GEOHYDROLOGY AND SUSCEPTIBILITY OF MAJOR AQUIFERS TO SURFACE CONTAMINATION IN ALABAMA; AREA 2

By C.R. Bossong

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CONVERSION FACTORS

For use of readers who prefer to use metric (International System) units, conversion factors for inch-pound units used in this report are listed below:

Multiply inch-pound unit	By	To obtain metric unit
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
gallon per minute (gal/min)	0.06308	liter per second (L/s)
million gallons per day (Mgal/d)	0.04381	cubic meter per second (m^3/s)

Altitudes, as used in this report, refer to the distance above sea level.

Sea level: In this report "sea level" refers to the 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 "Sea Level Datum of 1929."

GEOHYDROLOGY AND SUSCEPTIBILITY OF MAJOR AQUIFERS TO SURFACE CONTAMINATION IN ALABAMA; AREA 2

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ABSTRACT

The U.S. Geological Survey, in cooperation with the Alabama Department of Environmental Management, is conducting a series of geohydrologic studies to delineate the major aquifers and their susceptibility to contamination in Alabama. This report delineates and describes the geohydrology and susceptibility of the major aquifers to contamination in Area 2--Blount, Cherokee, DeKalb, Etowah, Jackson, and Marshall Counties. The area is underlain by Paleozoic clastic and carbonate units that have been folded and faulted. Most of the major aquifers in the area are carbonate units that crop out in valleys (Knox-Shady aquifer), or in thin belts along the flanks of valleys (Tuscumbia-Fort Payne aquifer). The Pottsville aquifer is a clastic unit that crops out in mountain areas.

Most public-supply wells in the area are completed in the carbonate aquifers and tap water supplies contained in secondary features that have been enlarged by solutioning processes. Public water-supply wells completed in the carbonate aquifers usually produce about 0.5 to 1.0 million gallons per day. Wells completed in the Pottsville aquifer generally do not produce as much water as wells in the carbonate aquifers. Water levels at nearly 500 wells indicate that the potentiometric surface for each aquifer is a subdued reflection of topography and that ground water moves towards streams.

Each of the aquifers is recharged throughout its outcrop in the study area and is susceptible to contamination from the surface within its outcrop. Solution features such as sinkholes occur in carbonate areas and are highly susceptible to contamination. Generalized topographic settings that have low slopes, permeable surface material, and are poorly or internally drained occur throughout the area and represent areas where aquifers may also be highly susceptible to contamination.

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INTRODUCTION

The Alabama Department of Environmental Management (ADEM) is developing a comprehensive program in Alabama to protect ground water defined by the U.S. Environmental Protection Agency (EPA) as "Class I and II" from surface contamination (U.S. Environmental Protection Agency, 1984). The U.S. Geological Survey, in cooperation with ADEM, is conducting a series of geohydrologic studies in Alabama to delineate the major aquifers, their recharge areas, and areas susceptible to contamination. This report summarizes these factors for major aquifers in Area 2--Blount, Cherokee, DeKalb, Etowah, Jackson, and Marshall Counties (see plate 1).

Purpose and Scope

The purpose of this report is to describe the geohydrology of the major aquifers and their susceptibility to contamination from the surface. Geologic and hydrologic data compiled as part of previous investigations provided about 90 percent of the data used to evaluate the major aquifers in the area. All wells used for municipal and rural water supplies were inventoried, and water levels were measured in these wells where possible. Data on water use were compiled during the well inventory. Water-level data were used to compile generalized potentiometric maps of the aquifers. Areas susceptible to contamination from the surface were delineated partly from topographic maps and other available data, and partly from field investigation.

Location and extent of the Area

The study area comprises about 4,600 square miles in northeastern Alabama. About 56 percent of the area is forested, 38 percent is agricultural land, and the remainder is mostly urban or wetland (Alabama Department of Economic and Community Affairs, 1984). The 1982 population was reported to be 333,090. Population growth has been approximately 15 percent per decade during the past 30 years; this rate is projected to decrease about 10 percent by the end of this century (Alabama Department of Economic and Community Affairs, 1984). The largest urban center, Gadsden, has a population of approximately 100,000; other major cities in the area are Fort Payne, Guntersville, Oneonta, and Scottsboro (plate 1).

Physical Features

The study area lies in the Appalachian Plateaus and the Valley and Ridge physiographic provinces (Fenneman, 1938) and includes the Cumberland Plateau and Alabama Valley and Ridge sections as defined by Sapp and Emplaincourt (1975).

The northwestern part of the area in Blount, DeKalb, Jackson, and Marshall Counties lies in the Cumberland Plateau section. The terrain is dominated by relatively flat plateaus, especially south of the Tennessee River in the Blount, Lookout, and Sand Mountain districts (fig. 1). The altitude of the plateau surface is about 1,500 to 1,800 feet above sea level.

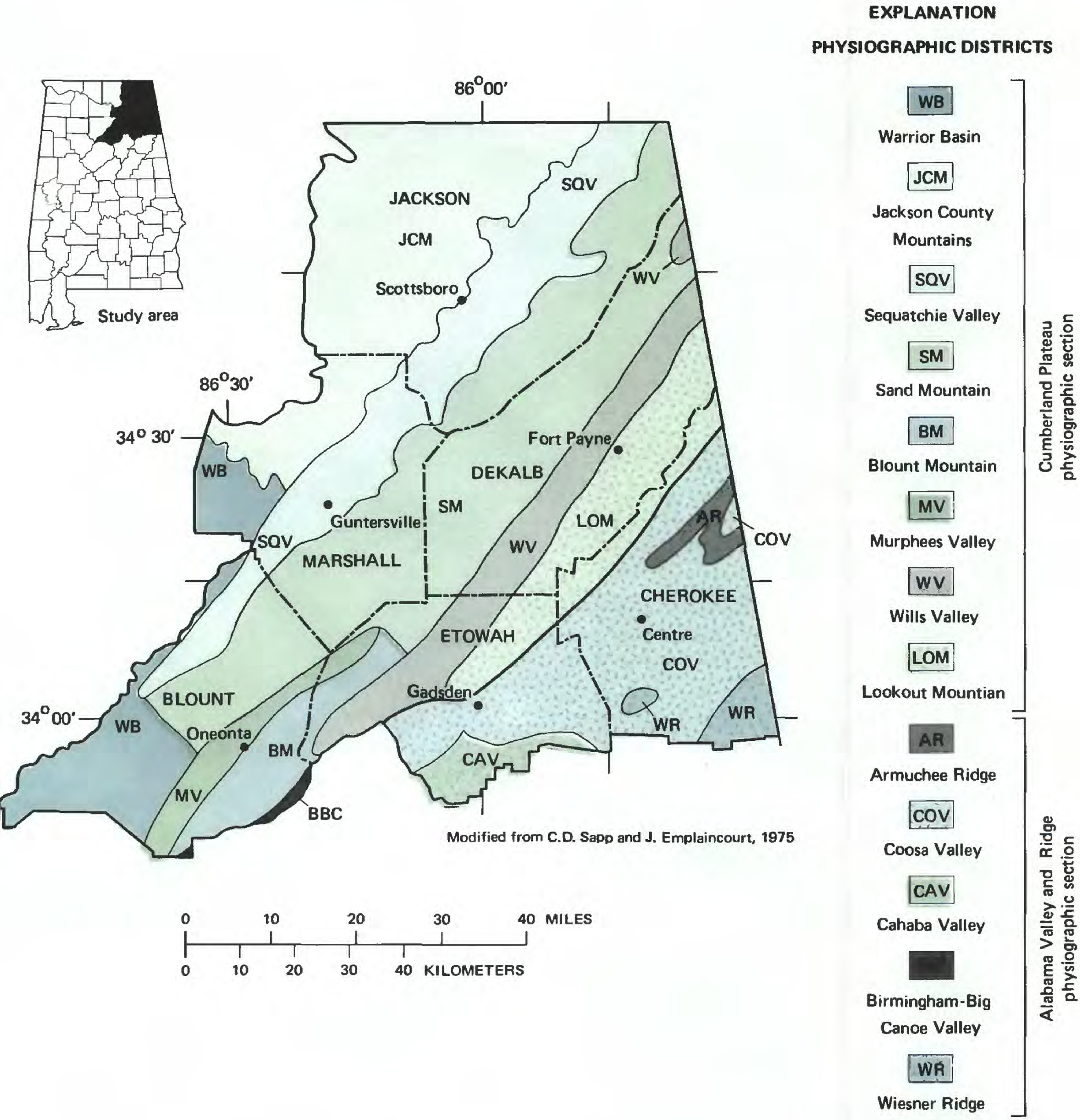

Figure 1.--Physiographic districts of the study area.

In the Murphrees, Sequatchie, and Wills Valley districts, streams have cut narrow linear valleys into the plateau surface resulting in base altitudes of about 500 to 600 feet. North of the Tennessee River in the Jackson County Mountain district, drainage patterns are more dendritic. Drainage is to the Tennessee River and its tributaries in all of Jackson and parts of DeKalb and Marshall Counties. Drainage in the remainder of the Cumberland Plateau section is to the Locust and Mulberry Forks of the Black Warrior River.

The southeastern part of the area in Cherokee, DeKalb, and Etowah Counties lies in the Alabama Valley and Ridge section. Topography is controlled by geology and is characterized by a series of relatively narrow, linear ridges that have been classified as the Armuchee and Weisner Ridge districts. These ridges trend northeastward and have altitudes of about 1,500 to 1,600 feet. Streams drain relatively wide valleys in the Birmingham-Big Canoe, Cahaba, and Coosa Valley districts. The altitudes of the valley floors generally range from 500 to 600 feet. Most drainage in the area is to the Coosa River and its tributaries.

Previous Investigations

The geology of the area has been discussed in several published reports. Adams (1926) presents an early and comprehensive description of the geology. Thomas (1972) developed a description of the Mississippian stratigraphy, and Drahovzal and Neathery (1971) describe Ordovician stratigraphy.

Several reports have been published that describe the geology and water resources for individual counties in the area. The reports include results of geologic mapping and well inventories. They are a valuable source of geologic and hydrologic information for the study area and are listed by county below:

Blount	-- Faust, R.J., and Harkins, J.R., 1980
Cherokee	-- Causey, L.V., 1965
Etowah	-- Causey, L.V., 1961
Marshall	-- Sanford, T.H., 1966

Additional summaries of geology and hydrology which include several measured water levels for DeKalb and Jackson Counties have been compiled by R.J. Faust and R.V. Chandler, respectively. The summaries were completed in the late 1960's and early 1970's and reside in files at the U.S. Geological Survey office in Tuscaloosa, Alabama.

GEOLOGY

Clastic and calcareous sedimentary rocks ranging in age from Cambrian to Pennsylvanian crop out in the study area (fig. 2). Mississippian and Pennsylvanian formations in the Cumberland Plateau section, except in southwestern Blount County, generally are undisturbed and are nearly horizontal (fig. 3). Ordovician, Silurian, and Devonian formations in the Cumberland Plateau are exposed in geologic structures and may dip quite steeply. Cambrian through Pennsylvanian formations in the Alabama Valley and Ridge section are folded and faulted extensively.

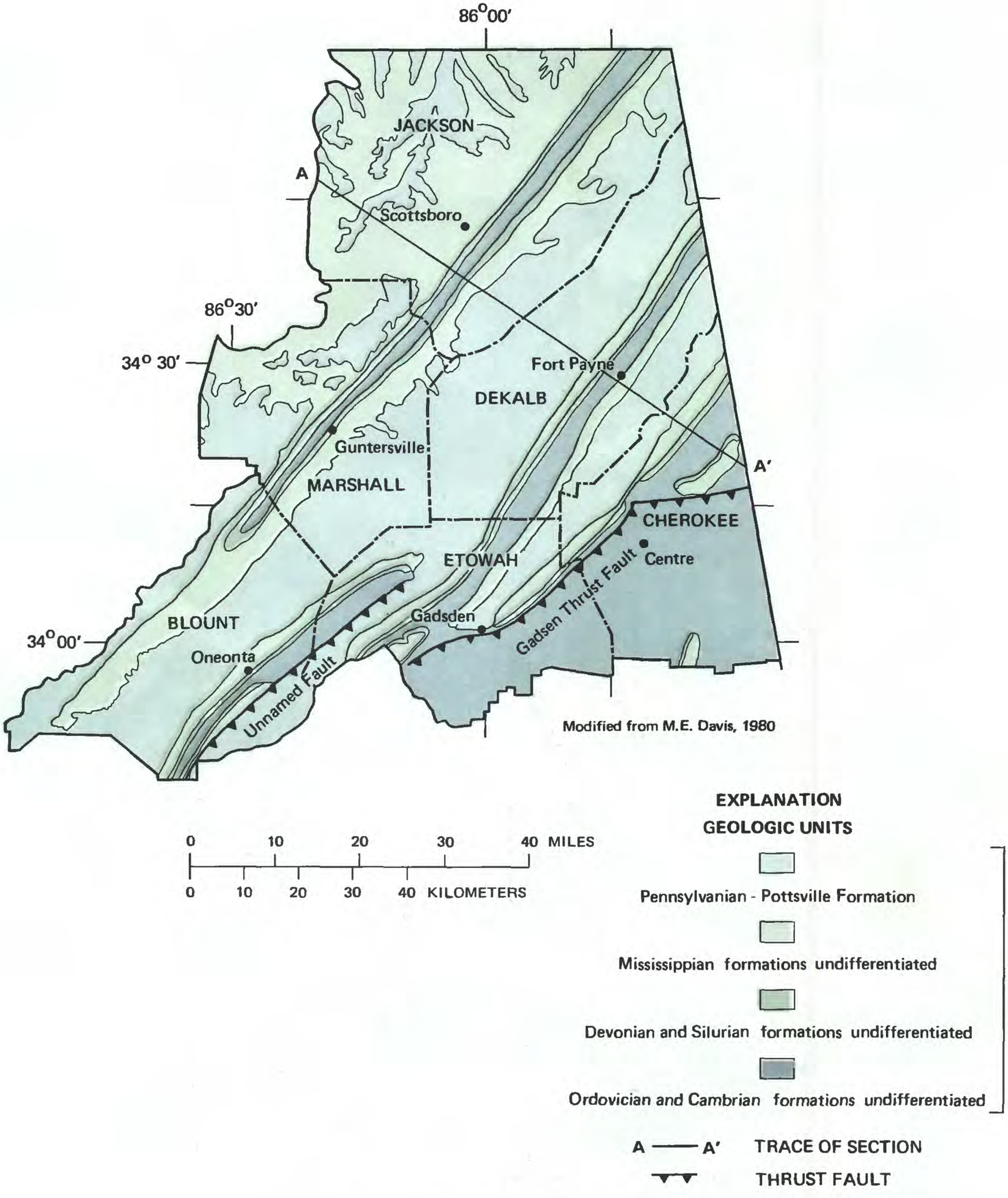

Figure 2.--Generalized geology of the study area.

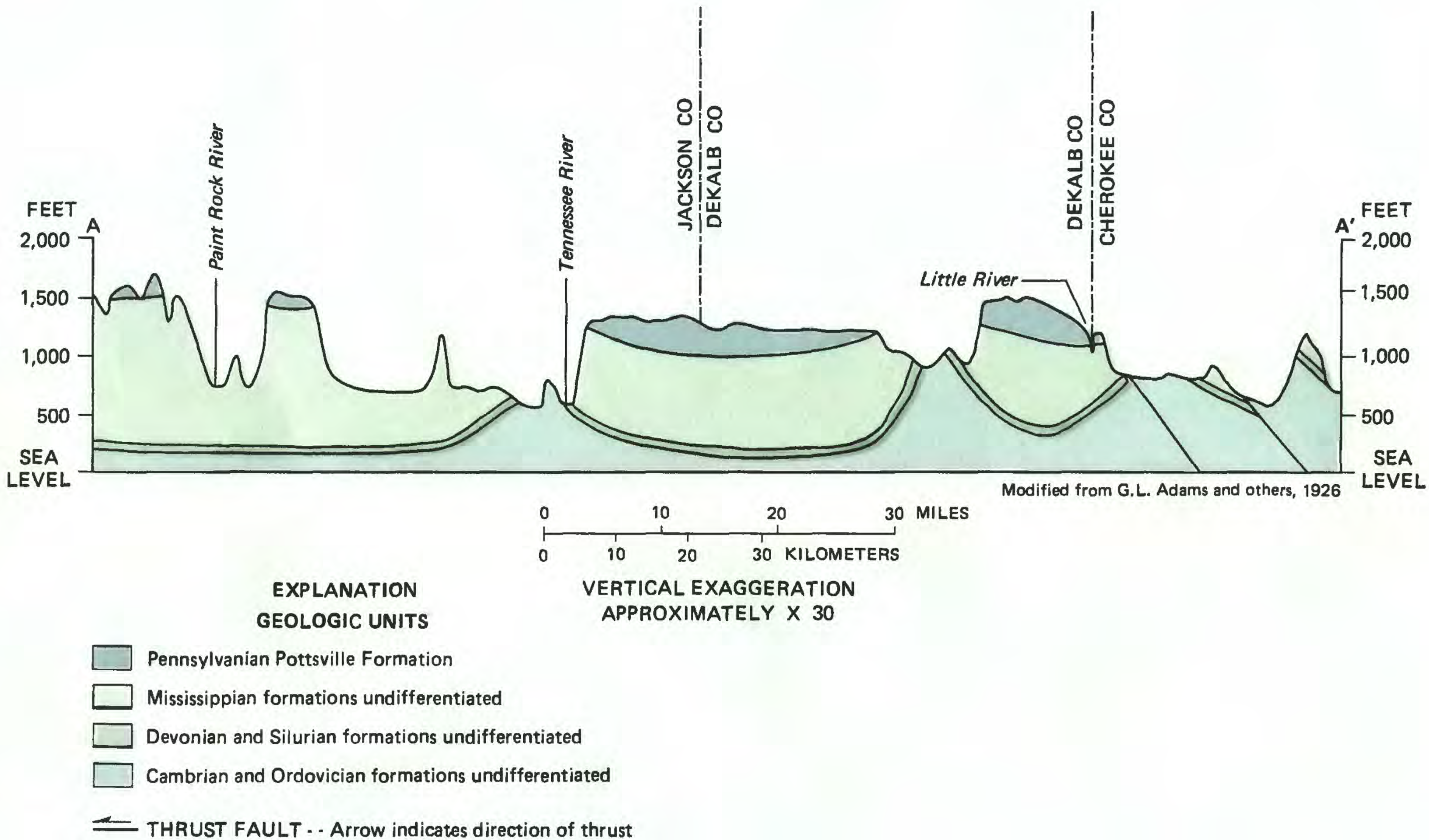

Figure 3.--Generalized subsurface geology of the study area.

The Cumberland Plateau section includes several mappable geologic structures south of the Tennessee River. The most prominent structural features are northeastward trending folds that are associated with physiographic features such as Murphrees, Sequatchie, and Wills Valleys, and Blount, Lookout, and Sand Mountains. The general nature of the structures can be described as a series of broad synclinal mountains separated by narrow symmetrical to asymmetrical anticlinal valleys. Thrust faults and additional minor folding are usually associated with the folds, and geologic structure may be complex on a local scale.

The geology in the Alabama Valley and Ridge section is more complex than in the Cumberland Plateau section. A major thrust fault, the Gadsden fault, cuts across the central part of the area and separates it into two relatively distinct sub-areas. Folds and faults north of the Gadsden fault trend northeastward and are similar to those in the Cumberland Plateau section. These structures are associated with topographic features such as Birmingham-Big Canoe and Cahaba Valleys. South of the Gadsden fault the number and complexity of faults increases; structures trend in a more easterly direction, forming topographic features such as Armuchee and Weisner Ridges.

Stratigraphy and Lithology

Stratigraphic relations for most formations in the study area have been described at a regional level but are poorly defined at some localities due to complications introduced by folding and faulting. Lithologic changes from relatively impermeable to relatively permeable are significant with respect to the major aquifers that occur in Upper Cambrian and Mississippian formations. A summary of the thickness, lithology, and water-bearing properties for all geologic units in the study area is given in table 1.

Formations from the Cambrian System that crop out, principally in the Coosa Valley, are the Weisner Formation, Shady Dolomite, Rome Formation, and the Conasauga Formation. Additional Cambrian formations are included in the Cambrian and Ordovician undifferentiated. The total thickness for the Cambrian exposed in the study area is difficult to determine due to the complex structure, but probably is greater than 6,000 feet. The Weisner Formation consists of quartzite interbedded with shale and conglomerate. The Shady Dolomite is a dolomitic limestone and, where it crops out, the surface is mantled with a layer of residual weathered material referred to as regolith. The Rome Formation consists mainly of shale and sandstone. The Conasauga Formation grades from shale with thin interbeds of limestone and dolomite in the west to shale with relatively thick interbeds of limestone and dolomite in the east. It crops out extensively in Etowah and Cherokee Counties and has a well developed regolith.

The Cambrian and Ordovician undifferentiated includes the Copper Ridge Dolomite, Chepultepec Dolomite, and the Longview and Newala Limestones. These formations crop out in Cahaba and Wills Valleys and southeastern Cherokee County, and have an estimated thickness of greater than 1,100 feet. The dolomite formations are lithologically similar, and consist of medium- to thick-bedded dolomite with local lenses of limestone which may be extremely cherty. The Longview consists of cherty limestone with some dolomite and the Newala Limestone consists principally of limestone with very little chert. The outcrop of all four formations, where they crop out in valleys, is mantled by a thick regolith.

Ordovician units include the Chickamauga Limestone and the overlying Inman Formation, Leipers Limestone, and Sequatchie Formation which crop out in narrow belts along the flanks of and within geologic structures, and have an aggregate thickness estimated to be greater than 500 feet. The lower part of the Chickamauga Limestone locally includes some conglomerate with sandstone and chert pebbles; however, the principal lithology is fine- to coarsely-crystalline, thin- to medium-bedded limestone. The Inman Formation and Leipers Limestone have lithology similar to the Chickamauga Limestone but are thinner and crop out in very narrow belts along the flanks of geologic structures. The Sequatchie Formation lithology is argillaceous limestone with some shale.

The Silurian and Devonian Systems are represented by three formations which crop out principally on the flanks of geologic structures. The Red Mountain Formation is the single Silurian formation in the study area. The formation thickens from about 200 feet in the northwest part of the area to about 700 feet in the southeast, and consists of shale and ferruginous sandstone. The Devonian System includes the Frog Mountain Sandstone and the Chattanooga Shale. The Frog Mountain consists of coarse-grained sandstone and crops out in the southeastern part of the area. Its thickness is difficult to determine due to faulting but is probably up to 300 feet. The Chattanooga Shale consists of up to 50 feet of black shale that usually contains pyrite.

The Mississippian System includes the Fort Payne Chert, Tuscumbia Limestone, Monteagle Limestone, Hartselle Sandstone, Pride Mountain Formation, Floyd Shale, Bangor Limestone, Pennington Formation, and Parkwood Formation. Some of these formations thin or grade laterally into others; in general, the stratigraphy consists of a northwestern carbonate facies that includes the Fort Payne Chert, Tuscumbia Limestone, Monteagle Limestone, Hartselle Sandstone, Pride Mountain Formation, and Bangor Limestone that grades into a southeastern clastic facies which includes the Floyd Shale, Pennington Formation, and Parkwood Formation. The reader is referred to Thomas (1972) for a detailed description of Mississippian stratigraphy.

The Mississippian carbonate units occur principally north of the Coosa Valley and, except for most of Jackson County, crop out in narrow bands along the flanks of geologic structures. The Bangor Formation and, to a lesser extent, the Tuscumbia Limestone crop out more extensively in Jackson County. The Fort Payne Chert, Tuscumbia Limestone, and Monteagle Limestone are lithologically similar, consisting of massive to bedded limestone with chert nodules and beds. The aggregate thickness of these units is about 600 feet in much of the Cumberland Plateau section; however, they thin considerably to the southeast. The Pride Mountain Formation is a clastic unit that intertongues with the Monteagle Limestone in the southwestern part of the area. The Hartselle Sandstone is absent in most of the area but is as much as 150 feet thick at some places. The Hartselle consists of fine-grained quartzose sandstone. The Bangor Limestone is a thick-bedded crystalline and oolitic limestone that may be as much as 600 feet thick in much of the Cumberland Plateau section. The formation grades southeast into the Floyd Shale, Pennington Formation, and the Parkwood Formation.

The Mississippian clastic formations crop out principally in the southeastern part of the study area. The Floyd Shale is a dark grey shale that may be as much as 400 feet thick. The Pennington Formation may be as much as 100 feet thick and consists of shale and carbonaceous sandstone with some limestone. The Parkwood Formation includes some lower Pennsylvanian rocks and consists of shale and sandstone and may be as much as 400 feet thick.

The Pennsylvanian System consists of the Pottsville Formation which crops out extensively on the synclinal mountain tops such as Lookout and Sand Mountains and caps many ridges in Jackson County. The formation may be as much as 800 feet thick and consists of tightly-indurated and cemented sandstone, conglomerate, shale, and siltstone with thin beds of coal.

HYDROLOGY OF THE MAJOR AQUIFERS

The major aquifers in the study area are, in descending order, the Pottsville aquifer, the Tuscumbia-Fort Payne aquifer, and the Knox-Shady aquifer. All three of these aquifers crop out throughout much of the study area but, due to the folded and faulted geologic structure, are not always continuous from one area to another. The Tuscumbia-Fort Payne and the Knox-Shady aquifers are principally carbonate aquifers that include several geologic units. These aquifers are sometimes subdivided into smaller units when they are addressed at a more local scale. The recharge areas for the major aquifers as well as areas susceptible to contamination from the surface are shown on plate 1. Also shown on plate 1 are the locations of public water-supply wells and the potentiometric surface for the Pottsville and Knox-Shady aquifers. Details for the construction of public water-supply wells, water levels, and other pertinent data are given in table 2.

The Pottsville aquifer crops out in the Blount, Lookout, and Sand Mountain districts and includes the Pottsville Formation. Rocks in the aquifer are tightly cemented and have little primary porosity and permeability. They, like the carbonate aquifers, contain water in secondary features. Solutioning is not an effective agent for enhancement of secondary features in the Pottsville aquifer due to its principally silicic lithology and the yields of public water-supply wells completed in this aquifer are less than those for the carbonate aquifers. Most public water-supply wells completed in the Pottsville aquifer yield less than 0.15 Mgal/d (million gallons per day).

The Tuscumbia-Fort Payne aquifer crops out in the thin belts along the flanks of the Birmingham-Big Canoe, Cahaba, Murphrees, Sequatchie, and Wills Valley districts, and along thrust belts in the southeastern part of the study area. The principal water-bearing units in the Tuscumbia-Fort Payne aquifer are the Tuscumbia Limestone and the Fort Payne Chert. The aquifer also includes the following overlying units which are listed in descending order:

the Bangor Limestone, Pride-Mountain Formation, Hartselle Sandstone, and the Monteagle Limestone.

The Knox-Shady aquifer crops out in the valley floors of the Birmingham-Big Canoe, Cahaba, Murphrees, and Wills Valley districts. The principal water-bearing units in the Knox-Shady aquifer are, in descending order: the Newala Limestone, Longview Limestone, Chepultepec and Copper Ridge Dolomites, which are all members of the Knox Group, and the Shady Dolomite. The aquifer also includes the Conasauga and Rome Formations which are stratigraphically between the Knox Group and the Shady Dolomite, and the Weisner Formation which is overlain by the Shady Dolomite.

The Tuscumbia-Fort Payne and the Knox-Shady aquifers are tightly cemented and have little primary porosity and permeability. They contain water in secondary features such as fractures that are present due to regional stress patterns related to structural features, faulting, or stress relief fracturing along bedding planes. The hydraulic properties of these aquifers may be further enhanced because they consist principally of carbonate minerals that are subject to solutioning processes capable of affecting substantial enlargements to secondary features. If solutioning is extensive enough, interconnected networks of solution channels that are capable of yielding large quantities of water to wells may develop. Most public water-supply wells completed in the carbonate aquifers yield between 0.5 and 1.0 Mgal/d.

Recharge and Movement of Ground Water

The source of most water in the study area is precipitation which averages about 55 inches annually (U.S. Department of Commerce, 1985). Precipitation may infiltrate into soil and then evaporate, transpire or move to streams and lakes, or infiltrate and percolate to the water table and recharge the local ground-water system. Annual recharge to the Pottsville aquifer has been estimated to be about 2 to 3 inches (Kidd and Bossong, 1987) and is less than the recharge to the carbonate aquifers which have been estimated to be as much as 10 inches (Zurawski, 1978).

All three major aquifers in the study area are recharged throughout their outcrops, however, recharge is likely to be more active or concentrated where there are features such as sinkholes, which may provide surface runoff direct access to aquifers. Recharge is also affected to some extent by land surface slope, surface drainage, and the character of surface material. Relatively flat, poorly or internally drained areas may pond and store substantial amounts of surface water. If surface materials are permeable in these areas much of the ponded water may infiltrate and recharge local aquifers. Recharge may also be more active in areas where permeable features such as faults or fractures crop out or connect surface water bodies and aquifers.

Ground-water movement within the major aquifers is controlled by gravity and, in general, is from topographic highs to topographic lows where it is discharged to streams, such as the Locust and Mulberry Forks and the Paint Rock, Little, and Coosa Rivers, which are the major ground-water drains. The direction of ground-water movement generally is similar to that of surface drainage. Potentiometric maps, or contours of water levels measured in tightly cased wells, may be used to determine the direction of ground-water movement. Although data were not sufficient to prepare a potentiometric map for the Tuscumbia-Fort Payne aquifer, data were available to prepare potentiometric maps for Pottsville and Knox-Shady aquifers. The contours are shown on plate 1 and are based on measurements made during 1959-72; a period much longer than is normally used to construct a potentiometric map. However, because these aquifers are not stressed by widespread pumpage and because the contour interval used is 50 feet, these data may be used to depict the general direction of ground-water movement.

Ground-water movement in the carbonate aquifers that have solutionally enhanced secondary features may, on a local scale, be quite different than the general direction of ground-water movement shown on plate 1. In general, the majority of ground-water flow in carbonate aquifers takes place in solutionally enhanced secondary features. Consequently, water-bearing zones may be extremely local in such aquifers. For example, ground-water discharge in the form of spring flow from such anisotropic aquifers may be quite prevalent where secondary features crop out; however, a short distance away there may be virtually no ground-water discharge.

Natural Discharge and Ground-Water Withdrawals

A large part of recharge to the major aquifers is naturally discharged to springs and streams. Streamflow records for streams draining outcrop areas for the carbonate aquifers indicate that the ground-water discharge to streams is about 5 inches on an annual basis (Bingham, 1982). Many streams that drain the Pottsville aquifer are intermittent and indicate that ground-water discharge from the Pottsville aquifer often cannot sustain streamflow through extended rainless periods. Ground-water discharge from the Pottsville aquifer is probably about 2 inches on an annual basis.

Additional discharge from the major aquifers occurs as withdrawals from wells, both domestic and public water supply. Total ground water used in the study area is estimated to be about 10 Mgal/d or about 0.06 inches on an annual basis (Baker and Mooty, 1987). Approximately one half of this is withdrawn by municipal public water suppliers. The Knox-Shady aquifer is used by several small communities throughout the valley districts and is the most common source of water for public water-supply wells in the study area. The Tuscumbia-Fort Payne aquifer has a limited outcrop in the study area, however, it is widely used as a source for public water supply where it crops out due to its ability to yield up to 1 Mgal/d of water to wells. The Pottsville aquifer is widely used as a source for public water supply in the mountain districts of the study area.

Effects of Withdrawals from the Aquifers

Large long-term withdrawals of water from an aquifer commonly create a depression in the potentiometric surface of the aquifer. There are no indications of such depressions in the potentiometric maps for the aquifers in the study area. This is due, in part, to the absence of major pumping centers that make large long-term withdrawals of water from the aquifers. It is also due to the presence of secondary features such as solution channels, which may confine the effects of withdrawals to the network of secondary features that conduct water to a discharging well and, consequently, make it difficult to observe the effects.

SUSCEPTIBILITY OF MAJOR AQUIFERS TO SURFACE CONTAMINATION

Aquifers are susceptible to surface contamination wherever recharge occurs. The source of contamination may be point sources such as leaking waste ponds or nonpoint sources such as agricultural areas that have received fertilizer and pesticide applications. Parts of the study area where aquifers are potentially susceptible to contamination from the surface are categorized into areas that are susceptible and highly susceptible.

The major aquifers crop out extensively in the study area. Recharge occurs throughout their outcrops and any contaminants present on the surface of these areas can be expected to enter the underlying aquifer. Consequently, the major aquifers are susceptible to contamination throughout their outcrop (plate 1).

Specific areas and general topographic and geologic settings that are highly susceptible to contamination occur in the study area. Sinkholes represent specific areas where surface water may enter the ground-water system with little or no filtration and are areas that may be highly susceptible to contamination from the surface. Sinkholes commonly occur throughout the carbonate parts of the study area. Areas where sinkholes have occurred and major aquifers may be highly susceptible to contamination are indicated on plate 1. Additional information concerning the locations of sinkholes and other karst features can be obtained from 7.5 minute topographic maps and field inspection.

General topographic settings that may be highly susceptible to contamination from the surface include poorly or internally drained areas within the major aquifer outcrops where permeable surface materials are present. Surface runoff commonly ponds and is stored in these areas as a result of their poor drainage characteristics. In areas where surface materials are permeable, the ponded water has a much greater chance of infiltrating to recharge the major aquifers. Examples of this setting in the study area include depressions and swampy areas bordering streams. Depressions where major aquifers may be highly susceptible to contamination have been previously mapped (U.S. Geological Survey, 1977) and are shown on plate 1.

General geologic settings that have potential to be highly susceptible to contamination from the surface include areas where faults or fractures crop out within the major aquifer outcrops. These features generally are permeable and may provide nearly direct access from surface water to the underlying aquifers. Most of the major faults in the study area have been mapped and are shown in figure 3. However, many additional and unmapped minor faults occur in the study area. The most probable areas for significant minor faulting is in the Valley and Ridge section where faulting and folding is most extensive.

CONCLUSIONS

Paleozoic rocks in the study area have been folded and faulted into a series of valleys and ridges that trend northeastward. Ground water used for public supply is obtained from three major aquifers: the Pottsville, Tuscumbia-Fort Payne, and the Knox-Shady. The Pottsville aquifer is clastic and crops out in the Mountain parts of the study area. The Tuscumbia-Fort Payne aquifer is principally carbonate and crops out along the flanks of most major valleys in the area. The aquifer consists of the Fort Payne Chert, Tuscumbia and Monteagle Limestones, Hartselle Sandstone, Pride Mountain Formation, and the Bangor Limestone. The Knox-Shady aquifer is a major source of ground water in the area and crops out in most of the major valleys of the area. The aquifer consists of the Weisner Formation, Shady Dolomite, Conasauga Formation, Copper Ridge and Chepultepec Dolomites, Longview Limestone, and the Newala Limestone.

The carbonate aquifers are subject to solution processes that result in significant, locally cavernous, secondary porosity and permeability. Wells constructed in cavernous or well-developed secondary features may produce up to 1 Mgal/d. The Pottsville aquifer may yield as much as 0.25 Mgal/d per well where it is sufficiently thick. Recharge to the aquifers occurs throughout their areas of outcrop, and may be concentrated in areas where sinkholes or other highly permeable features occur at the surface.

All of the aquifers are susceptible to contamination from the surface where they crop out and are recharged. Areas with solutionally developed features, such as sinkholes that commonly occur in the limestone areas, may be highly susceptible to contamination. In addition, areas that are poorly or internally drained and have permeable surface materials, and areas where faults or fractures crop out may be highly susceptible to contamination from the surface.

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Table 1. Generalized column of geologic formations in the study area and their water-bearing properties

Erathem	System	Series	Thickness (feet)	Stratigraphic unit	Lithology	Water-bearing properties
Paleozoic	Pennsylvanian		300-500	Pottsville Formation	Sandstone, shale, and coal beds	Sandstone, normally yields only moderate amounts of water to drilled wells. May yield as much as 0.25 Mgal/d (million gallons per day) where fractured and weathered. Commonly high in iron.
	Mississippian	Upper	3,500	Parkwood Formation	Clay, shale, claystone, and mudstone	Water may be suitable for domestic purposes but is commonly high in iron.
				Pennington Formation	Shale and carbonaceous sandstone	
				Floyd Shale	Predominantly a dark-gray clay shale	Small amounts of water. Sufficient for domestic use.
				Bangor Limestone	Oolitic limestone, lower beds may contain a gray clay shale	Abundantly water bearing where solution channels are developed. Calcium bicarbonate waters.
				Hartselle Sandstone	Light-colored quartzose sandstone, nearly all fine-grained, well-sorted sandstone	Yields moderate amounts of water to drilled wells. Variable quality.
				Pride Mountain Formation	Medium- to dark-gray fissile clay shale	Yields moderate amounts of water to drilled wells. Variable quality.
				Tuscumbia Limestone	Light-gray micrite and light-gray bioclastic limestone and chert in beds generally more than 1 foot thick	Solution channels feed many large springs and yield adequate water to drilled wells. Cherty subsoil; excellent aquifer. Calcium biocarbonate waters.
		Lower		Fort Payne Chert	Chert and siliceous limestone	
	Devonian		0-50	Chattanooga Shale	Black shale	Relatively impermeable and not an aquifer.
			25-300	Frog Mountain Formation	Medium- to very coarse-grained sandstone	Little water; variable quality.
	Silurian		2-700	Red Mountain Formation	Interbedded sandstone, siltstone, shale, hematite with thin interbeds of bioclastic limestone	Yields sufficient for domestic use. Commonly high in iron content.
	Ordovician		500+	Western facies: Sequatchie Formation, Leipers Limestone, Inman Formation, Chickamauga Limestone	Fine- to coarse-grained, medium- to thick-bedded, pure argillaceous limestones	Yields calcium bicarbonate waters. Shales and argillaceous limestones yield little water.
	Cambrian and Ordovician		3,900	Knox Group: Newala Limestone, Longview Limestone, Chepultepec Dolomite, Copper Ridge Dolomite	Range from siliceous dolostone in the lower part to fine- to coarse-grained limestone in the upper part	Abundantly water bearing. Solution channels supply springs and drilled wells. Water suitable for most uses. The cherty subsoil of the Copper Ridge Dolomite forms an excellent ground-water reservoir. Copper Ridge Dolomite is subject to having excessive iron concentrations.
	Cambrian		1,000	Conasauga Formation	Interbedded limestone and dolomite in west to shale with limestone and dolomite in east	The interbedded limestones and sandstones may be highly productive while the dolomite and shales yield little water.
			1,000	Rome Formation	Interbedded sandstone, siltstone and shale	Yields moderate amounts of water of variable quality.
			500-1,000	Shady Dolomite	Sandy dolostone and dolomitic limestone	Aquifer yields abundant calcium and magnesium bicarbonate waters of moderate hardness.
			1,000+	Wiesner Formation	Quartzite with interbedded shale and conglomerate	Yields moderate amounts of water of variable quality.

Table 2.-- Records of public water supply wells and springs in the study area

NOTE: Well numbers correspond to those shown on plate 1.

Geographic coordinate number: Lat (DDMMSS) Long (DDMMSS) sequential number (xx).

Depth of well and water: Depth of well given in feet; reported water levels are in feet above (-) or below land surface; measured water levels are in feet and tenths.

Water-bearing unit: ₽pv, Pottsville Formation; Mb, Banqor Limestone; Mtf, Fort Payne Chert, Tuscumbia Limestone, Monteagle Limestone undifferentiated; Srm, Red Mountain Formation; Oc, Chickamuga Limestone; ЄO, Cambrian and Ordovician rocks undifferentiated; Єc, Conasauga Formation.

Altitude of land surface: Altitudes qiven in feet above NGVD from topographic map or determined by aneroid barometer; altitudes given in feet and tenths determined by instrumental leveling.

Method of lift: N, none: S, submergible; T, turbine; J, jet.

Use of well: P, public water supply; A, abandoned water supply.

Well no.	Geographic coordinate number	Well owner	Driller and year completed	Depth of well (feet)	Diameter of well (inches)	Water bearing unit	Altitude of land surface (feet)	Water level: Above or below land surface (feet)	Water level: Date of measurement	Method of lift	Use of site	Remarks
1	345846085484101	Russell Cave National Monument	Dodson 1962	180	6	Mtf	710	47.12	1-28-87	S	P	System capacity 0.2 Mgal/d
2	345812085452501	Bridgeport	--	Spring	--	Mb	880	--	--	--	P	Gravity flow
3	345359085504601	Stevenson	--	Spring	--	Mb	1,050	--	--	--	--	Perriwinkle spring gravity
4	345450085462301	North Jackson Hospital	Campbell Drilling 1958	120	6	ЄO	630	--	--	S	P	System capacity 0.1 Mgal/d Test pumped 80 gal/min
5	345229085502401	Stevenson	--	Spring	--	Mtf	800	--	--	--	A	Sabe spring gravity
6	345307085481001	Stevenson Utilities	Campbell Drilling 1971	163	14	ЄO	640	42.75	2-15-71	T	P	System capacity 0.9 Mgal/d Test pumped 300 gal/min
7	345143085500601	Stevenson Utilities	Adams-Massey 1948	301	8	CO	630	22	9-48	T	A	System capacity 0.9 Mgal/d
8	345210085471501	Mead Paper Board	Miller 1973	83	6	ЄO-Oc	640	--	--	T	P	
9	344323086065601	Cumberland Mountain Water Authority	Graves Drilling 1976	161	8	Mb	640	20.00	6-22-76	T	A	Test pumped 330 gal/min
10	344329085580301	Hollywood Water Works	Campbell Drilling 1962	160	8	ЄO-Oc	660	7.5	12-03-62	T	P	System capacity 0.5 Mgal/d
11	344317085581101	Hollywood	Campbell 1975	--	8	ЄO-Oc	660	46.00	8-02-75	T	P	System capacity 0.5 Mgal/d Test pumped 70 gal/min

Table 2.-- Records of public water supply wells and springs in the study area--Continued

Well no.	Geographic coordinate number	Well owner	Driller and year completed	Depth of well (feet)	Diameter of well (inches)	Water bearing unit	Altitude of land surface (feet)	Water level: Above or below land surface (feet)	Water level: Date of measurement	Method of lift	Use of site	Remarks
12	343956086194901	Paint Rock Water System	- -	160	--	Mtf	610	12.08	1-17-99	--	--	System capacity <.1 Mgal/d
13	344029086030401	Scottsboro	Virginia Supply and Well 1953	522	12	Mtf	625	--	--	T	A	Test pumped 250 gal/min
14	344026086025201	Scottsboro	Peerson Drilling 1947	463	8	Mtf	630	--	--	--	A	Sealed Test pumped 130 gal/min
15	344125085500101	Pisgah Water Department	Campbell Drilling 1961	63	8	IPpv	1350	--	--	T	P	System capacity 0.2 Mgal/d flows Test pumped 325 gal/min
16	343809086161501	Woodville Water	Dodson Drilling 1969	136	6	Mtf	605	9.42	11-17-69	T	P	System capacity 0.3 Mgal/d Test pumped 350 gal/min
17	343737086160301	Woodville Water	Dalrymple Drilling 1963	163	6	Mb	590	12	2-1963	S	P	System capacity 0.3 Mgal/d Test pumped 300 gal/min
18	343418086063101	Skyline Shores Water	Campbell Drilling 1958	250	6	Oc	610	--	--	S	P	System capacity <.1 Mgal/d
19	343648085364801	Valley Head	-	Spring	--	Mtf	1,060	--	--	T	P	System capacity 0.6 Mgal/d Reported yield of 900 gal/min
20	343442085350701	Mentone	- 1954	51	5.63	IPpv	1,700	--	--	--	A	Test pumped 12 gal/min
21	343442085350601	Mentone	- 1954	50	5.63	IPpv	1,700	--	--	--	A	Test pumped 5 gal/min
22	343053086063801	South Sauty Camp	-- --	--	--	Oc	615	--	--	--	--	
23	342832086025701	Bucks Pocket State Park	Sand Mtn Drillers 1970	190	6	IPpv	670	70	6-18-70	S	P	-
24	342344085403801	Canyon Land Park	-- 1967	225	12	IPpv	1,150	--	--	S	P	-
25	342349085403501	Canyon Land Park	Owens 1965	165	6	IPpv	1,150	40	3-87	S	P	-
26	341903086295501	Arab Water Works	Campbell Drilling 1951	325	6	IPpv	1,057	80	1951	--	A	Test pumped 120 gal/min
27	341910086294801	Arab Water Works	Peerson Drilling 1935	337	8	IPpv	1,100	--	--	--	A	

Table 2.-- Records of public water supply wells and springs in the study area--Continued

Well no.	Geographic coordinate number	Well owner	Driller and year completed	Depth of well (feet)	Diameter of well (inches)	Water bearing unit	Altitude of land surface (feet)	Water level: Above or below land surface (feet)	Water level: Date of measurement	Method of lift	Use of site	Remarks
28	341915086294001	Arab Water Works	Virginia Well Supply 1954	302	10	IPpv	1,095	40.5	6-28-54	T	A	Test pumped 320 gal/min
29	341939086292501	Arab Water Works	Campbell Drilling 1950	350	8	IPpv	1,100	45	1952	--	A	Test pumped 120 gal/min
30	341837086294301	Arab Water Works	Campbell Drilling 1952	385	10	IPpv	1,095	--	--	T	A	Test pumped 85 gal/min
31	341649085595001	Crossville	- 1965	307	8	IPpv	1,105	35	1965	T	P	System capacity 0.4 Mgal/d Test pumped 225 gal/min
32	341807085545601	Collinsville	Graves Drilling 1980	358	6.25	€O	710	15.5	1-06-81	--	A	System capacity 0.4 Mgal/d welded cap
33	341809085544201	Collinsville	Graves Drilling 1984	275	8	€O	710	10.5	1-27-84	P	P	System capacity 0.4 Mgal/d Private Test pumped 50 gal/min
34	341716085410201	Little River Canyon Mouth Park	Graves 1967	180	--	Mtf	620	34	1-22-87	S	P	
35	341557085512601	Collinsville	-- --	Spring	--	Mtf	725	--	--	--	P	Gravity flow
36	341549085513401	Collinsville	Graves Drilling 1966	120	8	Mtf	725	30	3-04-66	--	--	System capacity 0.4 Mgal/d filled w/ rocks Test pumped 600 gal/min
37	341601085332401	Gaylesville	Sand Mountain Drilling 1966	150	6.63	€c	530	109	3-22-66	None	A	Test pumped 30 gal/min
38	341418085530501	Collinsville	Graves Drilling 1982	450	6.25	Mb	820	2.16	10-15-82	S	P	System capacity 0.4 Mgal/d Test pumped 85 gal/min
39	341323085362301	Cedar Bluffs	Peerson Drilling 1951	300	8	€c	580	10	8-31-53	None	A	Test pumped 60 gal/min
40	341225086253301	Douglas	Graves Drilling 1982	300	10	Mb	785	40.36	1-27-87	T	P	Reported yield 300 gal/min
41	341223086253001	Douglas	Graves Drilling 1982	290	6	Mb	635	11.02	1-27-87	--	--	Reported yield 300 gal/min
42	341207086252901	Douglas	Graves Drilling 1982	365	6	Mb	785	--	--	--	P	Reported yield 300 gal/min

Table 2.-- Records of public water supply wells and springs in the study area--Continued

Well no.	Geographic coordinate number	Well owner	Driller and year completed	Depth of well (feet)	Diameter of well (inches)	Water bearing unit	Altitude of land surface (feet)	Water level: Above or below land surface (feet)	Water level: Date of measurement	Method of lift	Use of site	Remarks
43	341210086101501	Boaz	-- 1965	295	15	IPpv	1,040	--	--	--	A	Test pumped 350 gal/min
44	341211086101101	Boaz	Adams-Massey 1955	230	8	IPpv	1,040	--	--	--	A	Test pumped 300 gal/min
45	341213086101301	Boaz	Adams-Massey 1948	200	10	IPPv	1,040	--	--	--	A	Test pumped 200 gal/min
46	341211086095501	Boaz	1927	--	10	IPpv	1,065	--	--	--	A	
47	340514086355601	Blountsville	Miller 1972	150	8.0	Mtf	675	51.15	1-13-87	T	P	
48	340516086351901	Blountsville	-	150	8.0	Mtf	690	--	--	T	P	
49	340502086353601	Blountsville	Miller 1972	143	6.25	Mtf	680	89	1-13-87	T	P	Test pumped 300 gal/min
50	340543086230201	Snead Water Works	Graves 1971	200	10	IPpv	840	--	--	T	P	System capacity 0.3 Mgal/d well flows
51	340329086183401	Walnut Grove	Adams-Massey 1961	252	6	€O	855	18.84	11-15-61	T	P	System capacity 0.3 Mgal/d Test pumped 200 gal/min
52	340239086200401	Altoona Water and Sewer	Interstate Drillers 1967	140	6	€O	870	9.23	4-23-77	T	P	Observation well G-3
53	340143086193901	Altoona Water and Sewer	- 1958	105	8	€O	930	--	--	T	P	System capacity 0.5 Mgal/d standby
54	340136086193401	Altoona Water and Sewer	Peerson 1958	252	8	€O	955	--	--	--	A	System capacity 0.5 Mgal/d Test pumped 104 gal/min
55	340316086063001	Ridgeville	- -	--	--	€O	585	7.21	1-21-87	S	P	System capacity 0.1 Mgal/d
56	340405086020501	Reece City	Adams-Massey 1962	150	6	Mtf	580	7.31	1-21-87	T	P	System capacity 0.2 Mgal/d
57	340438085545001	Northeast Etowah Water	Graves	--	--	€O	570	--	--	T	P	System capacity 0.6 Mgal/d
58	340526085533201	Northeast Etowah Water	-	--	--	€O	545	--	--	--	--	
59	340302085334801	Mt. Zion Water	Adams-Massey 1962	150	6	€c	650	--	--	T	P	
60	335952086343201	Cleveland Water Works	Graves 1977	270	12.0	IPpv	560	--	--	T	P	

Table 2.-- Records of public water supply wells and springs in the study area--Continued

Well no.	Geographic coordinate number	Well owner	Driller and year completed	Depth of well (feet)	Diameter of well (inches)	Water bearing unit	Altitude of land surface (feet)	Water level: Above or below land surface (feet)	Water level: Date of measurement	Method of lift	Use of site	Remarks
61	335924086340401	Cleveland Water Works	Campbell 1968	200	8.0	IPpv	500	7	1968	T	P	Test pumped 150 gal/min
62	335858086271401	Oneonta Utilities Board	Graves 1977	325	12.0	€0	790	--	--	--	--	Not on line in 1987. Has top welded.
63	335829085514901	Hokes Bluff	-- --	Spring	--	€0	600	--	--	--	--	System capacity 2.2 Mgal/d
64	335738086375601	Nectar Water System	Interstate Drillers 1979	380	--	IPpv	480	41.49	1-03-79	--	A	System capacity 0.4 Mgal/d Test pumped 130 gal/min
65	335731086373501	Necatar Water System	Interstate Drillers 1979	170	--	IPpv	445	14.08	11-18-79	T	P	System capacity 0.4 Mgal/d Test pumped 500 gal/min
66	335631086283101	Oneonta Utilities Board	JJ Hart 1947	173	10.0	€0	870	70	1947	T	P	System capacity 1.3 Mgal/d
67	335625086282001	Oneonta Utilities Board	H W Peerson 1954	273	10.0	€0	870	--	--	--	A	System capacity 1.3 Mgal/d Test pumped 220 gal/min
68	335655085554401	Glencoe	-- --	Spring	--	€0	570	--	--	T	P	
69	335645085553901	Glencoe	Adams-Massey 1969	287	8	€0	580	31.17	9-09-69	T	P	System capacity 1.9 Mgal/d Test pumped 230 gal/min
70	335642085553701	Glencoe	Adams-Massey 1972	230	6	€0	580	60	--	T	P	
71	335539086464701	Hayden Water Works	Peerson 1973	139	6.0	Mtf	510	32	11-08-74	T	P	System capacity 0.1 Mgal/d Test pumped 350 gal/min
72	335436086362701	Pine Bluff Water and Fire	-	--	--	IPpv	525	--	--	--	--	
73	335459086360401	Pine Bluff Water and Fire	Interstate Drillers 1979	170	6.0	IPpv	450	39.6	2-02-81	S	P	System capacity 0.5 Mgal/d Test pumped 300 gal/min
74	335450086355901	Pine Bluff Water and Fire	Peerson 1969	103	8	IPpv	500	--	--	T	P	System capacity 0.5 Mgal/d Test pumped 200 gal/min
75	335417086311001	Allgood Water Works	-- --	Spring	--	€0	760	--	--	T	P	System capacity 0.3 Mgal/d

Table 2.-- Records of public water supply wells and springs in the study area--Continued

Well no.	Geographic coordinate number	Well owner	Driller and year completed	Depth of well (feet)	Diameter of well (inches)	Water bearing unit	Altitude of land surface (feet)	Water level: Above or below land surface (feet)	Water level: Date of measurement	Method of lift	Use of site	Remarks
76	335221086515001	Rickwood Caverns	-- --	Spring	--	Mb	760	--	--	S	A	
77	335239086501601	Mt High Rock Spgs Water Auth	Graves Drilling 1979	143	8	Mb	640	8.58	1-13-87	S	P	System capacity 0.5 Mgal/d
78	335257086003101	Southside	Dodson Drilling 1976	100	6	€O	530	3.30	4-20-76	T	P	System capacity 1.2 Mgal/d Test pumped 400 gal/min
79	335253086003301	Southside	Graves Drilling 1976	278	6	€O	535	9.50	12-23-76	--	A	System capacity 1.2 Mgal/d welded top Test pumped 150 gal/min
80	335246085591501	Southside	Graves Drilling 1979	170	8	Mtf	640	58.58	12-12-79	T	P	System capacity 1.2 Mgal/d Test pumped 450 gal/min