GEOHYDROLOGY AND SUSCEPTIBILITY OF MAJOR AQUIFERS TO SURFACE CONTAMINATION IN ALABAMA; AREA 10

by Sydney S. DeJarnette

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 88-4077

Prepared in cooperation with the

ALABAMA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT

Tuscaloosa, Alabama

1989

DEPARTMENT OF THE INTERIOR

DONALD PAUL HODEL, Secretary

U.S. GEOLOGICAL SURVEY

Dallas L. Peck, Director

For additional information
write to:

District Chief
U.S. Geological Survey
520 19th Avenue
Tuscaloosa, Alabama 35401

Copies of this report can be
purchased from:

U.S. Geological Survey
Books and Open-File Reports
Box 25425
Federal Center, Building 810
Denver, Colorado 80225

CONTENTS

ILLUSTRATIONS

TABLES

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)
square mile (mi^2)	2.590	square kilometer (km^2)
cubic foot per second per square mile [$(ft^3/s)/mi^2$]	0.01093	cubic meter per second per square kilometer [$(m^3/s)/km^2$]
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)

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 10

By Sydney S. DeJarnette

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 to contamination of the major aquifers in Area 10 which includes Choctaw, Clarke, and Washington Counties.

The major aquifers in Area 10 are the Pliocene-Miocene aquifer which includes the Jackson Group and the Oligocene, Miocene, and Pliocene Series; the Lisbon aquifer which includes the upper part of the Tuscahoma Formation, the Hatchetigbee and Tallahatta Formations, the Lisbon Formation, and the Gosport Sand; and the Nanafalia-Clayton aquifer which includes the Naheola and Nanafalia Formations and the lower part of the Tuscahoma Formation (includes Clayton Formation east of the study area). Water in these aquifers generally is confined. The Nanafalia-Clayton aquifer is widely used for public water supplies in the northern part of Area 10. The Lisbon aquifer is used in the central part of the study area, and the Pliocene-Miocene aquifer is used in the southern part.

The potentiometric surfaces of the major aquifers have not been lowered significantly by long-term withdrawals in Area 10.

The recharge areas for all the major aquifers in the study area are susceptible to surface contamination. In most of the area, however, the major wells are some distance from the recharge area of the aquifer they tap, and are protected from surface contamination by the depth of the aquifer below the surface. Most of the recharge areas are in rural areas used for timberlands, farms, and pastures.

Permeable terrace and alluvial deposits overlie the outcrops of the major aquifers along the Tombigbee and Alabama Rivers. Presently, water discharges from these areas to the rivers, but if in the future pumpage increases causing a depression in the potentiometric surface of one of the underlying aquifers, the terrace and alluvial deposits will become a source of recharge and, potentially, a source of contamination.

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 recharge areas of the major aquifers and areas susceptible to contamination. The major aquifers as defined by this report are those currently used as sources of public water supplies in Choctaw, Clarke, and Washington Counties (see plate 1).

The dependence on ground water in this three-county area of southwest Alabama is not fully represented in this inventory, which is limited to public supply wells. Most of the area is dependent on domestic supply wells, which are numerous throughout the area.

Purpose and Scope

This report describes the results of a study to delineate and describe the geohydrology of the major aquifers and their recharge areas in the study area, and to delineate areas within the recharge areas that are most susceptible to contamination from the surface. Previously compiled geologic and hydrologic data provide about 75 percent of the data used to evaluate the major aquifers in the area. All wells used for municipal and rural public water supplies were inventoried, and water levels were measured in these wells where possible. Water-level data were used to compile generalized potentiometric maps of the aquifers. Data on water use also were compiled during the well inventory. Areas susceptible to contamination from the surface were delineated partly from topographic and geologic maps and partly from field investigation.

Location and Extent of the Area

The study area encompasses Choctaw, Clarke, and Washington Counties in southwest Alabama; an area of 3,220 square miles that is partly urban, partly suburban, and partly rural. The area includes the towns of Butler, Gilbertown, Thomasville, Grove Hill, Jackson, McIntosh, Chatom, and numerous other small towns and communities. The total population of the area was 61,362 in 1980 (Alabama Department of Economic and Community Affairs, 1984).

Physical Features

The study area includes parts of several physiographic districts, all within the East Gulf Coastal Plain physiographic section (fig. 1)(Sapp and Emplaincourt, 1975). The northern half of Choctaw County and the north edge of Clarke County are in the Southern Red Hills district. The northern part of this district is a lowland called the Flatwoods which extends only into the northeastern tip of Choctaw County. The central part of the district is a southward sloping upland of moderate relief. The southern part of the district, which extends from Choctaw County into Clarke County, is the rugged Buhrstone Hills.

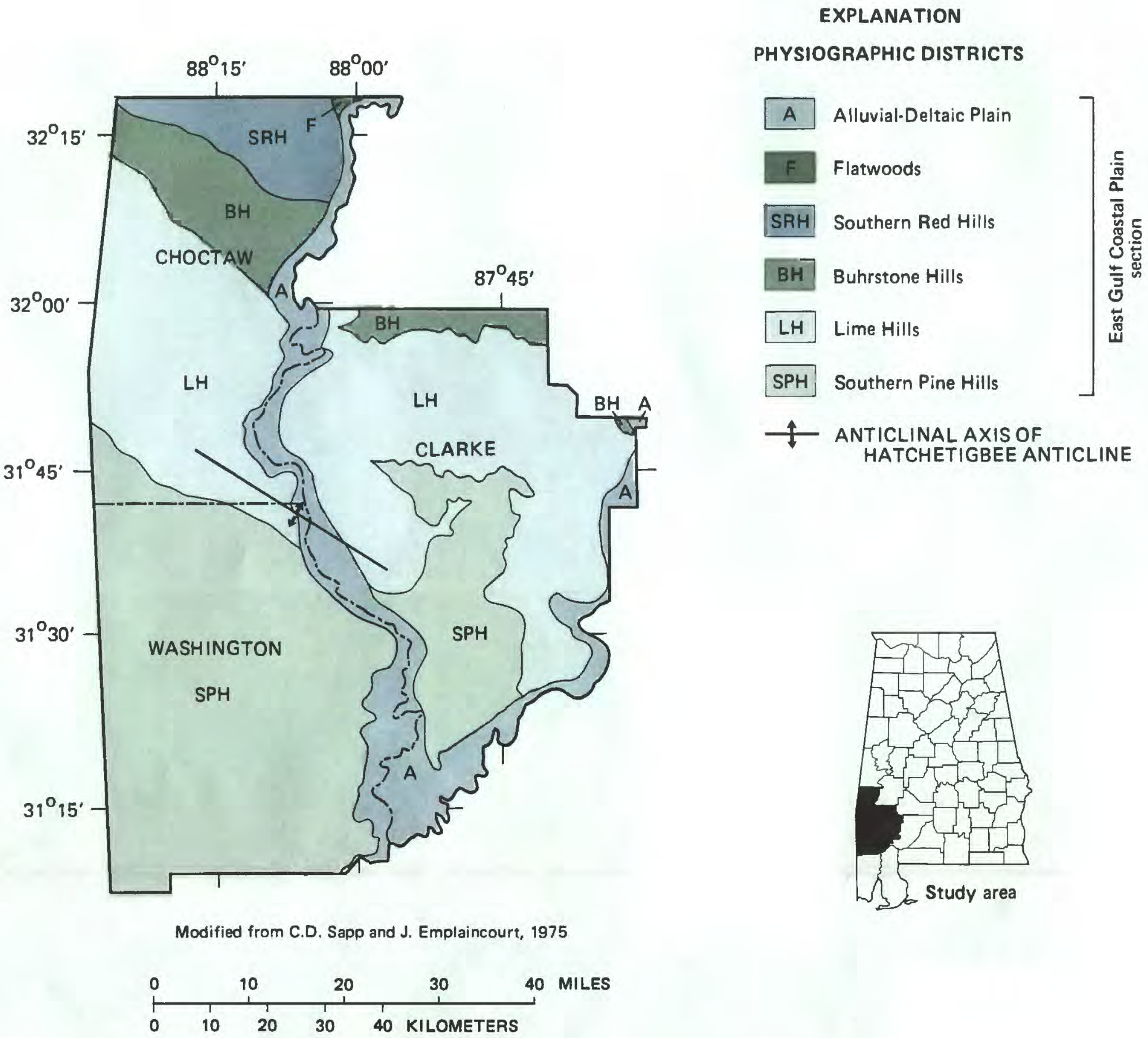


Figure 1.--Physiographic divisions of the study area.

South of the Southern Red Hills district is the Lime Hills district that includes most of the remainder of Choctaw County and a large part of central Clarke County. The Lime Hills district is a rugged topography developed on resistant limestone and includes the Hatchetigbee anticline in the southern part. The Hatchetigbee anticline is a geologic structure caused by movement of salt in the subsurface that uplifted the overlying sediments into a large fold. Erosion has cut through the folded layers to expose the oldest sediments along the axis of the anticline. The oldest exposed geologic unit is the Hatchetigbee Formation, from which the structure derives its name.

The Southern Pine Hills district lies to the south of the Lime Hills and includes most of Washington County and southern Clarke County and is characterized by an upland that slopes gradually southward; local relief is as much as 250 feet.

All three counties in the study area are traversed by valleys of the Alabama and Tombigbee Rivers that are in the Alluvial-Deltaic Plain district. The valleys are characterized by broad, flat, flood plains and terraces.

Previous Investigations

Information on the geology of the area was published as early as 1858 in the second biennial report of the Geological Survey of Alabama by Michael Toumey (1858). A detailed description of the geology of Alabama and a revised geologic map were published by the Geological Survey of Alabama in 1926 (Adams and others, 1926).

The earliest information on ground water in the area was published in 1907 (Smith, 1907). Other reports that contain information on the geology and ground-water resources of the area are "Geology and Ground-Water Resources of Choctaw County, Alabama" (Toulmin and others, 1951), "Water Availability of Clarke County, Alabama" (Causey and McCain, 1971), "Geology of Clarke County, Alabama" (Causey and Newton, 1972), "Water Availability of Washington County, Alabama" (Newton, McCain, and Turner, 1972), "Water Availability of Choctaw County, Alabama" (Newton and McCain, 1972), and "Geology of Choctaw County, Alabama" (Turner and Newton, 1971).

Acknowledgments

The author wishes to thank the many persons who have contributed information and assistance during the field investigation and during the preparation of this report. Special appreciation is extended to the waterworks personnel of the ground-water systems in the study area who have helped locate public-supply wells and furnished information on well construction and water use.

GEOLOGY

Geologic formations that crop out in and underlie the study area range in age from Tertiary to Quaternary (fig. 2). Unconsolidated sedimentary deposits of Tertiary age crop out in all three counties in Area 10. Quaternary alluvial and terrace deposits overlie older rocks in and adjacent to the flood plains of the Alabama and Tombigbee Rivers and other large streams in the study area. A summary of the thickness, lithology, and water-bearing properties and aquifer designation of each geologic unit underlying the study area is given in table 1. The following discussion of the geology of Area 10 is taken from Toulmin and others (1951), Causey and McCain (1971), Causey and Newton (1972), Newton and McCain (1972), Newton, McCain, and Turner (1972), and Turner and Newton (1971).

Several extensive structural features extend through the study area (figs. 2, 3). These structures include the Jackson fault, which trends north-northwestward through southwestern Clarke County; the Hatchetigbee anticline, which trends northwestward across western Clarke County and southeastern Choctaw County; and several other extensive faults (figs. 2, 3). Vertical displacement along the Jackson fault is as much as 1,400 feet (Causey and Newton, 1972). These structures influence the occurrence and movement of ground water in a large part of the study area.

Tertiary Deposits

Tertiary deposits in the study area include the Porters Creek, Naheola, Nanafalia, Tuscahoma, Hatchetigbee, Tallahatta, and Lisbon Formations; the Gosport Sand; the Jackson Group; and the Oligocene, Miocene, and Pliocene Series.

Porters Creek and Naheola Formations

The Porters Creek Formation crops out in northeastern Choctaw County. The Porters Creek consists of massive gray marine clays that form a relatively flat terrane called the Flatwoods. The thickness of the Porters Creek Formation in Choctaw County is about 350 feet.

The Naheola Formation overlies the Porters Creek Formation and crops out southwest of it in northeastern Choctaw County. It consists of fine- to coarse-grained sand, silty clay, and beds of lignite. It averages about 200 feet thick at outcrops.

Nanafalia Formation

The Nanafalia Formation crops out southwest of the Naheola Formation in northeastern Choctaw County. It consists of sand, sandy marl, sandy clay, and lignite. The Nanafalia ranges in thickness from about 100 feet at outcrops to about 250 feet in the subsurface.

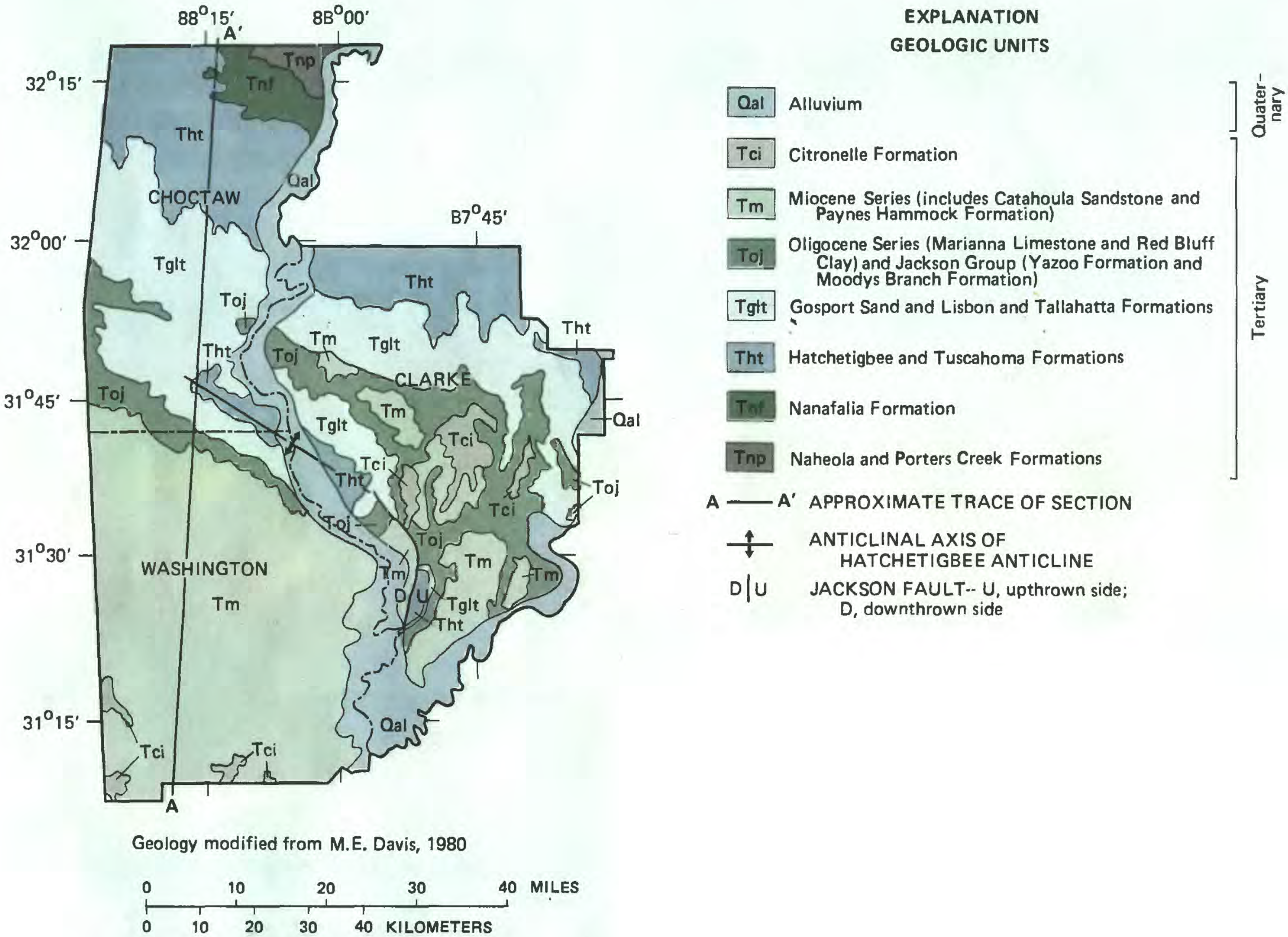
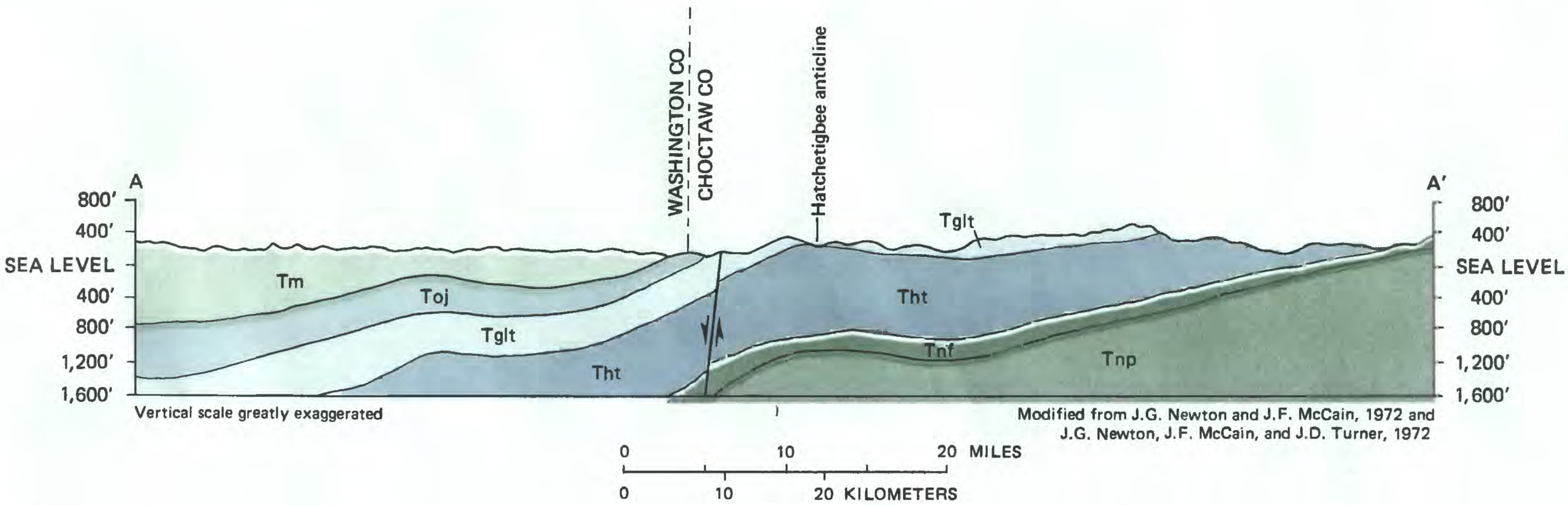


Figure 2. - - Generalized geology of the study area.



EXPLANATION

GEOLOGIC UNITS

Tm — Miocene Series (includes Catahoula Sandstone and Paynes Hammock Formation)

Toj — Oligocene Series (Marianna Limestone and Red Bluff Clay) and Jackson Group (Yazoo Formation and Moodys Branch Formation)

Tglt — Gosport Sand and Lisbon and Tallahatta Formations

Tht — Hatchetigbee and Tuscahoma Formations

Tnf — Nanafalia Formation

Tnp — Naheola and Porters Creek Formations

FAULT--Arrows indicate direction of movement

Figure 3.--Generalized subsurface section in the western part of the study area (line of section shown on figure 2).

Tuscahoma Formation

The Tuscahoma Formation crops out southwest of the Nanafalia Formation in northern Choctaw County and extends into northern Clarke County. The Tuscahoma consists of clay, fine- to coarse-grained sand, and fossiliferous glauconitic marl. The Tuscahoma ranges in thickness from about 350 feet at outcrops to more than 600 feet in the subsurface.

Hatchetigbee Formation

The Hatchetigbee Formation overlies the Tuscahoma Formation and crops out in central Choctaw County and northern Clarke County. It also crops out on the crest of the Hatchetigbee anticline in the southeastern part of Choctaw County and northeastern Washington County. The Hatchetigbee is about 250 feet thick at outcrops, and is more than 300 feet thick in the subsurface.

Tallahatta Formation

The Tallahatta Formation overlies the Hatchetigbee Formation and crops out in central Choctaw County, in north-central Clarke County, and around the Hatchetigbee anticline in southern Choctaw County and northeastern Washington County. It ranges in thickness from 270 to 400 feet in the study area, and consists of gray clay and siliceous cemented claystone with some thin layers of sandy clay, glauconitic sand and sandstone, and siltstone.

Lisbon Formation and Gosport Sand

The Lisbon Formation disconformably overlies the Tallahatta Formation and the Gosport Sand overlies the Lisbon. They are not differentiated on the geologic map because of their similar lithologies. They crop out in south-central Choctaw County, central Clarke County, and on the flanks of the Hatchetigbee anticline. The total thickness of the Gosport Sand and Lisbon Formation ranges from 125 to 250 feet. The base of the Lisbon is a distinctive light blue-green clayey sand; the middle parts of the Gosport and Lisbon consist chiefly of white and yellow fine- to medium-grained cross bedded sand with dark gray clay; the upper part is yellowish- and greenish-gray fine- to medium-grained sand and dark gray clay.

Jackson Group and Oligocene Series

The Jackson Group disconformably overlies the Gosport Sand and crops out in south-central and southwestern Choctaw County, northeastern Washington County and central Clarke County. It consists of the Moodys Branch Formation in the lower part and the Yazoo Formation in the upper part. The combined thickness of the units generally ranges from 110 to 160 feet. The Moodys Branch consists chiefly of gray fine- to coarse-grained sand; the Yazoo Formation consists of calcareous clay, sandy silt, marl, and limestone.

The Oligocene Series overlies the Yazoo Formation and crops out in southwestern Choctaw County, central Clarke County, and northeastern Washington County. The units present are the Red Bluff Clay and the Marianna Limestone. Combined they consist of about 70 to 140 feet of clay and limestone.

Miocene and Pliocene Series

The Miocene Series overlies the Oligocene Series and is overlain by the Pliocene Series. The Miocene and Pliocene Series cover a large part of Clarke and Washington Counties and the southwestern corner of Choctaw County (fig. 2). The Miocene consists of the Paynes Hammock Formation at the bottom and the Catahoula Sandstone at the top. The Pliocene consists of the Citronelle Formation. Weathered exposures of the Miocene and Pliocene are light gray and varicolored clay; yellow, pink, and tan sands; gravel; and sandstone. The series are more than 300 feet thick in Washington County.

Quaternary Deposits

Quaternary alluvial deposits overlie older formations throughout a large part of the study area (fig. 2). These deposits, which underlie flood plains of present and ancestral large streams, consist mainly of gravel, sand, silt, and clay. Alluvial deposits along the flood plains of the Alabama and Tombigbee Rivers are shown on the geologic map. Remnants of older alluvial deposits (usually mapped as high terrace deposits) are not shown on the geologic map, but form relatively flat uplands in several parts of the study area. The alluvial deposits generally range in thickness from 30 to 60 feet. They are not presently used as an aquifer in the study area.

HYDROLOGY OF THE MAJOR AQUIFERS

The major aquifers in the study area are the Nanafalia-Clayton aquifer, the Lisbon aquifer, and the Pliocene-Miocene aquifer (table 1). Water in these aquifers usually occurs under artesian conditions. The Nanafalia-Clayton aquifer consists of the Naheola and Nanafalia Formations, and the lower part of the Tuscahoma Formation in the study area. It derives its name from the fact that it includes the Clayton Formation where it is present east of the study area. The Lisbon aquifer includes the upper part of the Tuscahoma Formation, the Hatchetigbee and Tallahatta Formations, the Lisbon Formation, and the Gosport Sand. The Pliocene-Miocene aquifer for this report includes the Jackson Group and the Oligocene, Miocene, and Pliocene Series.

Recharge and Movement of Ground Water

Rainfall, which averages about 55 inches per year, is the source of recharge to the major aquifers. A large part of the rainfall runs off during and immediately after rainstorms, or is returned to the atmosphere by evaporation and transpiration of trees and other plants; a small part infiltrates to the water table to recharge aquifers. The recharge areas for the major aquifers in Area 10 generally coincide with their areas of use. The recharge area for the Nanafalia-Clayton aquifer is mainly in northern Choctaw County; the recharge areas for the Lisbon aquifer are mainly in central Choctaw and northern Clarke Counties; and the recharge areas for the Pliocene-Miocene aquifer are in Choctaw, Clarke, and Washington Counties (see plate 1). The recharge areas for all three consist largely of sloping uplands with some rugged hills, parts of which are wooded and parts cultivated. Water moves downdip from areas of recharge to areas of natural discharge or areas of ground-water withdrawals. The direction of movement generally is perpendicular to the potentiometric contour lines shown in figures 4, 5, and 6.

Remnants of high terrace deposits overlie parts of the recharge areas. These terrace remnants form relatively flat, permeable landscapes that impede runoff and probably increase recharge to the aquifers. Alluvial deposits overlie the major aquifers along the flood plains of the Alabama and Tombigbee Rivers. In these areas upward leakage from the aquifers into the alluvium presently prevents the downward movement of water to the aquifers.

Natural Discharge and Ground-Water Withdrawals

A large part of the recharge discharges through seeps and springs to provide the base (dry weather) flow of streams. A significant part of the recharge is also discharged directly to the rivers where they cut into the aquifers. Discharge to streams also can occur by upward leakage through confining beds between aquifers. Most of the remainder of the recharge is discharged through wells.

Average ground-water withdrawals by public water systems in 1984 were 0.65 Mgal/d (million gallons per day) for Choctaw County, 1.75 Mgal/d for Clarke County, and 1.00 Mgal/d for Washington County (Alabama Department of Environmental Management, 1984). Total maximum withdrawals of ground water in the study area in 1984 were about 6.5 Mgal/d. The maximum ground-water withdrawal capacity of all public water systems in the study area is about 11.5 Mgal/d. Records of public supply wells in the area are given in table 2, and their locations are shown on plate 1. The remaining discharge from wells is used for domestic, stock, industrial, and irrigation purposes. The amount of water withdrawn by private wells was estimated to be 7.9 Mgal/d in 1982 (Baker, 1983).

Effects of Withdrawals from the Aquifers

Long-term withdrawals of water from the major aquifers have not resulted in significant lowering of the potentiometric surface or formation of depressions on the potentiometric surface of water in the aquifers in Area 10 (figs. 4, 5, and 6).

The major discharge areas, based on the potentiometric maps, are the valleys of the Alabama and Tombigbee Rivers; these are natural discharge areas and not related to pumping.

SUSCEPTIBILITY OF THE AQUIFERS TO SURFACE CONTAMINATION

All areas of recharge for the major aquifers in the study area are susceptible to surface contamination (plate 1). However, throughout most of the study area the recharge areas are in rural areas that are used mainly for timberlands, farms, or pastures. These areas have low potential for contamination. Usually the depth of the water-producing zone being tapped (table 2)

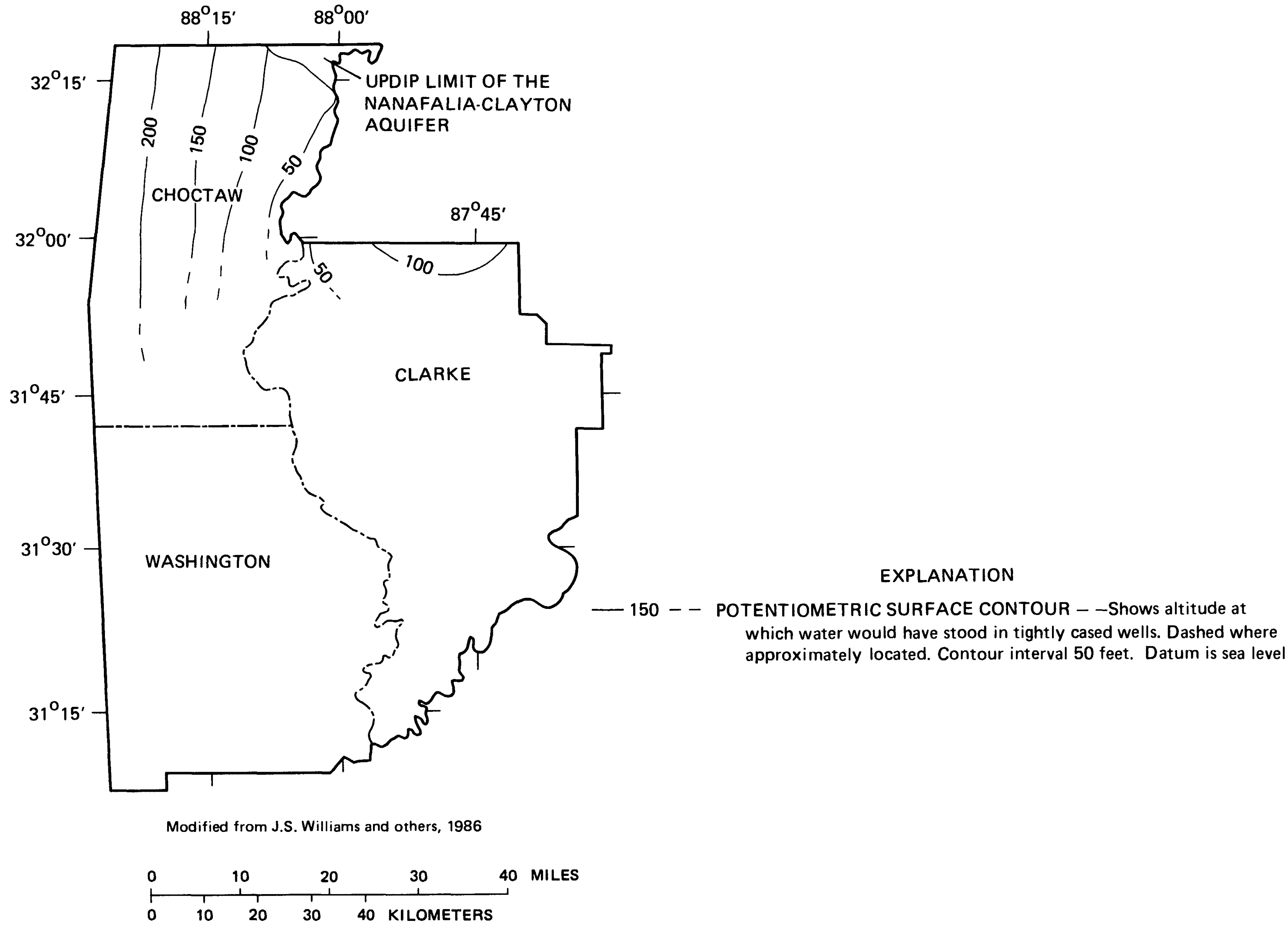


Figure 4.--Configuration of the potentiometric surface in the Nanafalia-Clayton aquifer, fall 1982.

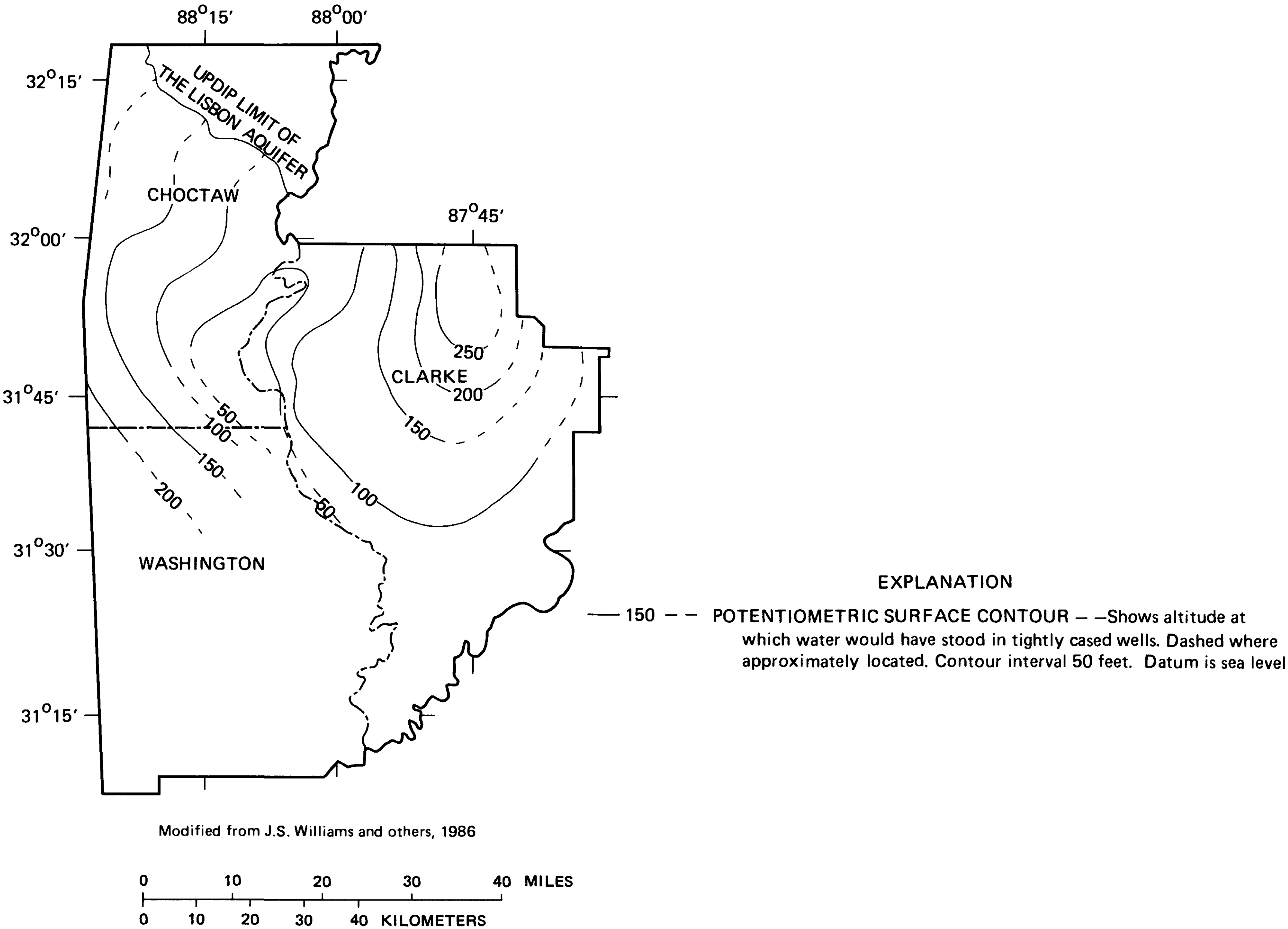


Figure 5.--Configuration of the potentiometric surface in the Lisbon aquifer, fall 1982.

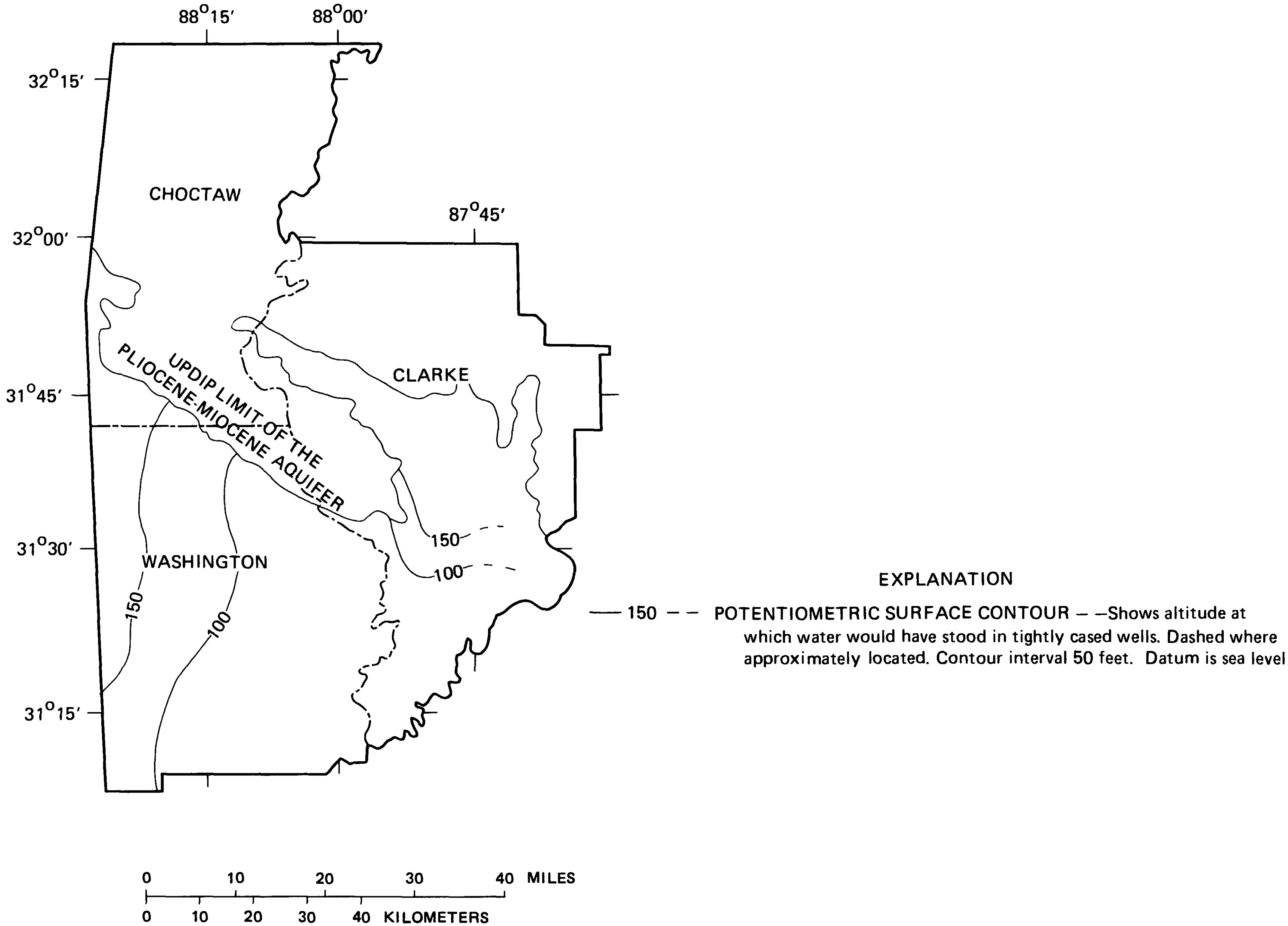


Figure 6.--Configuration of the potentiometric surface in the Pliocene-Miocene aquifer, 1967.

and its horizontal distance from the aquifer outcrop (plate 1) provide some buffer from surface contamination. Shallow wells in outcrop areas are more susceptible to contamination, but none are considered highly susceptible.

Terrace and alluvial deposits along the flood plains of the Alabama and Tombigbee Rivers overlie and are in hydraulic contact with the major aquifers in the study area. In these areas, upward leakage from the aquifers into the alluvium presently prevents the downward movement of water and possible contaminants into the aquifers. Pumpage along the flood plains of the Alabama and Tombigbee Rivers presently is minimal. However, future pumpage in these areas could result in the formation of depressions in the potentiometric surfaces of the major aquifers reversing the hydraulic gradient between the major aquifers and the rivers. This could result in vertical leakage from the rivers and the alluvial deposits to the major aquifers; thus, the areas along the flood plains of the Alabama and Tombigbee Rivers have high potential for susceptibility to contamination.

SUMMARY AND CONCLUSIONS

The major aquifers in the study area (defined as those currently used for public supplies) are the Nanafalia-Clayton, Lisbon, and Pliocene-Miocene aquifers. The recharge areas for these aquifers lie partly within Choctaw, Clarke, and Washington Counties. The aquifers underlie most of the study area and mainly consist of sand and gravel beds and some limestone. Water in the aquifers usually occurs under artesian conditions.

The Nanafalia-Clayton aquifer is a source of public water supply in Choctaw and Clarke Counties. The Lisbon is a source of water supply in Clarke, Choctaw, and Washington Counties. The Pliocene-Miocene aquifer is a source of public water supply in Washington and Clarke Counties. Long-term withdrawals of water from the major aquifers have not resulted in significant lowering of the potentiometric surface or the formation of depressions on the potentiometric surface of water in the major aquifers in Area 10.

All the recharge areas for the major aquifers are susceptible to surface contamination throughout most of the study area. However, the recharge areas are mainly in rural areas that are used for timberlands, farms, and pastures; these areas usually have low potential for contamination. Usually the depth to the zone being tapped and the horizontal distance from the outcrop to the well provide a buffer from surface contamination.

Areas potentially susceptible to surface contamination are the areas where permeable terrace and alluvial deposits overlie outcrops of the major aquifers. These areas are presently areas of discharge but, if future pumpage causes a depression in the potentiometric surface of the underlying aquifer, the alluvial aquifer will become a source of recharge and, potentially, a source of contamination.

SELECTED REFERENCES

Adams, G.I., Butts, Charles, Stevenson, L.W., and Cooke, C.W., 1926, Geology of Alabama: Geological Survey of Alabama Special Report 14, 312 p.

Alabama Department of Economic and Community Affairs, 1984, Alabama county data book 1984: Office of State Planning and Federal Programs, State of Alabama, 92 p.

Baker, R.M., 1983, Use of water in Alabama, 1982: Geological Survey of Alabama Information Series 59C, 49 p.

Causey, L.V. and McCain, J.F., 1971, Water availability of Clarke County, Alabama: Geological Survey of Alabama Map 97, 34 p.

Causey, L.V. and Newton, J.G., 1972, Geology of Clarke County, Alabama: Geological Survey of Alabama Map 95, 20 p.

Davis, M.E., 1980, Ground-water levels in Alabama for observation wells measured periodically August 1952 through July 1977: Geological Survey of Alabama Circular 105, 74 p.

Fenneman, N.M., 1938, Physiography of Eastern United States: New York, McGraw-Hill Book Co., 714 p.

Newton, J.G. and McCain, J.F., 1972, Water availability of Choctaw County, Alabama: Geological Survey of Alabama Map 125, 23 p.

Newton, J.G., McCain, J.F., and Turner, J.D., 1972, Water availability of Washington County, Alabama: Geological Survey of Alabama Map 135, 23 p.

Sapp, C.D. and Emplaincourt, J., 1975, Physiographic regions of Alabama: Geological Survey of Alabama Special Map 168.

Smith, E.A., 1907, The underground water resources of Alabama: Geological Survey of Alabama Monograph 6, 338 p.

Toulmin, L.D., LaMoreaux, P.E., and Lamphere, C.R., 1951, Geology and ground-water resources of Choctaw County, Alabama: Geological Survey of Alabama Special Report 21 and County Report 2, 197 p.

Toumey, Michael, 1858, The geology of Alabama: Geological Survey of Alabama, 2nd Biennial Report, 292 p.

Turner, J.D. and Newton, J.G., 1971, Geology of Choctaw County, Alabama: Geological Survey of Alabama Map 102, 15 p.

U.S. Environmental Protection Agency, 1984, A ground-water protection strategy for the Environmental Protection Agency.

Williams, J.S., DeJarnette, S.S., and Planert, Michael, 1986, Potentiometric surface, ground-water withdrawals, and recharge area for the Nanafalia-Clayton aquifer in Alabama, fall 1982: U.S. Geological Survey Water-Resources Investigations Report 86-4119, 1 sheet.

Williams, J.S., Planert, Michael, and DeJarnette, S.S., 1986, Potentiometric surface, ground-water withdrawals, and recharge area for the Lisbon aquifer in Alabama, fall 1982: U.S. Geological Survey Water-Resources Investigations Report 86-4120, 1 sheet.

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

System	Series	Geologic unit	Thickness (feet)		Lithology	Water-bearing properties	Quality of water
Quaternary	Holocene and Pleistocene	Alluvium and terrace deposits	0-60		Silt, clay, sand, and gravel	Will yield 10 gal/min (gallons per minute) or more locally where saturated sands are of sufficient thickness. Potential source of large supplies in southernmost part of Clarke County and eastern Washington County.	Water is soft, generally has a dissolved-solids content less than 50 mg/L (milligrams per liter), and commonly contains iron in excess of 0.3 mg/L.
Tertiary	Pliocene and Miocene	Pliocene and Miocene Series (includes Citronelle Formation, Catahoula Sandstone, and Paynes Hammock Formation)	0-300	Pliocene/Miocene aquifer	Sand and gravel, yellow, pink, and tan; light-gray and varicolored clay; blue to green sand, clay, and sandy clay; bluish-gray fossiliferous marl; light-gray sandstone; bluish-green fossiliferous sandy clay at base of series.	Yields as much as 0.3 Mgal/d (million gallons per day) per well at Grove Hill. Will yield 1 Mgal/d per well in southernmost part of Clarke County and most of Washington County.	Water is soft, generally has a dissolved-solids content less than 75 mg/L and commonly contains iron in excess of 0.3 mg/L. Locally the water is sufficiently acidic to be corrosive.
	Oligocene	Oligocene Series (includes Yazoo Formation and Moodys Branch Formation)	70-140		Limestone and marl, gray and pale-olive, sandy, fossiliferous; gray and greenish-gray clay; yellow hard fossiliferous limestone with indurated fossiliferous ledges; greenish-gray fine-grained sand and yellowish-green fossiliferous marl with limestone ledges at base of series.	Solutionally enlarged openings in limestone are a potential source of large supplies east and northeast of Coffeeville and south-central Clarke County.	Water is moderately hard to hard and low in dissolved solids. Locally contains iron in excess of 0.3 mg/L.
	Eocene	Jackson Group	110-160		Clay or clayey limestone, light greenish-gray and white, calcareous; light-gray fossiliferous marl; yellow, orange, and light-gray, fine- to medium-grained sand; bluish-gray clay and sandy clay; indurated glauconitic, fossiliferous sandy marl and limestone.	Will yield 10 gal/min. Potential source of larger supplies.	Water is soft to very hard. Locally contains iron in excess of 0.3 mg/L.
		Gosport Sand and Lisbon Formation	125-250	Lisbon aquifer	Sand, yellow, light-tan, pink, and brown, fine-grained; light-gray and greenish-gray silty clay; very fine to coarse-grained glauconitic sand; glauconitic fossiliferous green sand with indurated calcareous layers of sandstone; white to very light greenish gray claystone; fine- to coarse-grained crossbedded glauconitic sand at base of formation.	Yields 100 gal/min at Coffeeville. Potential source of 0.2 to 0.5 Mgal/d.	Water is soft to very hard but generally is hard. Commonly contains iron in excess of 0.3 mg/L.
		Tallahatta Formation	270-400		Claystone, white to very light greenish gray, thin-bedded to massive, siliceous, aluminous, interbedded with thin layers of clay, sandy clay, and sand; 5 to 8 ft of white to gray fine- to coarse-grained sand and fine gravel at base of formation.	Will yield 10 gal/min where basal sand is present and is a potential source of larger supplies where sands thicken in subsurface.	Limited data indicate water has a low dissolved-solids content and is hard to very hard.
		Hatchetigbee Formation	250-300		Sand, gray to yellow, cross-bedded; gray, brown, and purplish-red laminated clay and sandy clay; pale-olive to greenish-gray, fine-grained abundantly glauconitic fossiliferous sand and marl containing calcareous sandstone concretions in lower part of formation.	Will generally yield 0.2 Mgal/d per well and, in the vicinity of Fulton, may yield as much as 0.5 Mgal/d per well.	Water is soft to very hard and commonly contains iron in excess of 0.3 mg/L. Highly mineralized in southern Clarke County. Chloride content 28,000 mg/L at depth of 200 ft near Carlton.
	Paleocene	Tuscahoma Formation	350-600		Clay and sand, gray, laminated to thin-bedded; fine- to coarse-grained cross-bedded sand, fossiliferous green sand marl.	Will generally yield 0.2 Mgal/d per well. Potential source of larger supplies.	Water is soft to hard but generally is soft to moderately hard. Locally contains iron in excess of 0.3 mg/L.
		Nanafalia Formation	100-250	Nanafalia/Clayton aquifer	Clay and claystone, gray; greenish-gray glauconitic fossiliferous sand, sandstone, marl, and limestone; white or light colored micaceous sand.	Potential source of 1 Mgal/d per well in northern parts of Clarke and Choctaw Counties.	Water is soft and has a dissolved-solids content of less than 1,000 mg/L in northernmost part of county. Locally contains iron in excess of 0.3 mg/L.
		Naheola Formation, Porters Creek Formation, and Clayton Formation 1/	190-500		Sand, green and gray, clayey, glauconitic, and gray, finely sandy glauconitic micaceous clay in upper part of Naheola Formation; gray micaceous carbonaceous sand, clay, and silt in lower part. Porters Creek is gray marine clay.	Will probably yield less than 0.1 Mgal/d per well.	Water is highly mineralized, has chloride content of 21,000 mg/L at depth of 200 ft near Rockville in the southern part of Clarke County.

1/ Crops out to the east of the study area.

Table 2.--Records of public water-supply wells 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 level: 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.

Well diameter: casing diameter in inches.

Water-bearing unit: N-C, Nanafalia-Clayton aquifer; L, Lisbon aquifer; P-M, Pliocene-Miocene aquifer.

Altitude of land surface: Altitudes given in feet above sea level, from topographic map or determined by aneroid barometer.

Method of lift: N, none; F, flow; J, jet; P, piston; S, submergible; T, turbine.

Use of well: N, none; P, public water supply.

Well number	Geographic coordinate number	Well owner	Driller and year drilled	Well depth (feet)	Well diam. (inches)	Water bearing unit	Altitude of land surface	Water level above (-) or below Land Surface Datum	Date of measurement	Method of lift	Use of well	Remarks
1	321234088034401	Town of Pennington	Griner Drilling Co. 1979	240	8	N-C	100	- 11.58	1/18/79	F,T	P	Well 3. Casing: 8 in. from surface to 187 ft; 6 in. to 200 ft. 6 in. screen from 200 to 240 ft. Drawdown 28.18 ft after pumping 224 gal/min for 17 hrs 1/19/79.
2	321235088030801	Town of Pennington	Acme Drilling Co. 1968	30	12 6	N-C	100	2	3/07/68	T	P	Well 1. Casing: 12 in. from surface to 20 ft; 6 in. inner casing to 20 ft. 4 in. screen from 20 to 30 ft.
3	321206088031201	Town of Pennington	Acme Drilling Co. 1968	40	12 6	N-C	100	2	3/07/68	T	P	Well 2. Casing: 12 in. from surface to 30 ft; 6 in. inner casing to 30 ft. 4 in. screen from 30 to 40 ft.
4	321018088164401	Town of Lisman	Graves Drilling Co. 1980	391	12	N-C	160	57.5	11/04/80	T	P	Casing: 12 in. from surface to 340 ft. Screen from 336 to 391 ft. Drawdown 59 ft after pumping 400 gal/min for 24 hrs 11/05/80.
5	320745088191401	Town of Riderwood	J. E. Harmon 1917	137	4	N-C	185	39.9 45	5/17/46 6/07/67	J	P	Casing: 4 in. from surface to 80 ft;none below.
6	320533088132601	City of Butler	Gray Artesian Well Co. 1936	415	8 6	N-C	192	68 72.7	1936 6/13/67	T	N	Casing: 8 in. from surface to 382 ft; 6 in. from 382 to 393 ft. 6 in. screen from 393 to 415 ft. Drawdown 46 ft after pumping 40 gal/min for 8 hrs in 1936.
7	320538088130201	City of Butler	Peerson Drilling Supply Co. 1950	707	10 6	N-C	192	14 73	10/15/50 6/06/67	T	P	Casing: 10 in. from surface to 580 ft; 6 in. from 580 to 689 ft. 42 ft of 6 in. screen between depths of 580 and 707 ft. Drawdown 37 ft after pumping 200 gal/min for 8 hrs in 1950.

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

Well number	Geographic coordinate number	Well owner	Driller and year drilled	Well depth (feet)	Well diam. (inches)	Water bearing unit	Altitude of land surface	Water level above (-) or below Land Surface Datum	Date of measurement	Method of lift	Use of well	Remarks
8	320518088134001	City of Butler	Layne-Central Co. 1981	708	16 8	N-C	192	59	1/27/82	T	P	Casing: 16 in. from surface to 570 ft; 8 in. from 510 to 595 ft. 8 in. screen from 575 to 698 ft. Drawdown 39 ft after pumping 704 gal/min for 5 hrs 1/27/82.
9	320517088124501	City of Butler	Layne-Central Co. 1961	663	16	N-C	202	64.2	6/06/67	T	P	Casing: 16 in. from surface to 545 ft. 50 ft of 8 in. screen between depths of 545 and 663 ft. Drawdown 56.6 ft after pumping 548 gal/min for 8 hrs
10	315241088190401	Town of Gilbertown	Holland Well Co. 1975	220	12 10	L	130	118	4/02/76	T	P	Casing: 12 in. from surface to 192 ft. 10 in. screen from 192 to 220 ft. Drawdown 73 ft after pumping 150 gal/min for 6 hrs 4/06/76.
11	315435087445901	City of Thomasville	Layne-Central Co. 1944	702	10 6	N-C	361	220 327.3	9/05/44 10/10/66	T	N	Casing: 10 in. from surface to 660 ft; 6 in. from 607 to 663 ft. Screen from 663 to 698 ft. Drawdown 42 ft after pumping 125 gal/min for 8 hrs 9/05/44.
12	315443087444001	City of Thomasville	Layne-Central Co. 1949	738	12 6	N-C	366	225 327 333	11/21/49 9/03/65 10/10/66	T	N	Casing: 12 in. from surface to 670 ft; 6 in. from 595 to 674 ft and from 734 to 738 ft. Screen from 674 to 734 ft. Drawdown 74 ft after pumping 277 gal/min for 8 hrs 11/21/49.
13	315417087442801	City of Thomasville	Layne-Central Co. 1964	766	12 6	N-C	371	295	1964	T	N	Casing: 12 in from surface to 691 ft; 6 in. from 641 to 696 ft and from 756 to 766 ft. Screen from 696 to 756 ft. Drawdown 85 ft after pumping 225 gal/min for 8 hrs 5/28/64.
14	314546088052501	Town of Coffeeville	Peeples Drilling Co. 1963	287	12 6	L	172	108.2 84.5	10/04/66 7/18/83	T	P	Casing: 12 in. from surface to 247 ft; 6 in. from 196 to 247 ft. Screen from 247 to 287 ft. Drawdown 65 ft after pumping 108 gal/min for 8 hrs 9/25/63.

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

Well number	Geographic coordinate number	Well owner	Driller and year drilled	Well depth (feet)	Well diam. (inches)	Water bearing unit	Altitude of land surface	Water level above (-) or below Land Surface Datum	Date of measurement	Method of lift	Use of well	Remarks
15	314530088045801	Town of Coffeeville	Acme Drilling Co. 1967	287	12 8 6	L	170	97	10/67	T	P	Casing: 12 in. from surface to 255 ft; 8 in. from 214 to 256 ft. 6 in. screen from 256 to 282 ft. Drawdown 103 ft after pumping 108 gal/min for 8 hrs in 1967.
16	314736087432101	Town of Fulton	Layne-Central Co. 1974	290	18 10	N-C	300	63	1974	T	P	Casing: 18 in. from surface to 257 ft; 10 in. from 200 to 257 ft. 8 in. screen from 257 to 287 ft. Drawdown 94 ft after pumping 300 gal/min for 12 hrs in 1974.
17	314705087433201	Town of Fulton	Layne-Central Co. 1955	173	10 8	N-C	239	3.5	10/10/66	T	P	Casing: 10 in. from surface to 123 ft; 8 in. from 163 to 173 ft. Screen from 123 to 163 ft. Drawdown 41 ft after pumping 160 gal/min for 8 hrs in 1955
18	314219087471001	City of Grove Hill	Layne-Central Co. 1965	130	16 12	P-M	478	75 84.2	1965 4/14/67	T	P	Casing: 16 in. from surface to 110 ft. 12 in. screen from 110 to 130 ft. Drawdown 33 ft after pumping 250 gal/min for 8 hrs in 1965.
19	314224087464401	City of Grove Hill	Layne-Central Co. 1980	154	18 10	P-M	500	98.5	6/30/80	T	P	Casing: 18 in. from surface to 103 ft; 10 in. from surface to 107 ft. 10 in. screen from 107 to 137 ft. Drawdown 6 ft after pumping 190 gal/min for 24 hrs 8/17/80.
20	314147087462201	City of Grove Hill	Layne-Central Co. 1953	150	24 16 12	P-M	491	88.25 86.3	1953 1/10/67	T	P	Casing: 24 in. from surface to 100 ft; 16 in. from surface to 130 ft. 12 in. screen from 130 to 150 ft. Drawdown 33 ft after pumping 152 gal/min for 8 hrs in 1952.
21	313848087421101	Town of Whatley	Burrell Drilling Co. 1971	238	12 8	P-M	145	30	9/14/71	T	P	Casing: 12 in. from surface to 63 ft; 8 in. from surface to 107 ft. Drawdown 47 ft after pumping 107 gal/min for 24 hrs 9/15/71.

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

Well number	Geographic coordinate number	Well owner	Driller and year drilled	Well depth (feet)	Well diam. (inches)	Water bearing unit	Altitude of land surface	Water level above (-) or below Land Surface Datum	Date of measurement	Method of lift	Use of well	Remarks
22	313813088184901	Town of Millry	Layne-Central Co. 1963	265	12 6	P-M	120	- 7	1963	F,T	P	Casing: 12 in. from surface to 223 ft; 6 in. from 183 to 228 ft. 6 in. screen from 228 to 248 ft. Drawdown 69 ft after pumping 108 gal/min for 8 hrs in 1963. Measured flow 4.7 gal/min 4/15/67.
23	313813088184902	Town of Millry	Holland Well Co. 1974	266	8	P-M	120	flows	1/24/75	F,T	P	Casing: 8 in. from surface to 226 ft. Screen from 226 to 266 ft. Drawdown 70 ft after pumping 130 gal/min for 48 hrs 1/24/75.
24	313619088100701	Town of Frank-ville	Holland Well Co. 1985	190	16 8	P-M	210	118	5/02/85	T	P	Casing: 16 in. from surface to 160 ft; 8 in. to 170 ft. 8 in. screen from 170 to 190 ft. Draw-down 17 ft after pumping 300 gal/min for 12 hrs in 1985.
25	313040088010401	Town of Leroy	Acme Drilling Co. 1979	168	12 8	P-M	100	45	5/16/79	T	P	Casing: 12 in. from surface to 146 ft; 8 in. from 101 to 146 ft. 6 in. screen from 146 to 166 ft. Drawdown 72 ft after pumping 250 gal/min for 24 hrs 5/16/79.
26	313025087595901	Town of Leroy	Acme Drilling Co. 1972	174	12 8	P-M	100	40	9/21/72	T	P	Casing: 12 in. from surface to 152 ft; 8 in. from 115 to 151 ft. 6 in. screen from 151 to 171 ft. Drawdown 38 ft after pumping 180 gal/min for 8 hrs 9/21/72.
27	313017087590001	Town of Leroy	Acme Drilling Co. 1966	167	7 4	P-M	100	60.4	4/17/67	T	P	Casing: 7 in. from surface to 151 ft; 4 in. from 130 to 151 ft. Screen from 151 to 167 ft. Drawdown 30 ft after pumping 115 gal/min for 8 hrs 10/03/66.
28	313149087561201	City of Jackson	--	--	--	P-M	34	--	--	F,P	P	Hoven Spring. Measured flow 1,500 gal/min 10/26/66.

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

Well number	Geographic coordinate number	Well owner	Driller and year drilled	Well depth (feet)	Well diam. (inches)	Water bearing unit	Altitude of land surface	Water level above (-) or below Land Surface Datum	Date of measure-ment	Method of lift	Use of well	Remarks
29	313106087531701	City of Jackson	Layne-Central Co. 1965	263	24 12 10	P-M	246	145.5 125	1965 11/27/65	T	P	Casing: 24 in. from surface to 155 ft; 12 in. from 100 to 159 ft; 10 in. from 189 to 229 ft. Screened between 159 and 263 ft. Drawdown 66 ft after pumping 151 gal/min for 3 hrs in 1965.
30	313040087531001	City of Jackson	Gray Artesian Well Co. 1941	156	20 10	P-M	227	125.0	7/19/45	N	N	Casing: 20 in. from surface to 80 ft;10 in. from surface to 131 ft. Screen from 131 to 156 ft.
31	313040087531002	City of Jackson	Gray Artesian Well Co. 1923	152	20 10	P-M	227	107	9/20/66	T	P	
32	312754088152701	City of Chatom	1937	456	8 6	P-M	170	32		T	N	Casing: 8 in. from surface to 211 ft; 6 in. below. 6 in. screen at 294 ft. Drawdown 145 ft pumping 50 gal/mi
33	312744088151001	City of Chatom	Layne-Central Co. 1950	329	10 8 6	P-M	185	50 71.8 80.69	1950 4/10/67 2/07/68	T	P	Casing: 10 in. and 8 in. to 237 ft; 6 in. below. 6 in. screen from 279 to 299 ft and 329 to 349 ft. Drawdown 63 ft after pumping 107 gal/min for 8 hrs.
34	312736088143701	City of Chatom	Layne-Central Co. 1961	298	12 6	P-M	165	54.8	4/18/67	T	P	Casing: 12 in. from surface to 246 ft; 6 in. from 178 to 248 ft. 6 in. screen from 248 to 298 ft. Drawdown 17 ft after pumping 250 gal/min for 8 hrs in 1961.
35	312628088015301	Town of Wagar-ville	Holland Well Co.	385	4	P-M	65	23	1967	T	P	Screen: 4 in. from 368 to 385 ft. Will yield 100 gal/min.
36	312037088243101	Town of Fruitdale	Acme Drilling Co. 1966	273	6 4	P-M	245	88	1966	S	P	Casing: 6 in. surface to 250 ft; 4 in. from 217 to 217 to 255 ft. 4 in. screen from 255 to 273 ft. Drawdown 70 ft after pumping 60 gal/min for 8 hrs in 1966.

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

Well number	Geographic coordinate number	Well owner	Driller and year drilled	Well depth (feet)	Well diam. (inches)	Water bearing unit	Altitude of land surface	Water level above (-) or below Land Surface Datum	Date of measurement	Method of lift	Use of well	Remarks
37	311600088012201	Town of McIntosh	Holland Well Co. 1967	245	6 4	P-M	50	23	6/67	T	P	Casing: 6 in. from from surface to 218 ft; 4 in. from 211 to 225 ft. 4 in. screen from 225 to 245 ft. Drawdown 15 ft after pumping 150 gal/min for 8 hrs in 1967
38	311303088184601	Deer Park-Vinegar Bend Water & Fire Protection Authority	Graves Well Drilling Co. 1982	463	12 6	P-M	150	52.6	5/11/82	T	P	Casing: 12 in. from surface to 410 ft; 6 in. from 360 to 403 ft. 6 in. screen from 403 to 464 ft. Drawdown 30 ft after pumping 300 gal/min for 24 hrs 5/18/82.
39	311053088061001	Fairford Water & Fire Protection Authority	Holland Well Co. 1987	500		P-M	230			T	P	Under construction.
40	310953088023601	Town of Calvert	Holland Well Co. 1971	232	8 4	P-M	150	90	1/18/71	T	P	Casing: 8 in. from surface to 200 ft; 4 in. from 191 to 212 ft. 4 in. screen from 212 to 232 ft.

☆ U.S. GPO: 1989—649-719