sulfate-bicarbonate type. In contrast, water from Mississippian and pre-Mississippian rocks and from regolith overlying Mississippian rocks was generally of the calcium-bicarbonate type with similar properties from unit to unit.

Median pH values ranged from 6.6 to 7.5, and

median specific conductance ranged from 63 to 330 $\mu\text{mho/cm}$. Lowest values for these properties were observed in the Pennsylvanian rocks and regolith overlying Mississippian rocks; highest values were observed in Mississippian and pre-Mississippian rocks. Median values for hardness of water varied from soft in the Mississippian regolith and in the Pennsylvanian sandstone and shale to hard in the pre-Mississippian limestone. Generally, chloride concentrations were less than 10 mg/L for all waters.

Iron and sulfate may cause some problems in the area. Locally, iron exceeds the 300 $\mu\text{g/L}$ recommended limit for drinking water (U.S. Environmental Protection Agency, 1979), especially in waters from Pennsylvanian rocks and the regolith overlying Mississippian rocks. Sulfate may exceed the 250 mg/L recommended limit in some areas where wells tap Mississippian or pre-Mississippian rocks (fig. 8.0-1). Otherwise the water is generally good and suitable for most uses.



REGOLITH FROM MISSISSIPPIAN ROCKS

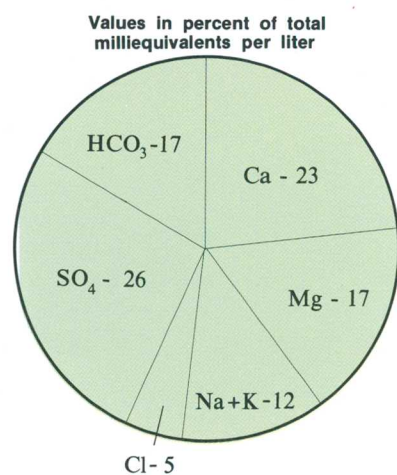
Constituent or property	Concentrations in milligrams per liter unless otherwise specified			
	Minimum	Maximum	Median	Number of analyses
Calcium (Ca)	4.5	52	13.0	79
Magnesium (Mg)	0.9	22	3.4	79
Sodium (Na)	0.8	30	3.0	75
Potassium (K)	0.5	36	2.6	75
Bicarbonate (HCO ₃)	0	230	50.0	105
Sulfate (SO ₄)	0.2	85	3.0	79
Chloride (Cl)	1.2	42	7.5	104
Iron (Fe)	< 0.01	72	0.15	78
Silica (SiO ₂)	1.6	9.5	4.7	75
Specific conductance (micromhos per centimeter at 25°C)	39	697	132	106
Hardness (CaCO ₃)	17	200	54.0	104
pH (units)	3.3	8.1	6.6	106
Solids (residue at 180°C)	44	209	80.0	45
Temperature (°C)	13.5	20.0	16.0	70

MISSISSIPPIAN ROCKS

Constituent or property	Concentrations in milligrams per liter unless otherwise specified			
	Minimum	Maximum	Median	Number of analyses
Calcium (Ca)	1.6	610	44.5	99
Magnesium (Mg)	0.3	210	6.8	99
Sodium (Na)	1.0	1,400	3.1	82
Potassium (K)	0.0	65	1.2	80
Bicarbonate (HCO ₃)	0	1,190	118	239
Sulfate (SO ₄)	0	3,600	9.0	86
Chloride (Cl)	< 0.1	38,000	4.2	237
Iron (Fe)	0.0	18	0.1	97
Silica (SiO ₂)	< 0.1	78	8.2	79
Manganese (Mn)	0.006	0.08	0.015	4
Specific conductance (micromhos per centimeter at 25°C)	22	62,200	240	240
Hardness (CaCO ₃)	6	81,000	120	238
pH (units)	5.6	10.8	7.5	240
Solids (residue at 180°C)	47	6,000	160	55
Temperature (°C)	13.0	25.0	16.5	148

PRE-MISSISSIPPIAN ROCKS

Constituent or property	Concentrations in milligrams per liter unless otherwise specified			
	Minimum	Maximum	Median	Number of analyses
Calcium (Ca)	13	250	66.0	18
Magnesium (Mg)	1.5	55	12.0	18
Sodium (Na)	1.4	240	7.6	17
Potassium (K)	0.7	6.0	1.8	17
Bicarbonate (HCO ₃)	43	350	195	28
Sulfate (SO ₄)	0.2	510	21.0	19
Chloride (Cl)	0.2	180	4.0	28
Iron (Fe)	< 0.01	0.35	0.04	8
Silica (SiO ₂)	6.8	11	8.4	12
Manganese (Mn)	0.02	0.24	0.065	8
Specific conductance (micromhos per centimeter at 25°C)	82	1,400	330	28
Hardness (CaCO ₃)	32	830	125	28
pH (units)	6.5	8.5	7.2	28
Solids (residue at 180°C)	98	1,030	278	12
Temperature (°C)	12.0	18.7	16.0	26



PENNSYLVANIAN ROCKS

Constituent or property	Concentrations in milligrams per liter unless otherwise specified			
	Minimum	Maximum	Median	Number of analyses
Calcium (Ca)	6.5	43	16.0	3
Magnesium (Mg)	2.4	65	6.9	3
Sodium (Na)	3.4	42	8.1	3
Potassium (K)	1.9	3.4	1.9	3
Bicarbonate (HCO ₃)	4	272	20.0	30
Sulfate (SO ₄)	4	166	27.0	4
Chloride (Cl)	0.4	40	3.0	29
Silica (SiO ₂)	7.6	17	8.6	3
Specific conductance (micromhos per centimeter at 25°C)	20	810	63.0	24
Hardness (CaCO ₃)	5	374	20.0	30
pH (units)	6.0	8.3	7.0	30
Solids (residue at 180°C)	56	109	--	2
Temperature (°C)	14.5	17.0	16.0	16

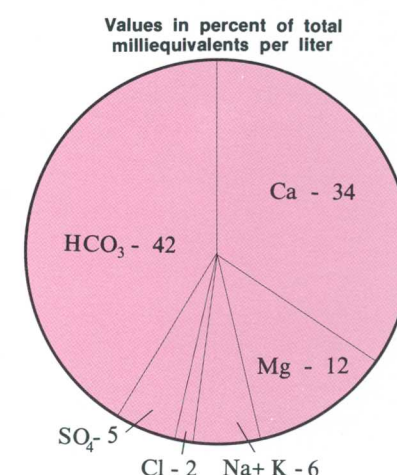


Figure 8.0-1 Quality of ground water.

9.0 WATER-DATA SOURCES

9.1 Introduction

NAWDEX, WATSTORE, and OWDC 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. These activities are:

(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 is available.

(2) The National Water Data Storage and Retrieval System (WATSTORE), 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.

9.0 WATER-DATA SOURCES--Continued
9.2 National Water-Data Exchange (NAWDEX)

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 (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 Assistant 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
TENNESSEE
U.S. Geological Survey
Water Resources Division
A-413 Federal Building - U.S. Courthouse
Nashville, TN 37203
Telephone: (615) 251-5424
FTS 852-5424

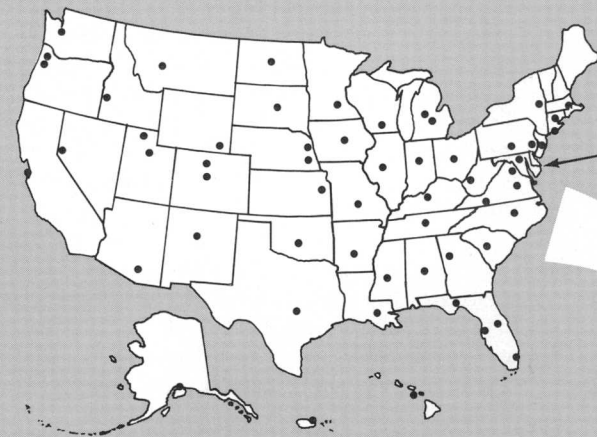
Hours: 7:45 - 4:30 Central Time

or

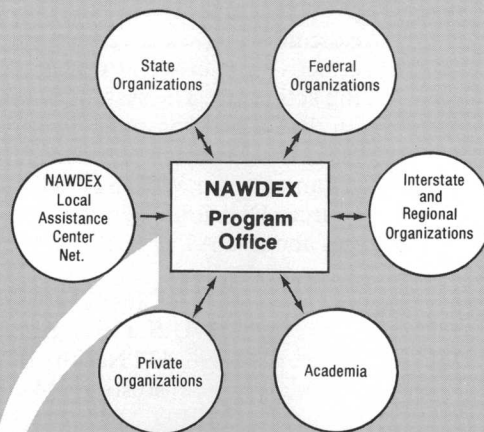
NAWDEX ASSISTANCE CENTER
ALABAMA
U.S. Geological Survey
Water Resources Division
520 19th Avenue
Tuscaloosa, AL 35401
Telephone: (205) 752-8104
FTS 229-2957

Hours: 7:30 - 4:00 Central Time

A PROGRAM TO PROVIDE ACCESS TO WATER DATA



**LOCAL ASSISTANCE CENTERS
59 OFFICES IN 45 STATES AND
PUERTO RICO**



USER SERVICES

- Data Search Assistance
- Request-Referral Service
- Access to Major Water Data Bases
- Data Source Identification
- Nationwide Index of Water Data

Figure 9.2-1 Access to water data.

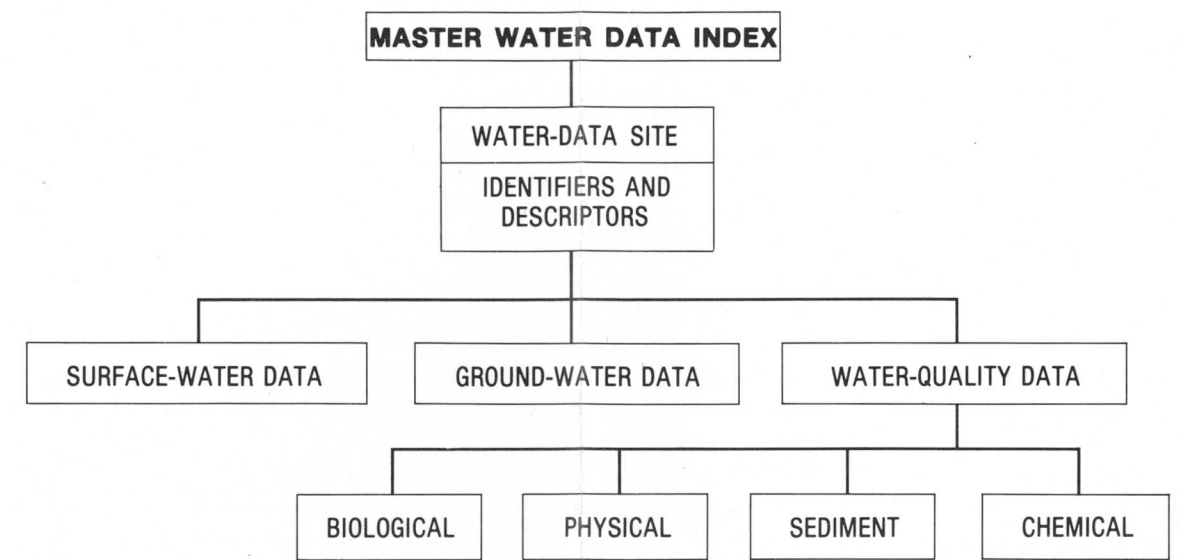


Figure 9.2-2 Master water-data index.

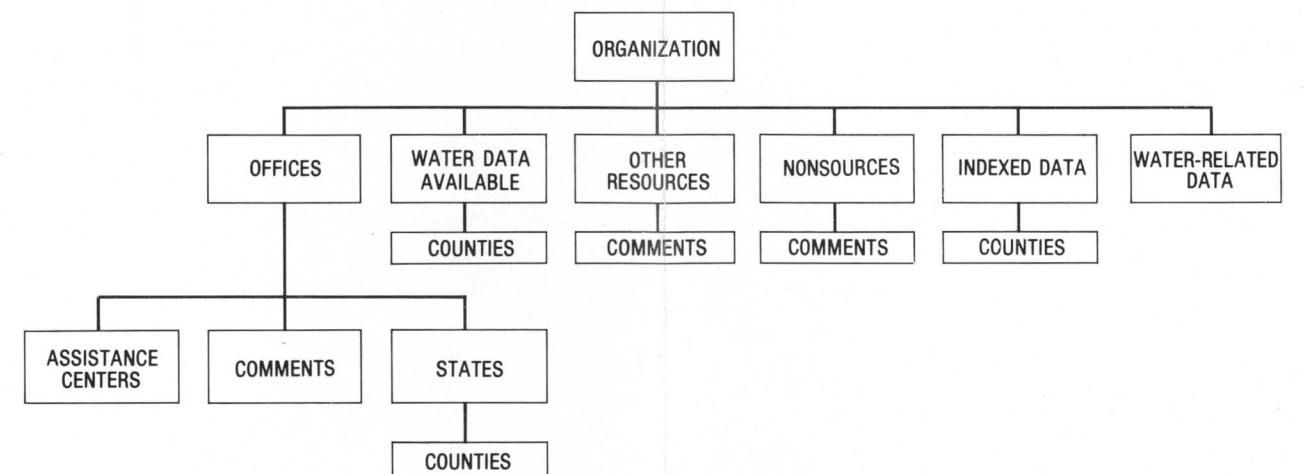


Figure 9.2-3 Water-date sources directory.

9.0 WATER-DATA SOURCES--Continued
9.3 WATSTORE

WATSTORE Automated Data System

The National Water Data Storage and Retrieval System (WATSTORE) 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 (WATSTORE) 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, Virginia. Data may be obtained from WATSTORE through the Water Resources Division's 46 district offices. General inquiries about WATSTORE may be directed to:

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

or

U.S. Geological Survey
Water Resources Division
A-413 Federal Building - U.S. Courthouse
Nashville, TN 37203

or

U.S. Geological Survey
Water Resources Division
520 19th Avenue
Tuscaloosa, AL 35401

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 WATSTORE system consists of several files

in which data are grouped and stored by common characteristics and data-collection frequencies. The system is also 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 WATSTORE 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 characteris-

tics 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 WATSTORE 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 accommodate 255 data elements and currently contains data for nearly 70,000 sites.

All data files of the WATSTORE 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 WATSTORE 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 WATSTORE 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, Virginia. 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, Colorado, and Atlanta, Georgia, 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 WATSTORE.

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, WATSTORE 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 WATSTORE 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 WATSTORE. 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: WATSTORE 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: WATSTORE 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 WATSTORE 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 WATSTORE system or in the form of punched cards or card images on magnetic tape.

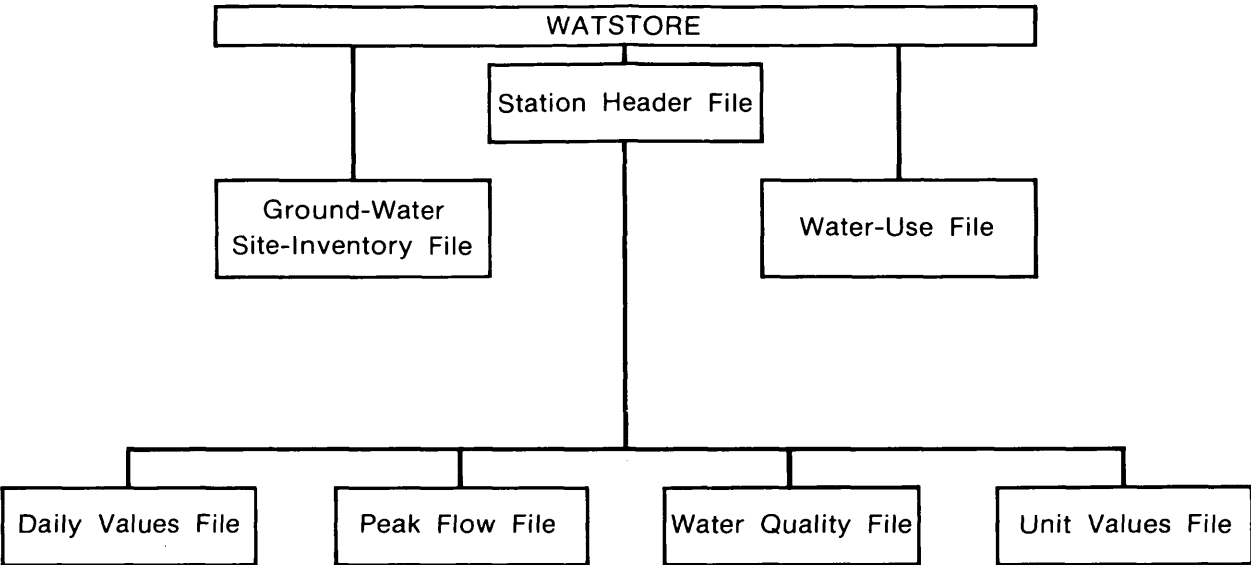


Figure 9.3-1 Files of stored data.

9.0 WATER-DATA SOURCES--Continued

9.4 Index to Water-Data Activities in Coal Provinces

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 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
A-413 Federal Building - U.S. Courthouse
Nashville, TN 37203

Telephone: (615) 251-5424
FTS 852-5424

or

U.S. Geological Survey
Water Resources Division
520 19th Avenue
University, AL 35401

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

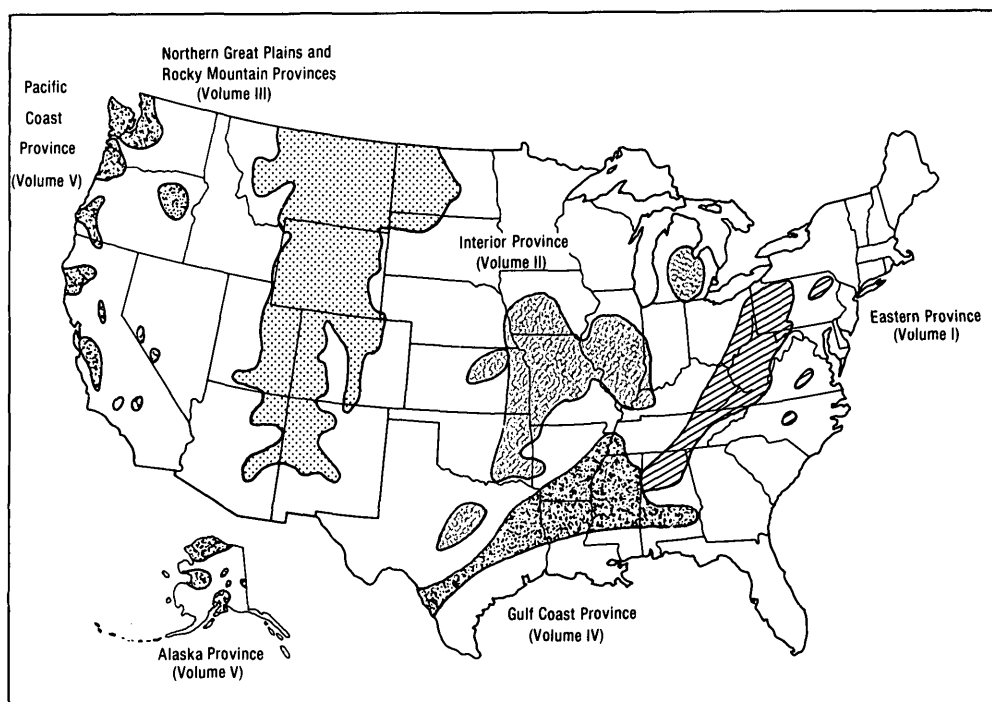


Figure 9.4-1 Index volumes and related provinces.

10.0 SUPPLEMENTAL INFORMATION FOR AREA 21

10.1 Stream-Use Classification - Tennessee and Alabama Streams

TENNESSEE STREAMS

Definition of Classification Codes

DOM	Domestic water supply	REC	Recreation
IND	Industrial water supply	IRR	Irrigation
FISH	Fish and aquatic life	LW&W	Livestock watering and wildlife
	NAV		Navigation

STREAM	DESCRIPTION (miles above mouth)	CLASSIFICATION						
		DOM	IND	FISH	REC	IRR	LW&W	NAV
Tennessee River	Tennessee-Alabama State Line (Mile 416.5) to Mile 422	x	x	x	x	x	x	x
Unnamed Tributary	At Tennessee River Mile 417.5, Mile 0.0 to origin			x		x	x	
Battle Creek	Mile 0.0 to origin	x	x	x	x	x	x	
Big Fiery Gizzard Cr.	Mile 0.0 to origin			x	x		x	
Little Fiery								
Gizzard Creek	Mile 0.0 to origin			x	x	x	x	
Unnamed Tributary	At Little Fiery Gizzard Mile 0.6, Mile 0.0 to origin			x		x	x	
Elk River	Mile 36.3 to origin	x	x	x	x	x	x	
Mulberry Creek	Mile 0.0 to origin		x	x	x	x	x	
East Fork Mulberry Cr.	Mile 0.0 to 9.0		x	x	x		x	
East Fork Mulberry Cr.	Mile 9.0 to 11.1		x	x			x	
East Fork Mulberry Cr.	Mile 11.1 to origin	x	x	x	x	x	x	
Spring Branch	Mile 0.0 to origin	x	x	x	x	x	x	
Beans Creek	Mile 0.0 to origin		x	x	x	x	x	
Factory Branch	Mile 0.0 to origin		x	x	x	x	x	
Mathias Branch	Mile 0.0 to origin		x	x	x	x	x	
Hurricane Creek	Mile 0.0 to 11.0		x	x	x	x	x	
Hurricane Creek	Mile 11.0 to 13.0 (origin)		x	x			x	
Boiling Fork Creek	Mile 0.0 to 11.0	x	x	x	x	x	x	
Wagner Creek	Mile 0.0 to 1.5	x	x	x	x	x	x	
Wagner Creek	Mile 1.5 to 2.5		x	x			x	
Wagner Creek	Mile 2.5 to origin		x	x	x		x	
Boiling Fork Creek	Mile 11.0 to 13.1		x	x			x	
Boiling Fork Creek	Mile 13.1 to origin		x	x	x	x	x	
Rock Creek	Mile 0.0 to 6.0		x	x	x	x	x	
Rock Creek	Mile 6.0 to 10.8		x	x			x	
Rock Creek	Mile 10.8 to origin		x	x	x	x	x	
Rollins Creek	Mile 0.0 to 2.5	x	x	x	x	x	x	
Rollins Creek	Mile 2.5 to origin			x				
Mud Creek	Mile 0.0 to 6.0		x	x	x	x	x	
Mud Creek	Mile 6.0 to 8.1 (origin)		x	x			x	
Caldwell Creek	Mile 0.0 to origin		x	x	x	x	x	
All other tributaries in the Elk River basin, named and unnamed, which have not been specifically treated shall be classified				x	x	x	x	

ALABAMA STREAMS

Definition of Classification Codes (in descending order of quality)

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

THE TENNESSEE RIVER BASIN

INTERSTATE WATERS

Stream	From	To	Classification
Tennessee River			
Wheeler Lake	Elk River	U.S. Highway 31 (see Note 1 this basin)	S,F&W
Wheeler Lake	U.S. Highway 31	Flint Creek	PWS,S,F&W
Wheeler Lake	Flint Creek	Indian Creek	S,F&W
Wheeler Lake	Indian Creek	Flint River	PWS,F&W
Wheeler Lake	Flint River	Guntersville Dam	S,F&W
Guntersville Lake	Guntersville Dam	Upper end of Buck's Island (see Note 2 this basin)	PWS,S,F&W
Guntersville Lake	Upper end of Buck's Island	Roseberry Creek	S,F&W

ALABAMA STREAMS--Continued

Definition of Classification Codes (in descending order of quality)

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

THE TENNESSEE RIVER BASIN--Continued

INTERSTATE WATERS--Continued

<u>Stream</u>	<u>From</u>	<u>To</u>	<u>Classification</u>
Tennessee River--Continued			
Guntersville Lake	Roseberry Creek	Alabama-Tennessee State Line (see Note 3 this basin)	PWS,S,F&W
Piney Creek	Wheeler Lake	County road vicinity of Wooley Springs	F&W
Piney Creek	County road vicinity of Wooley Springs	Alabama-Tennessee State Line	A&I
Limestone Creek	Wheeler Lake	Alabama-Tennessee State Line	F&W
Flint River	Wheeler Lake	Alabama-Tennessee State Line	F&W
Paint Rock River (Including Estill and Larkin Forks)	Wheeler Lake	Alabama-Tennessee State Line	F&W
Crow Creek	Guntersville Lake	Alabama-Tennessee State Line	F&W

INTRASTATE WATERS

Swan Creek	Tennessee River	Highway 24 Crossing	F&W
Swan Creek	Highway 24 Crossing	Town Creek	A&I
Swan Creek	Town Creek	its source	F&W
Town Creek (Athens)	Swan Creek	its source	A&I
Flint Creek	Tennessee River	L&N Railroad	F&W
Flint Creek	L&N Railroad	Alabama Highway 36	PWS,F&W
Flint Creek	Alabama Highway 36	its source	A&I
Shoal Creek	Flint Creek	its source	A&I
Cotaco Creek	Tennessee River	its source	S,F&W
Brown Creek	Cotaco Creek	Jct. with Gilliam Creek	A&I
Gilliam Creek	Brown Creek	its source	A&I
Bradford Creek	Barren Fork Creek	its source	F&W
Indian Creek	Tennessee River	its source	F&W
Unnamed Tributary of Indian Creek	Indian Creek	its source	F&W
Huntsville Spring Branch	Indian Creek	Redstone Arsenal Boundary (south)	F&W
Huntsville Spring Branch	Redstone Arsenal Boundary (south)	its source	F&W
Aldridge Creek	Tennessee River	its source	F&W
Sand Branch	Hurricane Creek	its source	A&I
Short Creek	Tennessee River	its source	F&W
Drum Creek	Short Creek	its source	F&W
East Fork of Drum Creek	Drum Creek	its source	A&I
Turkey Creek	Short Creek	its source	A&I
Town Creek (DeKalb County)	Tennessee River	its source	F&W
South Sauty Creek	Tennessee River	its source	S,F&W
North Sauty Creek	Tennessee River	its source	PWS
Roseberry Creek	Tennessee River	its source	F&W
Flat Rock Creek	Tennessee River	its source	S,F&W
Widow's Creek	Tennessee River	its source	S,F&W
Long Island Creek	Tennessee River	its source	S,F&W
Turkey Creek	Wade Creek	its source	PWS,F&W
Benji's Creek	Crow Creek	its source	F&W

- Note 1. That portion of Wheeler Lake in the immediate vicinity of the discharge from the city of Decatur's sewage treatment plant is not considered suitable for SWIMMING AND OTHER WHOLE-BODY WATER-CONTACT SPORTS.
2. Those portions of Guntersville Lake in the immediate vicinity of discharges from the City of Guntersville's sewage treatment plants are not considered suitable for SWIMMING AND OTHER WHOLE-BODY WATER-CONTACT SPORTS nor for sources of PUBLIC WATER SUPPLY.
3. That portion of Guntersville Lake in the immediate vicinity of the discharge of sewage from the City of Bridgeport is not considered suitable for use as a source of PUBLIC WATER SUPPLY nor for SWIMMING AND OTHER WHOLE-BODY WATER-CONTACT SPORTS.

10.0 SUPPLEMENTAL INFORMATION FOR AREA 21
10.1 Stream-Use Classification - Tennessee
and Alabama Streams

10.0 SUPPLEMENTAL INFORMATION FOR AREA 21--Continued

10.2 List of Surface-Water Network Sites

Site number	Station		Location		Drainage area (mi ²)	Type of record and period collected		
	Number	Name	Latitude (° , ' , ")	Longitude (° , ' , ")		Discharge	Chemical quality	Sediment
1	03571775	Battle Creek above Cave Cove, Tenn.	35 10 55	085 46 12	16.9	1962-67, 1970		
2	03571800	Battle Creek near Monteagle, Tenn.	35 08 03	085 46 15	50.4	1955-	1979-81	1979-81
3	03571823	Big Fiery Gizzard Creek near South Pittsburg, Tenn.	35 06 42	085 44 37	52.1	1953-55		
4	03571827	Kelly Cove Creek at Smithtown, Tenn.	35 04 48	085 44 11	4.42	1955, 1957, 1979-81	1979-80	1980
5	03571835	Sweden Creek near South Pittsburg, Tenn.	35 03 52	085 45 55	28.2	1943, 1953-55, 1979-81	1979-81	1979-81
6	03571850	Tennessee River at South Pittsburg, Tenn.	35 00 41	085 41 51	22,640	1930-	1967-	1975-
7	03571855	Poplar Spring Branch at Richard City, Tenn.	34 59 32	085 43 16	5.25	1962-67, 1970		
8	03572030	Depot Branch at Sewanee, Tenn.	35 11 10	085 55 05	.42	1950-52, 1954, 1956		
9	03572090	Crow Creek at Anderson, Tenn.	34 59 39	085 54 09	78.2	1953-54, 1957, 1969		
10	03572092	Crow Creek near Anderson, Tenn.	34 59 28	085 54 07	78.4	1979-81	1979-81	1979-81
11	03572110	Crow Creek at Bass, Ala.	34 56 03	085 55 03	130	1975-	1973-81	1979-81
12	03572210	Flat Rock Creek at Flat Rock, Ala.	34 45 55	085 42 30	28.3	1973, 1979-81	1979-81	1979-81
13	03572230	Dry Creek near Fabius, Ala.	34 47 00	085 47 00	9.50	1973, 1979-81	1979-81	1979-80
14	03572300	Mud Creek near Scottsboro, Ala.	34 47 17	085 58 37	73.9	1963-65, 1973-74	1965	1979-80
15	03572400	Bryant Creek near Pisgah, Ala.	34 38 48	085 50 34	41.8	1963-65, 1974, 1979-80	1965, 1979-80	1979-80
16	03572405	Bryant Creek at Pisgah, Ala.	34 39 29	085 51 29	49.0	1963-65, 1973-74, 1979-80		
17	03572415	Little Bryant Creek at Pisgah, Ala.	34 40 30	085 51 00	6.50	1973-74, 1980-81	1981	1980-81
18	03572500	Tennessee River near Scottsboro, Ala.	34 38 20	085 58 28		1934-39	1965	
19	03572700	South Sauty Creek near Macedonia, Ala.	34 29 58	085 57 52	102	1963-65, 1973, 1980	1965, 1979-80	1979-80
20	03572870	Town Creek at Guest Bridge, Ala.	34 25 38	085 52 33	-		1971-72	
21	03572900	Town Creek near Geraldine, Ala.	34 22 42	085 59 25	141	1957-	1966-72, 1975, 1977-81	1980
22	03572905	Town Creek at Elrod Bridge, Ala.	34 23 24	086 01 12	-		1971-72	
23	03572990	Short Creek near Myrtle tree Church, Ala.	34 15 26	086 07 29		1946-60, 1964-65	1965	
24	03573000	Short Creek near Albertville, Ala.	34 18 05	086 10 53	91.6	1945-53	1968	
25	03573430	Big Spring Creek near Brooks-ville, Ala.	34 13 08	086 24 30	12.8	1968-70	1968	
26	03573500	Tennessee River at Guntersville, Ala.	34 22 23	086 17 22	24,340	1930-39	1969-70	
27	03574230	Paint Rock River near Princeton, Ala.	34 49 40	086 14 36	-			
28	03574410	Clear Creek at Garth, Ala.	34 43 40	086 18 39	18.0	1943, 1952-54, 1957, 1960-61		
29	03574440	Cole Spring Branch near Paint Rock, Ala.	34 40 59	086 19 48	9.63	1971, 1974-75, 1978		
30	03574500	Paint Rock River near Woodville, Ala.	34 37 27	086 18 23	320	1935-	1955-66, 1968-69, 1972, 1977-	
31	03574550	Little Paint Creek near Woodville, Ala.	34 36 17	086 16 35	57.5	1943, 1953-54, 1957, 1970-73	1973	

Site number	Station		Location		Drainage area (mi ²)	Type of record and period collected		
	Number	Name	Latitude (° ' ")	Longitude (° ' ")		Discharge	Chemical quality	Sediment
32	03574560	Paint Rock River at Butler Mill, near Woodville, Ala.	34 34 47	086 18 05	392	1970-74	1973-78	
33	03574580	Tremble Creek near New Hope, Ala.	34 34 37	086 20 40	9.73	1970-74	1973	
34	03574600	Paint Rock River near New Hope, Ala.	34 30 45	086 20 25	415	1972-74	1973,1975-77	
35	03574673	Little Paint Rock Creek at Hebron, Ala.	34 29 04	086 23 11	9.43	1970-74	1973	
36	03574700	Big Huckleberry Creek near Belvidere, Tenn.	35 04 00	086 21 29	2.18	1957,1959, 1961-65		
37	03574709	Flint River above Stewart Branch, near Fisk, Ala.	34 59 20	086 31 32	-	1973,1975-78	1973,1975-78	
38	03574710	Stewart Branch near Hazel Green, Ala.	34 59 07	086 31 05	2.27	1970-73	1973	
39	03574715	Slate Rock Branch near Hazel Green, Ala.	34 59 00	086 32 38	1.71	1970-73	1973	
40	03574743	Walker Creek near Hazel Green, Ala.	34 58 34	086 34 24	26.2	1970-73	1973	
41	03574747	Fowler Creek near Hazel Green, Ala.	34 58 36	086 35 06	8.02	1970-74	1973	
42	03574755	Pigrum Branch near Hazel Green, Ala.	34 56 21	086 31 12	4.26	1970-73	1973	
43	03574770	Flint River near New Market, Ala.	34 52 44	086 28 50	132	1970-75	1973	
44	03574790	Mountain Fork at Mountain Fork Road, New Market, Ala.	34 55 04	086 24 05	23.1	1970-75,1980	1973	
45	03574795	Hester Creek near Plevna, Ala.	34 58 40	086 27 06	26.1	1962-65,1970-74	1973,1975-78	
46	03574796	Walker Branch near Plevna, Ala.	34 57 55	086 26 45	.44	1970-75		
47	03574802	Mountain Fork near New Market, Ala.	34 52 32	086 28 27	84.4	1944,1970-74	1973-78	
48	03574806	Brier Fork Flint River above Huckleberry Branch, near Hazel Green, Ala.	34 58 38	086 40 13		1970-72	1973	
49	03574815	Brier Fork near Hazel Green, Ala.	34 55 10	086 37 18	22.0	1970-74	1973	
50	03574817	Copeland Creek at Elkwood Section Road, near Hazel Green, Ala.	34 58 37	086 37 49	-	1970-73	1973	
51	03574820	Copeland Creek near Hazel Green, Ala.	34 55 29	086 36 15	9.36	1970-74	1973	
52	03574825	Brier Fork near Meridianville, Ala.	34 52 33	086 34 14	44.6	1949,1970-74	1973	
53	03574835	Brier Fork above Beaverdam Creek, near Meridianville, Ala.	34 51 12	086 32 35	47.8	1949,1970-74	1973,1975-78	
54	03574840	Morris Branch near Toney, Ala.	34 53 57	086 41 55	1.43	1970-74		
55	03574855	Beaverdam Creek at Pulaski Pike, near Meridianville, Ala.	34 51 40	086 38 34	19.5	1970-75		
56	03574872	Straight Ditch at Huntsville, Ala.	34 49 24	086 32 09	.17	1970-75		
57	03574998	Brier Fork near Chase, Ala.	34 49 24	086 29 05	112	1970-75	1973	
58	03575000	Flint River near Chase, Ala.	34 49 08	086 28 52	342	1961-80	1965-66,1968-69, 1971 1971-81	
59	03575020	Flint River near Cedar Gap, Ala.	34 47 15	086 29 05	-	1972-73	1971	1971
60	03575028	Chase Creek near Chase, Ala.	34 47 06	086 29 23	8.42	1970-75	1973	
61	03575040	Flint River near Mount Carmel, Ala.	34 47 13	086 28 51	362	1971-	1971-73,1975-81	1971
62	03575100	Flint River at Brownsboro, Ala.	34 44 27	086 26 29	375	1963,1970-73	1973	
63	03575120	Flint River west of Gurley, Ala.	34 41 47	086 25 20	390	1952,1970-75	1973,1975-78	
64	03575140	Hurricane Creek near New Market, Ala.	34 52 44	086 23 14		1970-75	1973,1975	
65	03575150	Hurricane Creek above Molder Branch, near Maysville, Ala.	34 48 07	086 24 12	28.9	1970-75	1973	
66	03575157	Hurricane Creek near Maysville, Ala.	34 45 19	086 23 32	50.0	1962-65,1971-74	1973	
67	03575210	Hurricane Creek west of Gurley, Ala.	34 41 53	086 24 55	72.5	1944,1970-73	1973	
68	03575250	Flint River near Gurley, Ala.	34 42 33	086 23 59	476	1948,1961, 1970-72 1958-62,1970, 1973	1970-71	
69	03575280	Flint River near Big Cove, Ala.	34 38 17	086 28 08	-		1973	
70	03575330	Flint River at Owens Cross Roads, Ala.	34 35 38	086 28 06	517	1970-74	1973	
71	03575340	Glover Cove Creek near Owens Crossroads, Ala.	34 36 15	086 24 49	3.52	1971-75		
72	03575400	Flint River near Owens Crossroads, Ala.	34 32 10	086 29 28	557	1970-74	1973-78	
73	03575480	Tennessee River at Pumping Station, near Huntsville, Ala.	34 34 06	086 33 16	25,610	1971-79	1971-79	
74	03575500	Tennessee River at Whitesburg, Ala.	34 34 18	086 33 29	25,610	1924-	1968,1971,1974	1971
75	03575696	Aldridge Creek near Lily Flagg, Ala.	34 37 44	086 32 23	13.9	1969-75	1971-75	1971
76	03575700	Aldridge Creek near Farley, Ala.	34 37 26	086 32 28	14.1	1961-64		
77	03575730	Aldridge Creek at Farley, Ala.	34 35 42	086 32 45		1961-65	1973	
78	03575734	Aldridge Creek near Whitesburg, Ala.	34 35 01	086 33 22	21.0		1971,1973	1971
79	03575788	Dupree Branch near Harvest, Ala.	34 46 38	086 42 51	3.91	1970-75	1973	
80	03575808	Dry Creek near Madison, Ala.	34 45 25	086 41 09	17.7	1970-73	1973	
81	03575810	Indian Creek at U.S. Highway 72, near Huntsville, Ala.	34 45 00	086 41 51	-	1970-75	1971,1973	1971
82	03575830	Indian Creek near Madison, Ala.	34 41 50	086 42 00	49.0	1959-66,1971-	1965,1968,1971, 1973	1971
83	03575849	Indian Creek 400 feet above Martin Road, near Madison, Ala.	34 38 46	086 41 12	62.7	1970-73		
84	03575851	Indian Creek 700 feet below Martin Road, near Huntsville, Ala.	34 38 37	086 41 12	-	1971,1973-74	1971,1973	1971
85	03575868	Fagan Creek at Huntsville, Ala.	34 43 29	086 35 16		1970-74	1973	
86	03575878	Dallas Branch at Huntsville, Ala.	34 44 32	086 35 20		1970-73	1973	
87	03575880	Five Points Ditch at Huntsville, Ala.	34 44 18	086 34 59	.62	1970-75		
88	03575888	Pinhook Creek at Holmes Avenue, at Huntsville, Ala.	34 43 48	086 35 40	22.8	1953-54,1970-73	1973	
89	03575890	Pinhook Creek at Huntsville, Ala.	34 43 39	086 35 36		1966-68,1971-73		
90	03575910	Pine Haven Ditch at Huntsville, Ala.	34 46 03	086 37 53	.16	1971-75		
91	03575930	Broglan Branch at Holmes Avenue, at Huntsville, Ala.	34 43 45	086 36 31	8.87	1971-74		
92	03575935	Broglan Branch at Huntsville, Ala.	34 43 11	086 35 43	9.66	1970-73	1973	
93	03575950	Huntsville Spring Branch at Johnson Road, Huntsville, Ala.	34 41 24	086 35 47	41.8	1971-75	1972-74,1976-78	
94	03575953	Drainage Ditch from Landfill near Huntsville, Ala.	34 41 00	086 35 56		1973-74	1970-71,1973-74	
95	03575955	Huntsville Spring Branch above Sewage Plant, Huntsville, Ala.	34 40 40	086 36 03		1972-73	1972-74,1977-78	
96	03575960	Huntsville Spring Branch at Martin Road, near Huntsville, Ala.	34 39 33	086 36 16	49.6	1948,1971-73, 1975-78,1981	1971-81	1971
97	03575980	McDonnell Creek at Patton Road, near Huntsville, Ala.	34 41 33	086 37 39	9.02	1970-73	1973	
98	03575994	McDonnell Creek at Martin Road, at Huntsville, Ala.	34 39 12	086 36 46	14.5	1971-74	1973	
99	03576000	Huntsville Spring Branch at Patton Road, near Huntsville, Ala.	34 37 32	086 37 46	72.9	1929-32,1971-73	1971,1973, 1975-78	1971
100	03576020	Huntsville Spring Branch at Dodd Road, near Huntsville, Ala.	34 37 08	086 39 54	83.9	1971-73	1973,1975-78	
101	03576070	Mill Creek at Madison, Ala.	34 41 32	086 46 05	4.74	1970-73	1973	
102	03576082	Bradford Creek at James Record Road, near Madison, Ala.	34 39 05	086 45 10	-	1972-73	1973	
103	03576090	Betts Spring Branch near Madison, Ala.	34 38 53	086 44 32	8.29	1970-73		
104	03576100	Miller Branch near Triana, Ala.	34 37 18	086 45 23	49.0	1959-73	1973	
105	03576110	Barren Fork Creek near Triana, Ala.	34 36 52	086 44 06		1970-75	1973,1975-78	
106	03576148	Cotaco Creek at Florette, Ala.	34 24 49	086 41 16	136	1966-81	1966,1968-69, 1971-81	1979-81

10.0 SUPPLEMENTAL INFORMATION FOR AREA 21--Continued

10.2 List of Surface-Water Network Sites--Continued

Site number	Station		Location		Drainage area (mi ²)	Type of record and period collected		
	Number	Name	Latitude (° , ' , ")	Longitude (° , ' , ")		Discharge	Chemical quality	Sediment
107	03576201	Limestone Creek near Bobo, Ala.	34 57 18	086 43 10	16.2	1970-73	1973	
108	03576206	Limestone Creek at Toney, Ala.	34 54 51	086 43 51	21.2	1970-73	1973	
109	03576208	Limestone Creek near Toney, Ala.	34 55 12	086 45 52	27.7	1970-73	1973	
110	03576225	Little Limestone Creek below Tyrone Creek, near Toney, Ala.	34 54 13	086 47 20	33.9	1972-75	1973	
111	03576229	Limestone Creek at Madison County Line, near Toney, Ala.	34 53 03	086 47 00	68.7	1970-73	1973	
112	03576235	Leslie Branch near Harvest, Ala.	34 51 14	086 47 04	4.95	1970-73	1973	
113	03576245	Copperrun Branch at Capshaw, Ala.	34 46 23	086 47 43	7.30	1970-73	1973	
114	03576247	Knox Creek at Capshaw, Ala.	34 45 34	086 47 09	8.75	1970-75	1973	
115	03576250	Limestone Creek near Athens, Ala.	34 45 06	086 49 24	119	1939-	1968-69	
116	03576400	Piney Creek near Athens, Ala.	34 48 10	086 53 00	55.8	1960-69	1968-69	
117	03576500	Flint Creek near Falkville, Ala.	34 22 23	086 56 01	86.3	1952-73, 1979-81	1965, 1968-69, 1971, 1979-81	1979-81
118	03576800	Blowing Spring Branch near Wren, Ala.	34 23 38	087 17 04	1.27	1963-66	1965	
119	03576810	Elam Creek near Wren, Ala.	34 24 57	087 16 10	6.69	1963-67	1965, 1968	
120	03577000	West Flint Creek near Oakville, Ala.	34 28 35	087 08 30	87.6	1952-57, 1963-65	1965, 1968	
121	03577150	Tennessee River at Decatur, Ala.	34 36 47	086 58 26	26,900	1926-	Water temperature 1970-77	
122	03577200	Swan Creek near Athens, Ala.	34 47 47	086 57 04	28.8	1963-65	1965	
123	03577202	Swan Creek at U.S. Highway 72, near Athens, Ala.	34 47 05	086 56 53	-		1967-68, 1970-72	
124	03577966	Elk River near Mt. View, Tenn.	35 21 29	085 50 10	25.7	1952, 1962-63	1979-81	1979-81
125	03577985	Dry Creek near Mt. View, Tenn.	35 19 21	085 49 29	22.4	1979-81	1980-81	1980-81
126	03578000	Elk River near Pelham, Tenn.	35 17 48	085 52 12	65.6	1951-	1979-82	1979-81
127	03578015	Juanita Creek near Monteagle, Tenn.	35 14 46	085 50 36	.43	1950-54, 1956-57		
128	03578027	Henley Creek near Mt. View, Tenn.	35 06 30	085 51 34	1.88	1953-54, 1956-57		
129	03578030	Caldwell Creek near Pelham, Tenn.	35 17 05	085 53 14	21.6	1944, 1953-54, 1956-57		
130	03578075	Petty Branch near Alto, Tenn.	35 16 43	085 55 02	.92	1953-54		
131	03578095	Betsy Willis Creek near Pelham, Tenn.	35 19 48	085 55 12	11.5	1975-81	1979-81	1979-81
132	03578180	Rose Creek near Alto, Tenn.	35 15 38	085 56 41	2.98	1953-54		
133	03578190	Mud Creek near Alto, Tenn.	35 16 28	085 56 14	18.4	1944, 1953-54, 1962, 1964-65, 1970, 1979-81	1979-81	1979-80
134	03578200	Yellow Branch near Alto, Tenn.	35 17 38	085 57 41	4.58	1953-54		
135	03578290	Beans Creek at U.S. Highway 41, near Hillsboro, Tenn.	35 22 43	085 56 58	14.8	1979-81	1979-81	1979-81
136	03578300	Beans Creek at Prairie Plains, Tenn.	35 20 34	085 57 37	18.1	1951, 1953-54, 1956-57		
137	03578390	Bradley Creek at Hillsboro (TVA), Tenn.	35 24 58	085 58 10	11.8	1962, 1964-65		
138	03578500	Bradley Creek near Prairie Plains, Tenn.	35 21 21	085 58 45	41.3	1952-59, 1960-		
139	03579100	Elk River near Estill Springs, Tenn.	35 17 08	086 06 20	275	1920-	1974-78	
140	03579505	Taylor Creek near Estill Springs, Tenn.	35 15 48	086 08 12	6.86	1953-54, 1956		
141	03579620	Rock Creek at Tullahoma, Tenn.	35 21 34	086 12 47	12.3	1960, 1966-67, 1969-70, 1974		

Site number	Station		Location		Drainage area (mi ²)	Type of record and period collected		
	Number	Name	Latitude (° ' ")	Longitude (° ' ")		Discharge	Chemical quality	Sediment
142	03579623	Rock Creek above Sewer Outfall, at Tullahoma, Tenn.	35 20 46	086 12 45	13.1	1948		
143	03579640	Blue Creek near Tullahoma, Tenn.	35 19 33	086 12 38	8.46	1960,1967		
144	03579660	Poorhouse Creek near Tullahoma, Tenn.	35 18 16	086 11 38	5.06	1960		
145	03579680	Rock Creek near Tullahoma, Tenn.	35 17 16	086 11 17	33.6	1960,1967,1974		
146	03579700	Rock Creek near Estill Springs, Tenn.	35 15 09	086 08 29	41.2	1944,1953-54, 1956,1960-66		
147	03579800	Miller Creek near Cowan, Tenn.	35 10 17	085 59 00	4.30	1952,1954-65		
148	03579900	Boiling Fork Creek at Cowan, Tenn.	35 09 45	086 00 20	17.0	1955-		
149	03580000	Boiling Fork Creek south of Cowan, Tenn.	35 09 28	086 00 57	20.2	1932-33,1948, 1950-52,1954-55, 1962		
150	03580050	Keith Cove Creek near Cowan, Tenn.	35 08 36	086 01 29	7.65	1953-54		
151	03580110	Boiling Fork Creek near Decherd, Tenn.	35 09 44	086 03 37	37.7	1979-81	1979-81	1979-80
152	03580200	Norwood Creek near Cowan, Tenn.	35 08 32	086 03 55	10.3	1962-67,1962-71		
153	03580250	Norwood Creek near Winchester, Tenn.	35 09 08	086 03 48	12.8	1953-54,1956		
154	03580300	Boiling Fork Creek above Winchester, Tenn.	35 11 14	086 05 42	55.9	1962-70	1966-67	
155	03580305	Boiling Fork Creek at Highway 41A, at Winchester, Tenn.	35 11 18	086 06 34	57.2	1944,1948, 1950-54,1956		
156	03580395	Wagner Creek south of Decherd, Tenn.	35 12 17	086 04 44	14.8	1948		
157	03580405	Wagner Creek near Decherd, Tenn.	35 12 04	086 05 41	15.0	1950-55		
158	03580500	Boiling Fork Creek at Winchester, Tenn.	35 11 55	086 07 29	77.1	1932-34		
159	03580530	Dry Creek near Winchester, Tenn.	35 11 12	086 08 09	21.3	1953-54		
160	03580570	Elk River Tributary near Belvidere, Tenn.	35 11 00	086 11 19	3.93	1953-54		
161	03580700	Hurricane Creek at Awalt, Tenn.	35 15 24	086 15 21	24.6	1959-66		
162	03580715	Kitchens Creek at Mansford, Tenn.	35 11 54	086 14 43	2.57	1953-54,1956		
163	03580748	Murrell Creek near Harmony, Tenn.	35 11 27	086 16 27	3.91	1953-54		
164	03580749	Murrell Creek at Tims Ford Dam, Tenn.	35 11 32	086 16 46		1969,1971-72,1975		
165	03580750	Elk River below Tims Ford Dam, Tenn.	35 11 32	086 16 52	534	1966-76	1966-67,1973, 1975-80	
166	03580775	Beans Creek at Beans Creek, Tenn.	35 03 46	086 14 48	19.0	1953-54,1956-57, 1962-65		
167	03580785	Robinson Creek near Old Salem, Tenn.	35 05 17	086 16 29	18.3	1953-54		
168	03580795	Caney Hollow Creek near Old Salem, Tenn.	35 06 48	086 16 01	8.87	1953-54		
169	03580800	Beans Creek near Lexie Crossroads, Tenn.	35 07 18	086 18 20	89.7	1944,1953-54, 1959-65,1972		
170	03580890	Elk River near Smithland, Tenn.	35 08 19	086 23 00	671	1971		
171	03580898	Tucker Creek near Champ, Tenn.	35 08 46	086 23 12	7.21	1962-65,1970		
172	03580910	Shelton Creek near Kelso, Tenn.	35 07 33	086 23 49	8.38	1953-54		
173	03580940	Teal Hollow Branch near Kelso, Tenn.	35 05 26	086 27 37	3.28	1953-54		
174	03580943	Dukes Creek near Kelso, Tenn.	35 07 42	086 27 40	8.34	1953-54		
175	03580988	East Fork Mulberry Creek above Lynchburg, Tenn.	35 17 06	086 22 14		1950,1962-64		
176	03581000	East Fork Mulberry Creek at Lynch- burg, Tenn.	35 16 53	086 22 21	23.1	1933,1959-66		
177	03581200	East Fork Mulberry Creek near Mulberry, Tenn.	35 13 02	086 26 42	49.4	1953-54		
178	03581375	West Fork Mulberry Creek near New Herman, Tenn.	35 19 11	086 28 15	11.7	1962,1964-65, 1970,1972		
179	03581500	West Fork Mulberry Creek at Mul- berry, Tenn.	35 12 34	086 27 46	41.2	1954-68,1979-		
180	03581600	Mulberry Creek near Mulberry, Tenn.	35 10 31	086 28 13	98.6	1944,1953-54, 1972		
181	03582000	Elk River above Fayetteville, Tenn.	35 08 04	086 32 23	827	1934-	1974,1977-80	
182	03582010	Lees Creek near Fayetteville, Tenn.	35 07 19	086 31 20	4.89	1953-54		
183	03582020	Stewart Creek at Liberty, Tenn.	35 07 02	086 32 14	8.75	1953-54		
184	03582120	Union Branch above Belleville, Tenn.	35 16 47	086 34 57	1.12	1975,1978		
185	03582190	Norris Creek near Howell, Tenn.	35 14 04	086 33 58	13.3	1962,1964-1965, 1970,1975		
186	03582200	Norris Creek Tributary near Belle- ville, Tenn.	35 13 55	086 33 50	.03	1955-65		
187	03582205	Norris Creek below Howell, Tenn.	35 13 33	086 33 56	15.1	1952,1975,1978-		
188	03582300	Norris Creek near Fayetteville, Tenn.	35 09 53	086 32 43	42.6	1954-		
189	03582310	Norris Creek at Fayetteville, Tenn.	35 09 32	086 33 29	44.4	1944,1953-54		
190	03582395	Tanyard Branch at Fayetteville,Tenn.	35 09 02	086 34 22	.47	1978-		
191	03582400	Elk River at Fayetteville, Tenn.	35 08 32	086 34 10	895	1975-78	Water temperature 1975-78	
192	03582500	Elk River near Fayetteville, Tenn.	35 08 10	086 35 15	897	1926-34	1976	
193	03582520	Cane Creek near Petersburg, Tenn.	35 19 49	086 39 14	18.4	1968,1975		
194	351921086381500	Cane Creek at Petersburg, Tenn.	35 19 21	086 38 15	26.1	1962,1964-65, 1968-70		
195	03582550	Little Cane Creek near Bledsoe, Tenn.	35 18 42	086 35 17	13.6	1975	1969-70	
196	03582591	Cane Creek near Egam, Tenn.	35 11 13	086 37 38	93.0	1968,1975, 1979-81		
197	03582600	Cane Creek near Fayetteville, Tenn.	35 09 30	086 36 32	106	1944,1953-54,1972		
198	03582635	Molino Creek near Molino, Tenn.	35 07 14	086 41 12	7.06	1953-54		
199	03582646	Swan Creek at Boonshill, Tenn.	35 12 33	086 43 50	22.5	1952,1975		
200	03582650	Swan Creek at Taylortown, Tenn.	35 11 32	086 45 05	32.0	1974		
201	03582670	Swan Creek at East Cyruston, Tenn.	35 09 28	086 43 00	49.0	1943,1953-54,1972		
202	03582700	Coldwater Creek at Coldwater, Tenn.	35 05 02	086 44 02	29.8	1952-54,1959-66		
203	03583000	Bradshaw Creek at Frankewing, Tenn.	35 11 35	086 50 42	36.5	1952,1962-65,1967		
204	03583200	Chicken Creek at McBurn, Tenn.	35 11 03	086 48 47	7.66	1955-		
205	03583230	Bradshaw Creek at Dellrose, Tenn.	35 06 39	086 48 23	68.2	1944,1953-54,1971		
206	03583235	Kelly Creek near Baugh, Tenn.	35 04 12	086 50 41	14.2	1944,1953-54		
207	03583250	Indian Creek at Bryson, Tenn.	35 05 20	086 52 17	25.8	1944,1953-54,1971		

10.0 SUPPLEMENTAL INFORMATION FOR AREA 21--Continued
10.3 List of Ground-Water Network Sites

Type of record and period collected					
Site number	Station number	Local number	Formation tapped	Water level	Chemical quality
Wells					
1	340944086283101	E-2	Fort Payne Chert		1967
2	341230086032601	EE-2			1967
3	341244086251801	A-2	Fort Payne Chert		1967
4	341344086005001	FF-5			1967
5	341508086274101	A-1	Pottsville Formation		1967
6	341552086044001	EE-1			1967
7	341608086022001	FF-3			1967
8	341726086495001	I-1			1963
9	341756086481001	D-2			1963
10	341800086555201	E-3			1963
11	341808086521401	D-1			1963
12	341837086294301	MAL-4	Pottsville Formation	1962-	
13	341940086032401	DD-1			1967
14	341944086181701	MAL-3	Bangor Limestone	1962-75	
15	342022086183401	MAL-2	Fort Payne Chert	1962-74	
16	342159086543701	X-107	Bangor Limestone		1961
17	342212086125501	P-4	Bangor Limestone	1968-	
18	342304085542001	U-2			1967
19	342320085570001	T-4			1967
20	342455086160201	MAL-1	Chickamauga Limestone	1961-78	
21	342456087054601	N-34			
22	342502086390701	R-144	Bangor Limestone	1958-78	
23	342510085591001	T-2	Bangor Limestone		1967
24	342522085514401	U-1			1967
25	342620085542201	T-1			1967
26	342635086563701	O-26			
27	342800085563001	P-3	Hartselle Sandstone	1959-	
28	342840085514001	P-2			1967
29	343050085500401	D-3			1967
30	343100085530001	P-1			1967
31	343222087021501	M-100	Mississippian System		1959
32	343238086252701	Z-47			1971, 1975
33	343312086582802	MOR-5	Residium-North Alabama	1965-74	
34	343316087091501	P-3	Hartselle Sandstone	1960-	

Type of record and period collected					
Site number	Station number	Local number	Formation tapped	Water level	Chemical quality
Wells					
35	343320086212401	T-20			1971
36	343344086223001	U-106			1969
37	343425086550001	MOR-4	Fort Payne Chert	1961-78	1967
38	343440085465601	H-1			1971, 1975
39	343458086060201	HH-3	Chickamauga Limestone	1968-	
40	343523086272901	U-67			
41	343530087045201	MOR-6	Fort Payne Chert	1978-	1971, 1975
42	343537086441301	X-37			
43	343540086344801	MAD-5	Fort Payne Chert	1959-77	
44	343604086574201	MOR-3	Fort Payne Chert	1961-68	1971
45	343608086325601	V-106			
46	343610085430001	I-1			1967
47	343615087032201	MOR-2	Tuscumbia Limestone	1961-	1975
48	343639086455001	X-45			1975
49	343750086432201	X-38			1970, 1972
50	343825086431401	MT-122			1975
51	343825086431402	X-44			
52	343825086433901	MT-123			
53	343828086503801	R-4	Fort Payne Chert	1960-	1970, 1975
54	343838086441001	MT-126			1972
55	343840086420801	P-78			
56	343844086442501	MT-130			1975
57	343852086441101	MT-129			1975
58	343901087110301	H-16	Tuscumbia Limestone	1960-	1970, 1975
59	343923086442301	MT-111			1972
60	343929086362501	Q-209			
61	343932086440901	P-68			1968, 1975
62	343933086273601	S-34			1971, 1975
63	343941086360601	Q-198			1969
64	344001086363601	Q-204			1973-75
65	344003086012101	JAC-1	Fort Payne Chert	1936-41, 1943-73	
66	344003086012102	JAC-2	Fort Payne Chert	1971-	1975
67	344010086433202	P-27			1973-75
68	344013086360001	Q-202			1973-75
69	344020086253501	Q-203			

10.0 SUPPLEMENTAL INFORMATION FOR AREA 21--Continued

10.3 List of Ground-Water Network Sites--Continued

Site number	Station number	Local number	Formation tapped	Type of record and period collected	
				Water level	Chemical quality
<u>Wells</u>					
70	344020086332001	MAD-3	Fort Payne Chert	1955-	
71	344030086430401	P-31			1975
72	344037086355301	Q-205			1973-74
73	344043086343701	CT-78			1971-72
74	344044086355401	Q-208			1972-74
75	344049086363601	CT-76			1972-74
76	344052086355101	Q-207			1972-74
77	344054086354901	Q-206			1972-74
78	344059086355001	Q-199			1971-74
79	344107086344501	CT-46			1971-74
80	344127086350201	CT-43			1971-74
81	344127086350401	MAD-2	Fort Payne Chert	1953-	
82	344132086425501	CT-61	Fort Payne Chert	1957-	1975
83	344209086450601	MT-171			1975
84	344213086221901	S-33			1970, 1975
85	344225086450201	MT-170			1975
86	344230085404001	E-1			1967
87	344241086361201	CT-74			1975
88	344254086354901	Q-79	Fort Payne Chert		1975, 1981
89	344320086454301	P-35			1971, 1975
90	344338086445901	MT-169			1975
91	344402086343901	MAD-1	Fort Payne Chert	1951-78	
92	344410085363001	C-3			1967
93	34443086345202	N-207			1971
94	344444086345301	N-51	Fort Payne Chert	1958-	1975, 1978, 1981
95	344445086345301	MAD-7	Fort Payne Chert	1962-78	
96	344445086581501	J 169		1968-	
97	344457086363701	MAD-4	Fort Payne Chert	1975-	1975
98	344540086355301	CT-22			1975
99	344545086244001	L- 32			1971
100	344617086261101	L- 90			1970-71
101	344637086301901	MT-138			1971
102	344651086523701	I-40			
103	344704086432401	O-70	Fort Payne Chert	1968-	1971, 1975
104	344710085361001	C-1			1967

Type of record and period collected					
Site number	Station number	Local number	Formation tapped	Water level	Chemical quality
Wells					
105	344736085485201	R-2	Monteagle Limestone	1966-75	
106	344746086401901	MT-149			1975
107	344748086401001	MT-162	Fort Payne Chert	1975-78	1974-75
108	344754086391701	MT-147			1975
109	344757086351401	N-263			1975
110	344759086350201	N-240			1975
111	344814086575701	LIM-3	Fort Payne Chert	1959-68	
112	344819086581601	LIM-4	Fort Payne Chert	1961-	
113	344830085432001	N-8			1967
114	344836086283601	MT-155			1975
115	344843086581201	LIM-1	Fort Payne Chert	1958-68	
116	344848086584301	LIM-2	Fort Payne Chert	1959-68	
117	344854086282301	MT-164	Fort Payne Chert	1975-78	1975
118	344855086291701	MT-154			1975
119	344858085475501	N-100	Tuscumbia Limestone	1975-	
120	344928086234901	I-57			1972
121	345004086344201	MT-153			1974-75
122	345103086340901	MT-148	Fort Payne Chert	1976-78	
123	345103086340902	MT-148			1975
124	345109086422001	MT-136			1975
125	345117086355101	MT-157			1975
126	345120086453401	F-89			1970
127	345131086463101	F-51			1971, 1975
128	345136086373101	MT-145			1975
129	345138086383101	MT-151	Fort Payne Chert	1975-78	1975
130	345159085503901	M-3	Monteagle Limestone	1968-	
131	345206086433001	MT-150			1975
132	345211086571401	G-76	Fort Payne Chert	1968-	
133	345258085480401	N-40	Fort Payne Chert		1981-
134	34539086333501	C- 31			1975
135	345546086235901	MT-144			1975
136	345555086242701	MT-160	Fort Payne Chert	1976-78	1975
137	345556086383001	D-14			1971
138	345612086252501	MT-117			1970

10.0 SUPPLEMENTAL INFORMATION FOR AREA 21--Continued

10.3 List of Ground-Water Network Sites--Continued

Site number	Station number	Local number	Formation tapped	Type of record and period collected	
				Water level	Chemical quality
<u>Wells</u>					
139	345622086244201	MT-121			1970
140	345639086244401	MT-119			1970, 1975
141	345654086525501	A-42	Fort Payne Chert	1968-	
142	345704086251501	MT-118			1970, 1975
143	345745086433101	MAD-6	Fort Payne Chert	1958-	
144	345747086245401	MT-12	Fort Payne Chert	1958-	1975
145	345929086510001	A-13	Fort Payne Formation		1959, 1981-
146	350033086422900	Li:G-4		1980-	
147	350034086422800	Li:G-1	Fort Payne Formation	1975-76	1975-76
148	350036086420101	Li:G-11			1979
149	350239086332000	Li:H-1	Fort Payne Formation		1977
150	350254086155800	Fr:F-10			1977
151	350312086155700	Fr:F-1	Fort Payne Formation	1962-70	
152	350724086114200	Fr:M-10			1977
153	351007086264400	Li:O-3	Leipers-Inman-Catheys Formations Undifferentiated		1978
154	351240086044000	Fr:N-2			1977
155	351346086423801	Li:S-18	Bigby and Cannon Limestones		1978
156	351347086424000	Li:M-7	Hermitage Formation		1978
157	351358086311300	Li:N-1	Bigby and Cannon Limestones		1975
158	351359086310900	Li:N-6	Bigby and Cannon Limestones		1978
159	351400085520001	Ma:K-11	Sewanee Conglomerate		1954
160	351422085502200	Fr:O-10			1977
161	351525086340100	Li:S-21	Bigby and Cannon Limestones		1978
162	351528086340200	Li:S-4	Bigby and Cannon Limestones		1975
163	351530086340300	Li:S-1	Bigby and Cannon Limestones	1975	1975
164	351531086340500	Li:S-9	Bigby and Cannon Limestones		1978
165	351534086335600	Li:S-20	Bigby and Cannon Limestones		1978
166	351548086342300	Li:S-2	Bigby and Cannon Limestones		1975
167	351600085440001	Gy:F-11	Sewanee Conglomerate		1954
168	351703085515500	Gy:E-10			1977
169	351835086120300	Fr:R-6	Fort Payne Formation		1975
170	351910086040301	Fr:S-11	Mississippian System		1958
171	352031086322800	Li:S-3	Bigby and Cannon Limestones		1975
172	352253086030601	Cf:G-1	St. Louis Limestone		1960

Site number	Station number	Station name	Type of record and period collected	
			Discharge	Chemical quality
Springs				
173	03571780	T. H. Martin Spring No. 1 at Martin Springs, Tenn.	1931-32,1952-54	
174	03571810	Bible Spring near Comfort, Tenn.	1931-32,1952-54	
175	03572150	E 2 Champion Spring, Ala.	1968,71	
176	03572160	N 2 Brown Spring, Ala.	1966-81	
177	341308086243101	Big Spring near Guntersville, Ala.	1928,1961-62, 1968-69,1971	1975
178	03574435	Cole Spring near Paint Rock, Ala.	1974,1977	
179	343757086183301	Blue Spring (George Dicus-Owner), Ala.		1976
180	03574570	Bethel Spring near Woodville, Ala.	1970-73	1973
181	03574630	New Hope Spring at New Hope, Ala.	1953,1970-73,1980-	1973
182	03574787	Watercross Spring near New Market, Ala.	1970-73,1980	1973-78
183	03574818	Steger Spring near Hazel Green, Ala.	1972,1975	1973
184	03574843	Turner Spring near Toney, Ala.	1971-73	1973
185	03574871	Meridianville Spring at Meridianville, Ala.	1965,1970-72,1975	
186	03575015	Boiling Spring near Maysville, Ala.	1952,1970-75	1973-78
187	03575024	Acuff Spring near Chase, Ala.	1949-54,1956-59, 1970-72,1977	1977
188	03575110	Dug Hill Springs near Brownsboro, Ala.	1964,1970-73,1975	1973
189	03575152	Murphy Spring near Maysville, Ala.	1970-73	
190	03575193	Beason Spring near Gurley, Ala.	1971-74	
191	03575205	Blair Spring at Gurley, Ala.	1970-71	
192	03575252	Esslinger Spring near Owens Cross Roads, Ala.	1971-73	1973
193	03575370	Brazelton Spring near Owens Cross Roads, Ala.	1970-72	
194	03575372	Rock Spring near Owens Cross Roads, Ala.	1970-72	
195	03575692	Esslinger Spring at Huntsville, Ala.	1961-62,1971-73, 1975	1973
196	03575760	Kelly Spring near Harvest, Ala.	1929,1970-72	1973-74,1976-78
197	03575784	Nichols Spring near Harvest, Ala.	1970-72	
198	343822086411001	Williams Spring near Huntsville, Ala.	1929,1970-73,1979	1973-74
199	03575860	Big Spring at Huntsville, Ala.	1934,1943-44,1948-49, 1951,1955-62,1965-72	1968
200	03575963	Byrd Spring at Huntsville, Ala.	1949-59,1970-72	1973-74,1976-79
201	03575977	Boiling Spring at Huntsville, Ala.	1967-69	
202	03576062	Betts Spring near Madison, Ala.	1970-73	1973
203	03576075	Boiling Spring at Madison, Ala.	1963,1971-72	
204	03576143	R 157 Hughes Spring, Ala.	1968-	
205	03576175	K 1 Cave Spring, Ala.	1968-	
206	03578400	Pond Spring at Hillsboro, Tenn.	1952-53	
207	03580100	Francis Spring near Cowan, Tenn.	1952-54	
208	03580190	Talley Williams Spring near Winchester, Tenn.	1952-54	
209	03580420	Sharp Spring at Winchester, Tenn.	1932-34,1952-54	
210	03580600	Blue Spring near Estill Springs, Tenn.	1934,1952-53	
211	03580780	Rattlesnake Spring near Huntland, Tenn.	1961-63	
212	03580900	Warren Hollow Spring at State Fish Hatchery, near Flintville, Tenn.	1966-69	
213	03580902	Crowder Spring at State Fish Hatchery, near Flintville, Tenn.	1966-69	
214	03580990	Jack Daniel Spring at Lynchburg, Tenn.	1970-78	
215	03581300	Warren Hollow Spring at Mt. Herman, Tenn.		1975
216	03581434	Buckeye Spring near Lynchburg, Tenn.		1975
217	03581474	Gimlet Spring near Belleville, Tenn.	1975	1975
218	03582045	Ditch Spring near Belleville, Tenn.		1975
219	03582175	John Gill Spring near Belleville, Tenn.	1975	1975
220	03582203	Giles Hollow Spring near Howell, Tenn.		1975
221	03582505	Telephone Line Spring near Talley, Tenn.		1975
222	03582531	Sanders Spring near Petersburg, Tenn.	1975	1975
223	03582533	Old Orchard Spring at Petersburg, Tenn.	1975	1975
224	03582535	Steed Spring at Chestnut Ridge, Tenn.	1975	1975
225	03582542	Freeman Spring at Chestnut Ridge, Tenn.		1975
226	03582544	Helton Hollow Spring near Chestnut Ridge, Tenn.		1975
227	03582552	Burchett Spring near Petersburg, Tenn.	1975	1975
228	03582560	McCrady Hill Spring near Petersburg, Tenn.	1975	1975
229	03582561	Finley Cemetery Spring at Browns Shop, Tenn.		1975
230	03582562	Duckworth Hollow Spring at Browns Shop, Tenn.		1975
231	03582564	Driver Cemetery Spring near Browns Shop, Tenn.		1975
232	03582579	Patton Hollow Spring near Howell, Tenn.	1975	1975
233	03582583	Howell Spring at Howell, Tenn.	1975	1975
234	03582647	Boonshill Spring at Boonshill, Tenn.	1975	1975
235	03583278	Saddle Gap Cave Spring near Browns Shop, Tenn.	1975	1975
236	03585528	G 39 Wheeler Spring, Ala.	1968-	
237	03585638	A 1 Blowing Spring, Ala.	1968-	

10.0 SUPPLEMENTAL INFORMATION FOR AREA 21--Continued
10.4 Average Flow Data

Average annual and range in monthly flow per square mile at selected sites

Site number	Period of record	Average annual flow [(ft ³ /s)/mi ²]	Minimum, mean, and maximum monthly flow [(ft ³ /s)/mi ²]												
			OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	
21	1958-80	2.01	Min	0.000071	0.0036	0.056	0.510	0.936	1.33	0.655	0.389	0.082	0.0064	0.014	0.0046
		Mean	.642	1.44	2.47	3.83	3.69	4.86	3.26	1.57	.794	.950	.272	.373	
		Max	4.16	7.82	8.72	8.13	7.57	12.33	6.45	3.87	3.29	5.42	1.50	2.01	
30	1936-80	2.17	Min	.0091	.031	.108	.500	.769	1.80	.856	.217	.084	.044	.032	.014
		Mean	.594	1.32	2.82	4.30	4.88	4.97	3.34	1.79	.716	.731	.322	.491	
		Max	8.12	9.55	10.38	11.00	12.32	13.08	9.43	4.70	2.87	4.58	1.72	3.55	
58	1932-80	1.66	Min	.193	.247	.333	.442	.830	.994	.673	.368	.278	.224	.230	.173
		Mean	.611	1.01	1.83	3.02	3.39	3.62	2.34	1.47	.819	.825	.529	.512	
		Max	4.63	5.99	6.40	9.82	9.70	10.23	6.64	4.34	3.10	3.94	1.96	1.94	
74	1925-35	1.69	Min	.288	.320	.496	1.23	.642	1.21	.968	.998	.468	.441	.197	.158
		Mean	.726	1.21	1.82	2.44	2.65	3.24	2.52	1.90	1.23	.975	.848	.723	
		Max	1.32	4.28	3.88	4.29	6.01	6.97	4.12	4.62	3.07	2.51	1.59	2.22	
106	1966-80	2.07	Min	.010	.0087	.654	.242	.941	1.65	.632	.239	.053	.033	.0099	.016
		Mean	.772	1.26	2.76	4.14	3.54	4.68	3.04	2.06	.415	.610	.407	.612	
		Max	3.88	7.17	8.20	7.02	8.19	10.78	6.61	4.69	1.04	3.43	3.35	1.96	
115	1941-70	1.65	Min	.097	.118	.212	.603	.849	.441	.462	.180	.142	.159	.100	.078
		Mean	.280	.891	2.12	3.28	4.01	3.50	2.39	1.26	.648	.692	.426	.382	
		Max	.774	6.80	7.77	9.92	9.81	8.84	6.18	4.02	2.06	3.18	2.76	1.55	
116	1960-68	1.68	Min	.058	.074	.163	.568	.789	1.12	.480	.226	.117	.057	.068	.077
		Mean	.228	.640	2.78	2.85	3.06	4.46	2.42	1.61	.690	.701	.509	.235	
		Max	.566	1.58	6.49	6.58	6.16	7.38	5.32	3.46	1.73	3.51	3.08	.565	
117	1954-70	1.70	Min	.00023	.00093	.015	.016	.857	1.36	.737	.169	.101	.028	.020	.0013
		Mean	.257	.999	2.09	3.06	4.07	3.79	3.42	1.24	.426	.572	.378	.272	
		Max	1.05	8.82	8.28	8.56	11.29	8.15	10.45	3.96	1.44	2.72	3.43	.981	
126	1952-80	2.20	Min	.029	.034	.277	1.51	1.03	2.09	1.25	.323	.162	.056	.036	.026
		Mean	.710	1.77	3.17	4.04	4.05	4.76	3.49	2.21	.736	.601	.399	.421	
		Max	5.20	8.57	7.24	10.35	9.16	10.78	7.96	5.32	2.71	1.80	1.84	2.65	
138	1952-59	1.57	Min	.104	.088	.123	1.20	1.85	1.53	1.09	.397	.239	.169	.152	.116
		Mean	.162	1.05	2.06	2.93	4.16	2.81	2.59	1.29	.797	.869	.329	.245	
		Max	.337	6.51	5.47	5.47	7.77	5.93	5.13	3.34	2.66	3.41	1.03	.385	
139	1921-51	1.74	Min	.145	.134	.168	.209	.695	1.05	.960	.362	.236	.225	.147	.170
		Mean	.339	.895	1.97	3.20	3.83	3.71	2.77	1.61	.927	.735	.582	.422	
		Max	.993	4.64	9.12	9.89	9.78	9.40	6.56	4.39	3.31	2.67	1.91	2.23	
154	1963-70	1.56	Min	.075	.104	.133	.562	1.05	1.76	.948	.624	.343	.175	.105	.077
		Mean	.267	.655	1.74	2.02	2.84	4.22	3.08	2.16	.621	.569	.403	.236	
		Max	.639	1.84	6.05	4.36	4.49	8.91	6.64	5.04	1.05	2.16	.837	.739	
179	1954-62	1.95	Min	.0090	.039	.379	1.34	1.01	1.06	.796	.199	.122	.0073	.000	.0019
		Mean	.413	1.66	3.40	3.30	4.51	3.47	3.25	1.01	.745	.597	.101	.602	
		Max	1.99	8.86	6.33	6.38	8.47	6.99	5.02	2.96	3.18	1.36	.308	1.99	
181	1935-51	1.68	Min	.195	.221	.281	.320	.751	1.60	.913	.375	.254	.288	.242	.210
		Mean	.311	.727	1.47	3.62	4.14	3.43	2.53	1.33	.838	.855	.556	.458	
		Max	.634	2.22	4.44	9.07	9.74	5.72	3.94	3.11	2.37	2.26	1.45	2.16	
192	1926-34	1.77	Min	.128	.154	.460	.695	.796	1.22	.946	.528	.230	.347	.236	.154
		Mean	.648	1.44	2.65	2.25	3.07	3.85	2.58	1.88	1.10	.721	.628	.468	
		Max	1.75	4.80	9.65	4.09	6.98	8.66	5.81	4.76	3.14	1.46	1.72	1.25	

10.0 SUPPLEMENTAL INFORMATION FOR AREA 21--Continued
10.5 Suspended-Sediment Data

Suspended-sediment concentrations, in milligrams per liter, in water in streams in Area 21

Site no.	Station name	Drainage area (mi ²)	Concentration		Number of samples
			Minimum	Maximum	
2	Battle Creek near Monteagle, Tenn.	50.4	6	41	16
4	Kelly Cove Creek at Smithtown, Tenn.	4.42	-	-	-
5	Sweden Creek near South Pittsburg, Tenn.	28.2	6	51	20
6	Tennessee River at South Pittsburg, Tenn.	22,640	3	49	13
10	Crow Creek near Anderson, Tenn.	78.4	6	41	26
12	Flat Rock Creek at Flat Rock, Ala.	28.3	1	81	23
13	Dry Creek near Fabius, Ala.	9.50	4	45	22
15	Bryant Creek near Pisgah, Ala.	41.8	1	280	178
17	Little Bryant Creek at Pisgah, Ala.	6.50	4	63	-
19	South Sauty Creek near Macedonia, Ala.	102	2	181	58
21	Town Creek near Geraldine, Ala.	141	-	-	-
58	Flint River near Chase, Ala.	342	29	50	39
59	Flint River near Cedar Gap, Ala.	-	-	-	-
61	Flint River near Mount Carmel, Ala.	362	43	54	48
74	Tennessee River at Whitesburg, Ala.	25,610	12	28	-
75	Aldridge Creek near Lily Flagg, Ala.	13.9	36	52	-
78	Aldridge Creek near Whitesburg, Ala.	21.0	51	391	231
81	Indian Creek at U.S. Highway 72, near Huntsville, Ala.	-	-	-	-
82	Indian Creek near Madison, Ala.	49.0	23	135	-
84	Indian Cr 700 ft bl Martin Rd, nr Huntsville, Ala.	-	43	102	-
96	Huntsville Sp Br at Martin Rd, near Huntsville, Ala.	49.6	48	134	-
99	Huntsville Sp Br at Patton Rd, near Huntsville, Ala.	72.9	62	78	-
106	Cotaco Creek at Florette, Ala.	136	17	87	45
117	Flint Creek near Falkville, Ala.	86.3	6	157	51
124	Elk River near Mt. View, Tenn.	25.7	1	108	35
125	Dry Creek near Mt. View, Tenn.	22.4	1	44	-
126	Elk River near Pelham, Tenn.	65.6	1	60	12
131	Betsy Willis Creek near Pelham, Tenn.	11.5	3	130	40
133	Mud Creek near Alto, Tenn.	18.4	2	130	35
135	Beans Creek at U.S. Hwy 41, near Hillsboro, Tenn.	14.8	7	118	39
151	Boiling Fork Creek near Decherd, Tenn.	37.7	3	187	46

* Includes storm-period sampling.

11.0 SELECTED REFERENCES

- Adams, G. I., Butts, Charles, Stephenson, L. W., and Cooke, Wythe, 1926, *Geology of Alabama*: Alabama Geological Survey Special Report 14, 312 p., and state map, scale 1:500,000.
- Bingham, R. H., 1982, Low-flow characteristics of Alabama streams: U.S. Geological Survey Water-Supply Paper 2083, 27 p.
- Burchett, C. R., and Hollyday, E. F., 1974, Tennessee's newest aquifer (abstract): Geological Society of America Abstracts with Programs, v. 6, no. 4, p. 338.
- Conant, L. C., and Swanson, V. E., 1961, Chattanooga shale and related rocks of central Tennessee and nearby areas: U.S. Geological Survey Professional Paper 357, 91 p.
- Culbertson, W. C., 1964, Geology and coal resources of the coal-bearing rocks of Alabama: U.S. Geological Survey Bulletin 1182-B, p. B1-B79.
- Dodson, C. L., and Harris, W. F., Jr., 1961, Interim report on the geology and ground-water resources of Morgan County, Alabama: Geological Survey of Alabama Information Series 17, 129 p.
- Elder, J. A., and Springer, M. E., 1978, General soil map, Tennessee: U.S. Soil Conservation Service, scale 1:750,000.
- Faust, R. J., and Jefferson, P. O., 1980, Geology and water availability of Cullman County, Alabama: Alabama Geological Survey Map 145, 30 p.
- Fenneman, N. M., 1938, *Physiography of eastern United States*: New York and London, McGraw-Hill, 714 p.
- Gamble, C. R., and Lewis, J. G., 1977, Technique for estimating depth of 100-year floods in Tennessee: Nashville, Tennessee, U.S. Geological Survey Open-File Report 77-668, 18 p.
- Geological Survey of Alabama, 1975, Environmental geology and hydrology Huntsville and Madison County, Alabama: Geological Survey of Alabama, Atlas Series 8, 118 p.
- Georgia Geological Survey, 1976, *Geologic map of Georgia*: Atlanta, Ga., 1:500,000.
- Gold, R. L., 1980, Low flow measurements of Tennessee streams: Tennessee Department of Conservation Water Resources Division, Water Resources Series no. 14, 362 p.
- _____, 1981, Low-flow frequency and flow duration of Tennessee streams: Nashville, Tennessee, U.S. Geological Survey Open-File Report 78-807, 365 p.
- Hains, C. F., 1973, Floods in Alabama, magnitude and frequency: Alabama Highway Department, 39 p. plus 3 appendices.
- _____, 1976, Regional flood depth-frequency relations for Alabama: Tuscaloosa, Alabama, U.S. Geological Survey Open-File Report 76-528, 14 p.
- Hajek, B. F., Gilbert, F. L., and Steers, C. A., 1975, Soil associations of Alabama: U.S. Department of Agriculture and Auburn University Agronomy and Soils Departmental Series Report 24, fig. 4.1, scale 1:1,000,000.
- Hardeman, W. D., 1966, *Geologic map of Tennessee, west-central sheet*: Tennessee Division of Geology, scale 1:250,000.
- Harkins, J. R., and others, 1981, Hydrology of area 22, eastern coal province, Alabama: U.S. Geological Survey Water Resources Investigations 81-135, 72 p.
- Harris, W. F., Jr., and McMaster, W. M., 1965, Geology and ground-water resources of Lawrence County, Alabama: Geological Survey of Alabama Bulletin 78, 70 p.
- Hayes, E. C., 1978, 7-day low flows and flow duration of Alabama streams through 1973: Alabama Geological Survey Bulletin 113, 163 p.
- Hem, J. D., 1970, Study and interpretation of the chemical characteristics of natural water, (2d ed.): U.S. Geological Survey Water-Supply Paper 1473, 363 p.
- Hilsenhoff, W. L., 1977, Use of arthropods to evaluate water-quality of streams: Wisconsin Department of Natural Resources Technical Bulletin no. 100, 16 p.
- Hollyday, E. F., and others, 1982, Hydrology of Area 20, Eastern Coal Province, Tennessee, Georgia, and Alabama: U.S. Geological Survey Water-Resources Investigations 82-440.
- Hynes, H. B. N., 1960, *The biology of polluted waters*: Liverpool University Press, Liverpool, England, 202 p.
- Lohman, S. W., 1972, Ground-water hydraulics: U.S. Geological Survey Professional Paper 708, 70 p.
- Malmberg, G. T., and Downing, H. T., 1957, Geology and ground-water resources of Madison County, Alabama: Geological Survey of Alabama County Report 3, 225 p.
- May, V. J., and others, 1981, Hydrology of Area 18, Eastern Coal Province, Tennessee: U.S. Geological Survey Water-Resources Investigations 81-492, 78 p.
- May, V. J., Wood, G. H., and Rima, D. R., 1970, A proposed streamflow-data program for Tennessee: Nashville, Tennessee, U.S. Geological Survey Open-File Report, 55 p.
- McMaster, W. M., 1963, Geology and ground-water

- resources of the Athens area, Alabama: Geological Survey of Alabama Bulletin 71, 45 p.
- McMaster, W. M., and Harris, W. F., Jr., 1963, Geology and ground-water resources of Limestone County, Alabama, a reconnaissance: Geological Survey of Alabama County Report 11, 43 p.
- Milici, R. C., Briggs, Garrett, Knox, L. M., Sitterly, P. P., and Statler, A. T., 1979, The Mississippian and Pennsylvanian (Carboniferous) Systems in the United States - Tennessee: U.S. Geological Survey Professional Paper 1110-G, 38 p.
- Miller, R. A., 1974, The geologic history of Tennessee: Tennessee Division of Geology Bulletin 74, 63 p.
- Mockus, Victor, 1964, Hydrologic soil groups, Chapter 7 in *Hydrology*, Section 4: U.S. Soil Conservation Service National Engineering Handbook, 28 p.
- National Academy of Sciences and National Academy of Engineering, 1972, Water quality criteria 1972: Environmental Protection Agency Report EPA-R3.73-033, 594 p.
- Newcome, Roy, Jr., and Smith, Ollie, Jr., 1958, Ground-water resources of the Cumberland Plateau in Tennessee, a reconnaissance report: Tennessee Division of Water Resources, Water Resources Series 1, 72 p.
- Olin, D. A., and Bingham, R. H., 1977, Flood frequency of small streams in Alabama: Alabama Highway Department, HPR Report No. 83, 44 p.
- Pennington, Wendell, 1980, Benthic populations of thirty three stream locations draining coal reserves of Tennessee: Tennessee Cooperative Fishery Research Unit, Tennessee Technological University, contract report to the U.S. Geological Survey no. 14-16-0009-80-941, 362 p.
- Perkins, H. F., and Shaffer, M. E., 1977, Soil associations and land use potential of Georgia soils: Georgia Agricultural Experiment Station, University of Georgia, Athens, GA, scale 1:750,000.
- Randolph, W. J., and Gamble, C. R., 1976, Technique for estimating magnitude and frequency of floods in Tennessee: Tennessee Department of Transportation, 52 p.
- Renfro, H. B., and Feray, D. E., 1970, Geological highway map of the Mid-Atlantic region - Delaware, Kentucky, Maryland, North Carolina, South Carolina, Tennessee, Virginia, and West Virginia: American Association of Petroleum Geologists, United States Geological Highway Map Series, map no. 4, scale approximately 1:1,875,000.
- Rickert, D. A., Ulman, W. J., and Hampton, E. R., editors, 1979, Synthetic fuels development, earth science considerations: U.S. Department of Interior, Geological Survey, 45 p.
- Roth, D. K., Engleke, M. J., Jr., and others, 1981, Hydrology of Area 4, Eastern Coal province, Pennsylvania, Ohio, and West Virginia: Columbus, Ohio, U.S. Geological Survey Open-File Report 81-343, 62 p.
- Sanford, T. H., Jr., 1966, Ground water in Marshall County, Alabama, A reconnaissance: Geological Survey of Alabama Bulletin 85, 66 p.
- Sapp, C. D., and Emplainscourt, Jacques, 1975, Physiographic regions of Alabama: Alabama Geological Survey Map 168, scale 1:1,000,000.
- Searcy, J. K., 1959, Flow-duration curves: U.S. Geological Survey Water-Supply Paper 1542-A, 33 p.
- Shannon, C. E., and Weaver, N., 1949, The mathematical theory of communication: Univ. of Illinois Press, 125 p.
- Smith, W. E., 1979, Pennsylvanian stratigraphy of Alabama in Thomas, W. A., Smith, W. E., and Bicker, A. R., The Mississippian and Pennsylvanian (Carboniferous) Systems in the United States--Alabama and Mississippi: U.S. Geological Survey Professional Paper 1110-I, p. I23-I36.
- Sun, P-C. P., Criner, J. H., and Poole, J. L., 1963, Large springs of east Tennessee: U.S. Geological Survey Water-Supply Paper 1755, 52 p.
- Surface Mining Control and Reclamation Act of 1977 - Public Law 95-87, 1977.
- Tennessee Department of Public Health, 1978, State-wide 208 water quality management plan: Division of Water Quality Control, several unnumbered vols.
- Tennessee Division of Water Resources, 1961, Tennessee's Water Resources: Tennessee Department of Conservation and Commerce, 128 p.
- Tennessee Valley Authority, 1978, Land use maps on the Cumberland Plateau: Tennessee Valley Authority Mapping Services Branch, scale 1:100,000 and 1:500,000.
- U.S. Department of Agriculture, 1981, Soil survey of Anderson County, Tennessee: Washington, D. C., Soil Conservation Service Soil Survey Report, 112 p.
- U.S. Department of Commerce, 1961, Rainfall frequency atlas of the United States: U.S. Weather Bureau, Technical Paper No. 40, 115 p, chart 47, scale 1:10,000,000.
- _____, 1962-1979, Climatological data annual summary Alabama: National Oceanic and Atmospheric Administration, v. 68-85, no. 13.
- _____, 1976, Climate of Alabama: National Oceanic and Atmospheric Administration, Climatography of the United States no. 60, 15 p.
- _____, 1977, Climate of Tennessee: National Oceanic and Atmospheric Administration, Climatography of the United States no. 60, 17 p.
- U.S. Environmental Protection Agency, 1976, National interim primary drinking water regula-

- tions: Environmental Protection Agency Report 570/9 - 76-003, 159 p.
- _____. 1979, National secondary drinking water regulations: Environmental Protection Agency Report 570/9 - 76-000, 37p.
- U.S. Geological Survey, 1965-1980, Water resources data for Alabama: U.S. Geological Survey Water Data Report, issued annually.
- _____. 1965-80, Water resources data for Tennessee: U.S. Geological Survey Water Data Report, issued annually.
- _____. 1971, Ground-water levels in the United States, 1964-68--Southeastern States: U.S. Geological Survey Water-Supply Paper 1978, 258 p.
- _____. 1974a, Hydrologic unit map - 1974 State of Alabama: U.S. Geological Survey, scale 1:500,000.
- _____. 1974b, Hydrologic unit map - 1974 State of Tennessee: U.S. Geological Survey, scale 1:500,000.
- _____. 1975, Ground-water levels in the United States, 1969-73--Southeastern States: U.S. Geological Survey Water-Supply Paper 2171, 250 p.
- _____. 1977a, Gadsden and Rome quadrangles: U.S. Geological Survey Land Use and Land Cover Series, scale 1:250,000.
- _____. 1977b, Ground-water levels in the United States, 1974--Southeastern States: U.S. Geological Survey Water-Supply Paper 2165, 116 p.
- _____. 1979, Index to water-data activities in coal provinces of the United States: Office of Water Data Coordination (OWDC), vol. 1, Eastern Province.
- _____. 1980, Directory of assistance centers of the National Water Data Exchange (NAWDEX): U.S. Geological Survey Open-File Report 80-1193, 10 p.
- Walton, W. C., 1962, Selected analytical methods for well and aquifer evaluation: Illinois State Water Survey Bulletin 49, 81 p.
- Wark, J. W., 1965, *in* Schneider, W. J., and others, Water Resources of the Appalachian Region, Pennsylvania to Alabama: U.S. Geological Survey Hydrologic Atlas HA-198, sheet no. 8 of 11.
- Wilson, C. W., Jr., Jewell, J. W., and Luther, E. T., 1956, Pennsylvanian geology of the Cumberland Plateau: Tennessee Division of Geology Geologic Folio, 21 p.
- Wilson, C. W., Jr., and Stearns, R. G., 1958, Structure of the Cumberland Plateau, Tennessee: Geological Society of America Bulletin, v. 69, p. 1283-1296.
- Zurawski, Ann, 1978, Summary appraisals of the nation's ground water resources - Tennessee region: U.S. Geological Survey Professional Paper 813-L, 35 p.