Geology and Ground-Water Resources of Lee and Sumter Counties Southwest Georgia

By VAUX OWEN, JR.

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1666

Prepared in cooperation with the Georgia Department of Mines, Mining, and Geology

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1963

UNITED STATES DEPARTMENT OF THE INTERIOR

STEWART L. UDALL, *Secretary*

GEOLOGICAL SURVEY

Thomas B. Nolan, *Director*

The U.S. Geological Survey has cataloged this publication as follows:

Owen, Vaux

Geology and ground-water resources of Lee and Sumter Counties, southwest Georgia. Washington, U.S. Govt. Print. Off., 1963.

iv, 70 p. maps, diagrs., tables. 24 cm. (U.S. Geological Survey. (Water-supply paper 1666)

Part of illustrative matter folded in pocket.

Prepared in cooperation with the Georgia Department of Mines, Mining, and Geology.

Bibliography: p. 64–67. (Continued on next card)

Owen, Vaux

Geology and ground-water resources of Lee and Sumter Counties, southwest Georgia. 1963. (Card 2)

1. Geology—Georgia—Lee Co. 2. Geology—Georgia—Sumter Co. 3. Water, Underground—Georgia—Lee Co. 4. Water, Underground—Georgia—Sumter Co. 5. Water-supply—Georgia—Lee Co. 6. Water-supply—Georgia—Sumter Co. (Series)

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C., 20402

CONTENTS

	Page
Abstract	1
Introduction	2
Purpose and scope of investigation	3
Location and extent of area	3
Previous investigations	4
Acknowledgments	5
Well-numbering system	5
Physical geography	6
Area I	7
Area II	7
Drainage	7
Climate	8
Economic development	11
Agriculture	11
Industry	11
Minerals	11
Transportation	11
Geology	12
Stratigraphy	12
Upper Cretaceous series	14
Paleocene series	15
Midway group	20
Eocene series	26
Wilcox group	26
Tuscahoma formation	27
Claiborne group	28
Tallahatta formation	29
Lisbon formation	32
Jackson group	34
Ocala limestone	34
Oligocene series	35
Flint River formation	36
Undifferentiated residuum	36
Structure	37
Regional structure	37
Structural belt	38
Andersonville fault	38
Faults in western Sumter County	39
Ground water	39
Artesian conditions	40
Upper Cretaceous series	40
Midway group	42
Tuscahoma formation	44
Tallahatta formation	44

Ground water—Continued
Artesian conditions—Continued Page
Lisbon formation 45
Ocala limestone 45
Water-table conditions 48
Undifferentiated residuum 49
Wells 50
Domestic supplies 51
Large-yield wells 53
Springs 57
Quality of water 59
Summary 63
Selected references 64
Index 69

ILLUSTRATIONS

[Plates are in pocket]

PLATE 1. Well-location map.
2. Geologic sections.
3–6. Structural contours:
3. Upper Cretaceous series.
4. Midway group.
5. Tuscahoma formation.
6. Claiborne group.

Page
FIGURE 1. Map of Georgia showing Lee and Sumter Counties 4
2. Physiographic divisions of the Coastal Plain 6
3. Average monthly rainfall and temperature at Americus 9
4. Average monthly rainfall and temperature at Albany 10
5. Geologic map 13
6. Hydrographs showing water-level fluctuations in dug and drilled wells 46
7. Hydrographs showing water-level fluctuations in deep and shallow wells 48
8. Hydrograph of well in Ocala limestone 49
9. Quality of water from wells 62

TABLES

Page
TABLE 1. Stratigraphic units in Lee County 16
2. Stratigraphic units in Sumter County 18
3. Records of selected wells, Lee County 52
4. Records of selected wells, Sumter County 54
5. Chemical analyses of ground water, Lee and Sumter Counties 60

GEOLOGY AND GROUND-WATER RESOURCES OF LEE AND SUMTER COUNTIES, SOUTHWEST GEORGIA

By VAUX OWEN, JR.

ABSTRACT

Lee and Sumter Counties are underlain by more than 5,000 feet of Lower Cretaceous, Upper Cretaceous, and Tertiary sedimentary rocks. Water is produced from wells that tap rocks of the Upper Cretaceous series and the Tertiary system at depths ranging from 60 to 1,000 feet. The Upper Cretaceous series is composed of the Tuscaloosa formation and the overlying undifferentiated Upper Cretaceous deposits. The Teritary system is composed of, in ascending order, the Clayton formation and the undifferentiated deposits of the Midway group, the Tuscahoma formation of the Wilcox group, the Tallahatta and Lisbon formations of the Claiborne group, the Ocala limestone of the Jackson group, the Flint River formation, and the undifferentiated residuum, which may be partly of early Quaternary and Recent age. The Tuscaloosa formation consists mostly of arkosic sand and gravel and also contains lenses of clay; the undifferentiated Upper Cretaceous deposits consist mostly of marl and also contain subordinate beds of sand, sandstone, clay, and limestone. The Clayton formation consists of limestone and marl, and the undifferentiated Midway deposits consist of interbedded sand, clay, and marl. The Tuscahoma formation consists mostly of glauconitic silt underlain by glauconitic sand. The Tallahatta formation is predominantly sand, and the Lisbon formation is predominantly soft limestone or marl. The Ocala limestone consists mostly of limestone and also includes a basal sand. The Flint River formation is present only as scattered boulders of chert in the undifferentiated residuum, which is composed of sandy clay or silt.

The principal structural feature of the region is the regional homocline which dips generally to the southeast. The dip increases with depth and generally ranges from 12 feet per mile on top of the Ocala limestone to 22 feet per mile on top of the Upper Cretaceous series. Dips in the homocline are greater along a southwest-northeast trending belt which crosses Sumter County than elsewhere in the region. Because data are limited, this belt is termed the "structural belt" in the present report although it may be a monocline, a fault, or a series of faults. The structural belt appears to have influenced depositional conditions and apparently marks the updip limit of the Lisbon formation and the Ocala limestone as well as that of a coquina bed at the top of the Tallahatta formation. The regional structure is also modified by the Andersonville fault in northeastern Sumter County and by similar faults in western Sumter County. The faults trend east-west and are downthrown on the north.

The principal aquifers used in the region are the undifferentiated Upper Cretaceous deposits, the Clayton formation, the undifferentiated Midway deposits, the Tallahatta formation, and the Ocala limestone. The Tuscaloosa for-

mation is not used as an aquifer because of its depth; the Tuscahoma and Lisbon formations, and undifferentiated residuum act mainly as confining beds because of their relatively low permeabilities.

Lee and Sumter Counties may be divided on the basis of ground-water use into a northern area, mostly in Sumter County, and a southern area, mostly in Lee County. These are termed Area I and Area II respectively in the report. Domestic supplies of water in Area I are obtained from screened wells 60 to 120 feet down deep that tap the Tallahatta formation or from open-hole wells 200 to 400 feet deep that tap the Clayton formation or Upper Cretaceous series. The largest yields of water in Area I are obtained from the upper Cretaceous series, which is tapped by screened wells ranging in depth from 300 to 1,000 feet and yielding as much as 1,000 gpm. Domestic supplies of water in Area II are obtained from open-hole wells 75 to 150 feet deep that tap the Ocala limestone. The largest yields in Area II are obtained from wells 175 to 320 feet deep tapping the Tallahatta formation; yields of more than 1,000 gpm have been reported from several of these wells.

Most ground water in Lee and Sumter Counties is of good quality and suitable for use without treatment. The Tallahatta formation in Area I yields water ranging in hardness from 7 to 42 ppm.; water from other aquifers ranges in hardness from 70 to 136 ppm. The Tallahatta formation in Area I and the Upper Cretaceous series yield water that is likely to contain more than 0.3 ppm iron. Water containing more than this amount of iron leaves stains on plumbing and laundry. A few wells that tap Midway group yield water that may contain more than 0.3 ppm iron. Water from other aquifers, as well as most water from the Midway group, contains less than 0.3 ppm iron.

INTRODUCTION

Ground water is an important economic resource in Lee and Sumter Counties, and though it supplies almost all the water used in the area, it has been developed only to a limited extent, chiefly for municipal and rural domestic supplies. There has been little development for industrial and agricultural purposes. Most ground-water supplies in the region are obtained from wells, which have certain advantages as sources of water supply; they may be located conveniently near the place of use and they furnish relatively pure water, which for most purposes is suitable for use without treatment.

The economy of Lee and Sumter Counties is primarily agricultural, and ground water could be developed extensively for supplemental irrigation. The annual precipitation is high in Lee and Sumter Counties, but irrigation during droughts would result in increased yields and fewer crop failures. Sumter County contains more than 300,000 acres and Lee County about 225,000 acres; however, only 65 acres in Sumter County and 294 acres in Lee County were irrigated in 1954 (U.S. Dept. Commerce, 1956).

A few industrial plants in Lee and Sumter Counties use ground water but additional large supplies are available. The cost of procuring water constitutes a large part of the basic operational costs of many industries; therefore, the availability of large supplies of ground water of good quality in Lee and Sumter Counties should be an inducement to such industries.

PURPOSE AND SCOPE OF INVESTIGATION

Lee and Sumter Counties are mostly in the Dougherty Plain unit of the Coastal Plain of Georgia, an area of relatively uniform geologic and hydrologic conditions, in which water is produced from Upper Cretaceous and Eocene aquifers.

The first detailed ground-water investigation in southwest Georgia was of Dougherty County (Wait, 1962). Dougherty County was chosen as the area of initial work because of the importance of the city of Albany and the relative abundance of geologic and hydrologic data available.

The present investigation was undertaken in order to extend the knowledge of ground-water conditions in the important Dougherty Plain unit and because considerable geologic and hydrologic data were available in Lee and Sumter Counties. This report was prepared in cooperation with the Georgia Department of Mines, Mining, and Geology. It is part of a broad program to evaluate the ground-water resources of the State and of the Nation. Work was begun in March 1958, and the data indicate that large quantities of ground water are available throughout the two counties.

The objective of the present investigation was to determine ground-water conditions in Lee and Sumter Counties. Ground-water conditions in the Coastal Plain are most easily understood in terms of the individual aquifers, each of which has certain characteristics of lithology, thickness, depth, and hydrologic properties. For this reason considerable emphasis was placed on stratigraphy. Stratigraphy of the area was determined by analysis of drill cuttings and outcrop material, and the results are presented in written descriptions, contour maps, and cross sections.

A general canvass of representative wells was made to determine facts about the present state of ground-water development. An effort was made to learn the general features of construction of wells because well depth, length and diameter of casings, use of screens, and quality and quantity of water available vary with the locality and the aquifer used.

LOCATION AND EXTENT OF AREA

Lee and Sumter Counties combined comprise an area of about 846 square miles, extending north-south about 42 miles and east-west about 30 miles in southwest Georgia (fig. 1). Americus, the county seat of

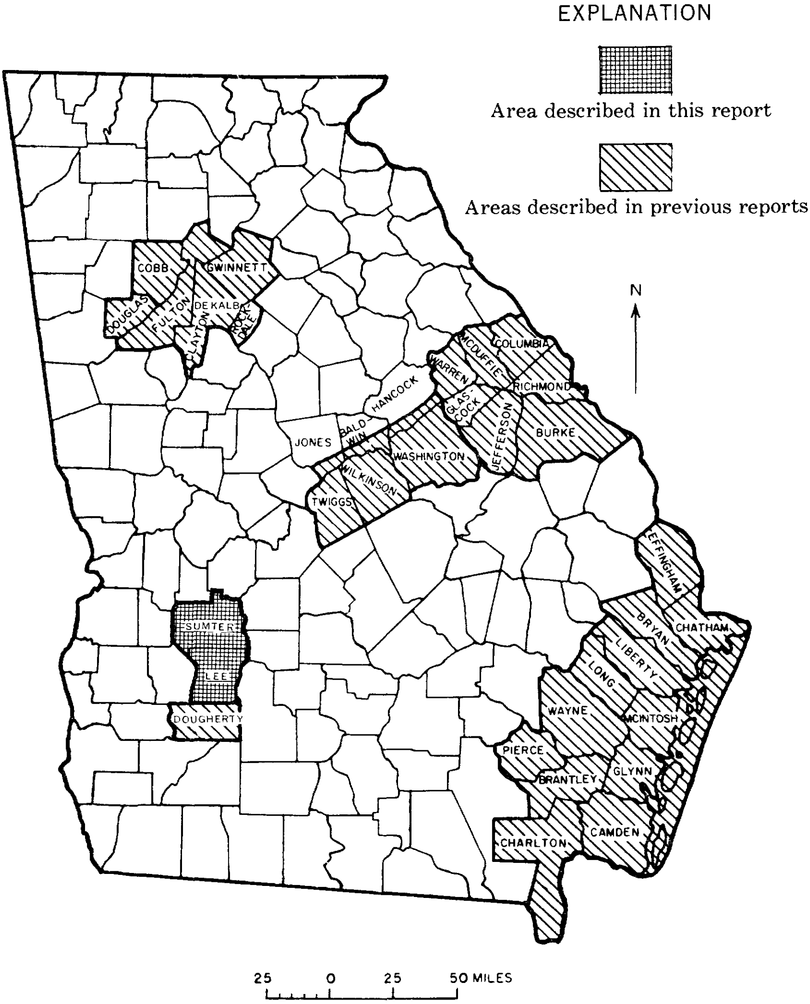


FIGURE 1.—Map of Georgia showing Lee and Sumter Counties and areas described in previous reports.

Sumter County and largest town in the area, is 135 miles south of Atlanta.

PREVIOUS INVESTIGATIONS

The first ground-water investigation in Georgia was made by Spencer (1891). His report contained some ground-water information, although the report was primarily concerned with geology. McCallie in 1898 reported on artesian wells in Georgia, and in 1908 he reported on the underground waters of Georgia. Both of these reports contained well logs and chemical analyses of a few wells in Lee and Sumter Counties.

The most comprehensive report to date on ground-water resources of the Coastal Plain of Georgia is that of Stephenson and Veatch (1915). This report contains geologic designations of aquifers and well logs and chemical analyses of several wells in Lee and Sumter Counties. Warren (1944, p. 18–a) included part of Lee County in a piezometric map of the principal artesian aquifer of the Coastal Plain of Georgia.

Other reports describing the ground-water resources of Georgia but not dealing specifically with Lee and Sumter Counties are Georgia Geological Survey Bulletins 52 (LaMoreaux, 1946), 55 (Herrick and LeGrand, 1949), 64 (LeGrand and Furcron, 1956), and 65 (Thomson, Herrick, and Brown, 1956). (See fig. 1.)

A preliminary report on the geology of the Coastal Plain of Georgia was contributed by Veatch and Stephenson (1911). Cooke summarized the geology of the Georgia Coastal Plain in a report issued in 1943. Both of these reports covered the entire Coastal Plain of Georgia. Individual outcrops in Lee and Sumter Counties were described and the counties were included in geologic maps. The most detailed investigation in the Lee and Sumter County area was reported by Zapp (1943). Zapp prepared a geologic map of the Andersonville bauxite district which includes parts of Sumter, Schley, and Macon Counties. MacNeil (1947) prepared a geologic map of the Tertiary and Quaternary formations of the Georgia Coastal Plain which differed greatly from all preceding maps. In general, MacNeil's interpretation has been followed in this report, and the geologic map (fig. 5) was adapted from his mapping. Other reports concerning the geology of the Coastal Plain of Georgia are listed in "Selected References" at the end of this report.

ACKNOWLEDGMENTS

The writer is indebted to the citizens of Lee and Sumter Counties, who without exception were courteous and cooperative in supplying information, in allowing their property to be examined, and in allowing measurements of their wells.

Special appreciation is expressed to the Layne-Atlantic Drilling Co. of Albany, the Southeastern Drilling Co. of Americus, and the Eubanks Drilling Co. of Pilema, all of whom supplied useful information and drill cuttings from wells.

WELL-NUMBERING SYSTEM

The well-numbering system in this report indicates the location of the well by latitude and longitude. Three sets of numbers are listed for each well, such as 3155–8405–7. The first two sets denote the approximate location of the well by placing it within a certain 5-minute rectangle of latitude and longitude. In the example above, 3155 corresponds to lat 31°55′ N. and 8405 corresponds to long 84°05′ W. These numbers denote the southeast corner of the 5-minute rectangle in which the well is located. The final set is a serial number and has no geographic significance. In the example above it indicates that the well was the seventh to be located within that rectangle. The wells used in the preparation of this report are located on plate 1, where the final set of numbers appears opposite each well. Some wells have additional numbers such as GGS–327 and ALB–31, which are well-sample library numbers; cuttings from such wells are on file and available for inspection at offices of the U.S. Geological Survey, 19 Hunter Street S.W., Room 416, Atlanta 3, Ga.

PHYSICAL GEOGRAPHY

C. W. Cooke (in LaForge and others, 1925, p. 19–54) divided the Coastal Plain of Georgia into six physiographic units (fig. 2). Most of Lee and Sumter Counties was included in the Dougherty Plain

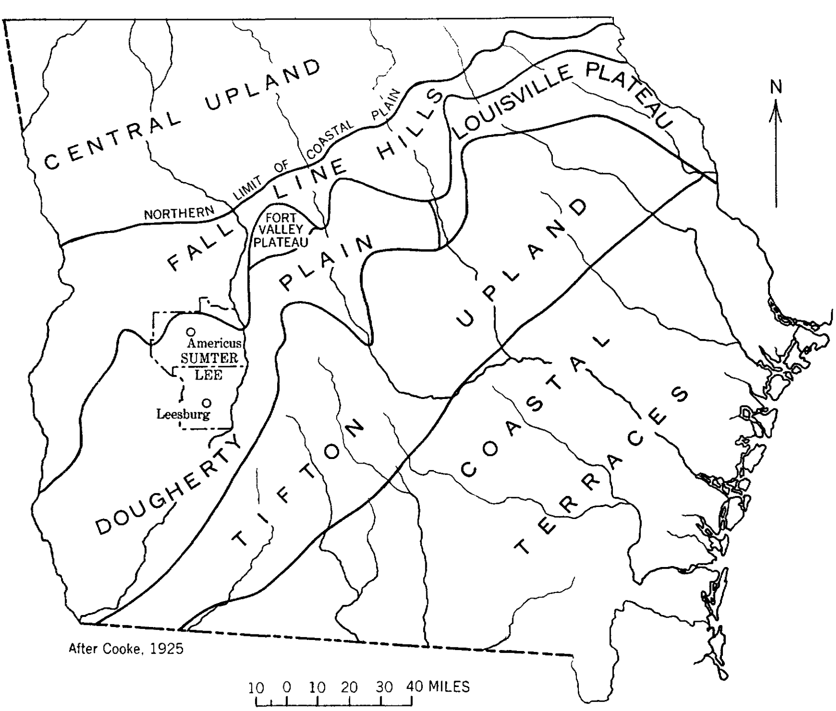


FIGURE 2.—Physiographic divisions of the Coastal Plain of Georgia.

unit but part of northern Sumter County was included in the Fall Line Hills unit. He did not precisely define the characteristics of the two units or the boundary between them and no attempt is made to do so in the present report. Instead, the topography is considered in terms of the two principal ground-water regions shown on plate 1. The Dougherty Plain, as defined by Cooke, includes all of Area II and the southern part of Area I.

AREA I

Area I is a dissected upland with stream valleys that are generally wide and swampy and are bordered by gentle to steep slopes. The interstream areas are rolling to almost level and are capped by residual material over wide areas. Maximum relief is about 150 feet except along the Flint River where it is about 200 feet. Some Ocala limestone underlies the southern part of this area but its occurrence is spotty and irregular and sinks and other solution features are not numerous.

AREA II

The Ocala limestone underlies all of Area II at shallow depth. The area is a mature plain having many shallow sinks and areas of interior drainage. The maximum relief does not exceed 70 feet. Along the Flint River and the lower courses of Kinchafoonee and Muckalee Creeks the valleys are narrower and steeper than elsewhere, and limestone exposures, relatively deep sinks, and large springs are found along the stream valleys.

DRAINAGE

Lee and Sumter Counties are entirely within the drainage basin of the Flint River, which forms the eastern boundary of both counties. The Flint River heads near Atlanta and is the only stream in the region that has its source in the Piedmont province. All its tributaries in the region rise in the Coastal Plain.

The largest tributary of the Flint River in Lee and Sumter Counties is Kinchafoonee Creek which heads in the belt of Upper Cretaceous rocks of Marion County. It flows through Marion and Webster Counties, along the southwest border of Sumter County, along the western border of northern Lee County, and through southwestern Lee County. It joins the second largest tributary of the Flint, Muckalee Creek, just south of Lee County, to form Muckafoonee Creek which flows a short distance to the Flint River. Muckalee Creek heads in the Upper Cretaceous rocks of Schley County and flows through central Sumter and Lee Counties to its confluence with Kinchafoonee Creek.

The valleys of the upper courses of Kinchafoonee and Muckalee Creeks are in marked contrast to the valleys of their lower courses and to the valley of the Flint River. From the vicinity of Leesburg north, Kinchafoonee and Muckalee Creeks appear to be streams in a mature cycle of development. They flow through broad, swampy valleys about 1 mile wide, between low banks in somewhat ill-defined channels which bifurcate and rejoin. The valleys are subject to extensive flooding during periods of heavy rainfall. South of Leesburg, Kinchafoonee and Muckalee Creeks have narrow valleys and no bordering swamps. They flow in well-defined channels with steep banks consisting, at many places, of limestone walls 10 to 15 feet high. Some of their tributaries enter the main stream as waterfalls.

The Flint River in most of Lee and Sumter Counties has a relatively narrow flood plain and generally flows between high banks in a well-defined channel. Occasional low swampy stretches occur along the river, but they are narrow and discontinuous.

The reason for the apparent youthful stage of the Flint River and the lower courses of Kinchafoonee and Muckalee Creeks is not known but it is likely due to rejuvenation of the Flint River system which has progressed upstream along the Flint River to a point north of northern Sumter County and upstream along the creeks to a point near Leesburg. Rejuvenation could have been brought about either by an elevation of land surface or by a lowering of sea level.

CLIMATE

Lee and Sumter Counties have a mild humid climate. Figures 3 and 4 show average monthly precipitation and temperature at two U.S. Weather Bureau stations, one 4 miles north-northeast of Americus and the other at Albany, 4 miles south of the Lee County line.

The record for the station near Americus indicates an average annual temperature of 64.3° F and average annual precipitation of 52.46 inches. December is the coldest month with an average temperature of 50.5° F and July the warmest with an average temperature of 81° F. July is generally the wettest month with an average precipitation of 5.74 inches and October the driest with an average precipitation of 1.94 inches. The figures are for the period 1886 through 1958.

The station at Albany indicates an average annual temperature of 65.9° F with an average annual precipitation of 48.61 inches. December is the coldest month with an average temperature of 52.7° F and July the warmest with an average temperature of 82.7° F. July is generally the wettest month with an average precipitation of 5.56 inches and October the driest with an average precipitation of 1.95 inches. The figures are for the period 1892 through 1958.

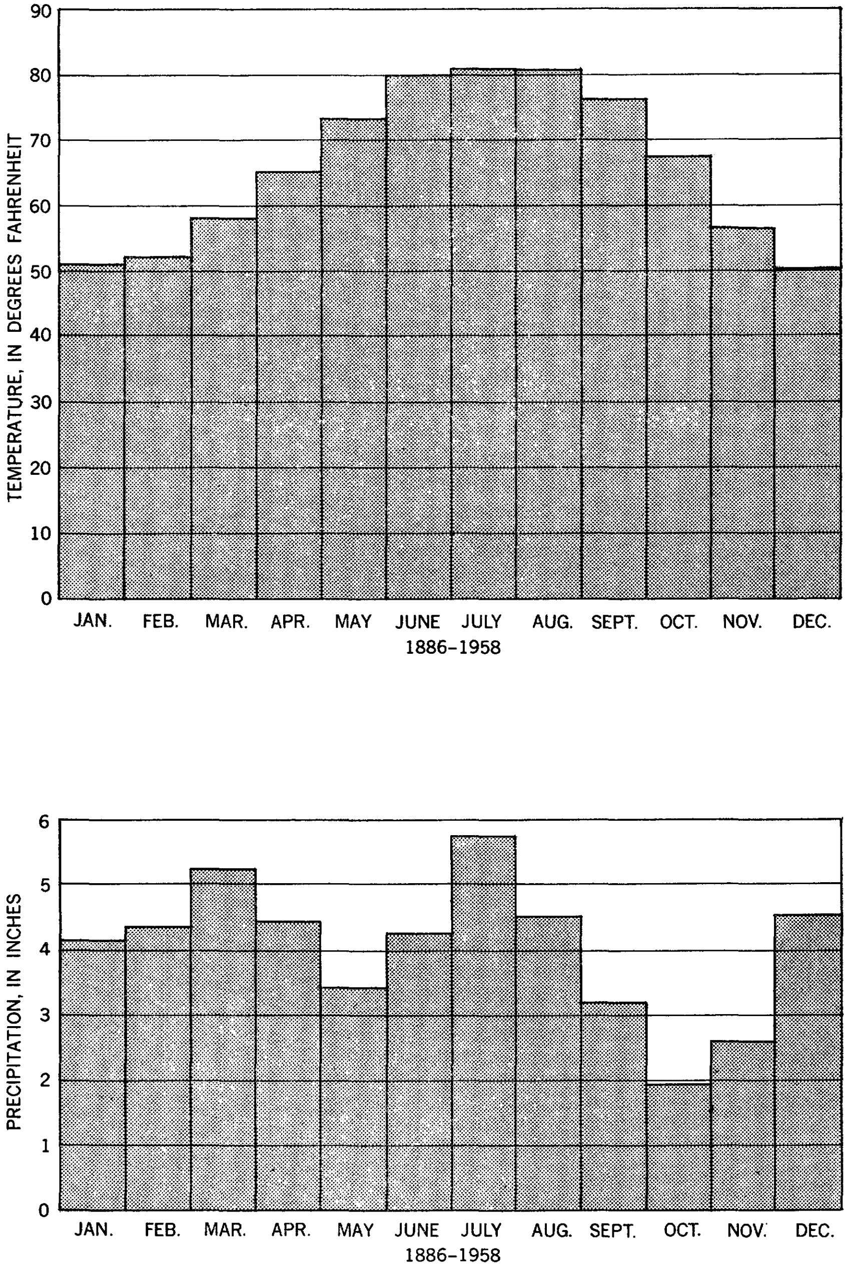


FIGURE 3.—Average monthly precipitation and temperature at Americus, Sumter County, Ga.

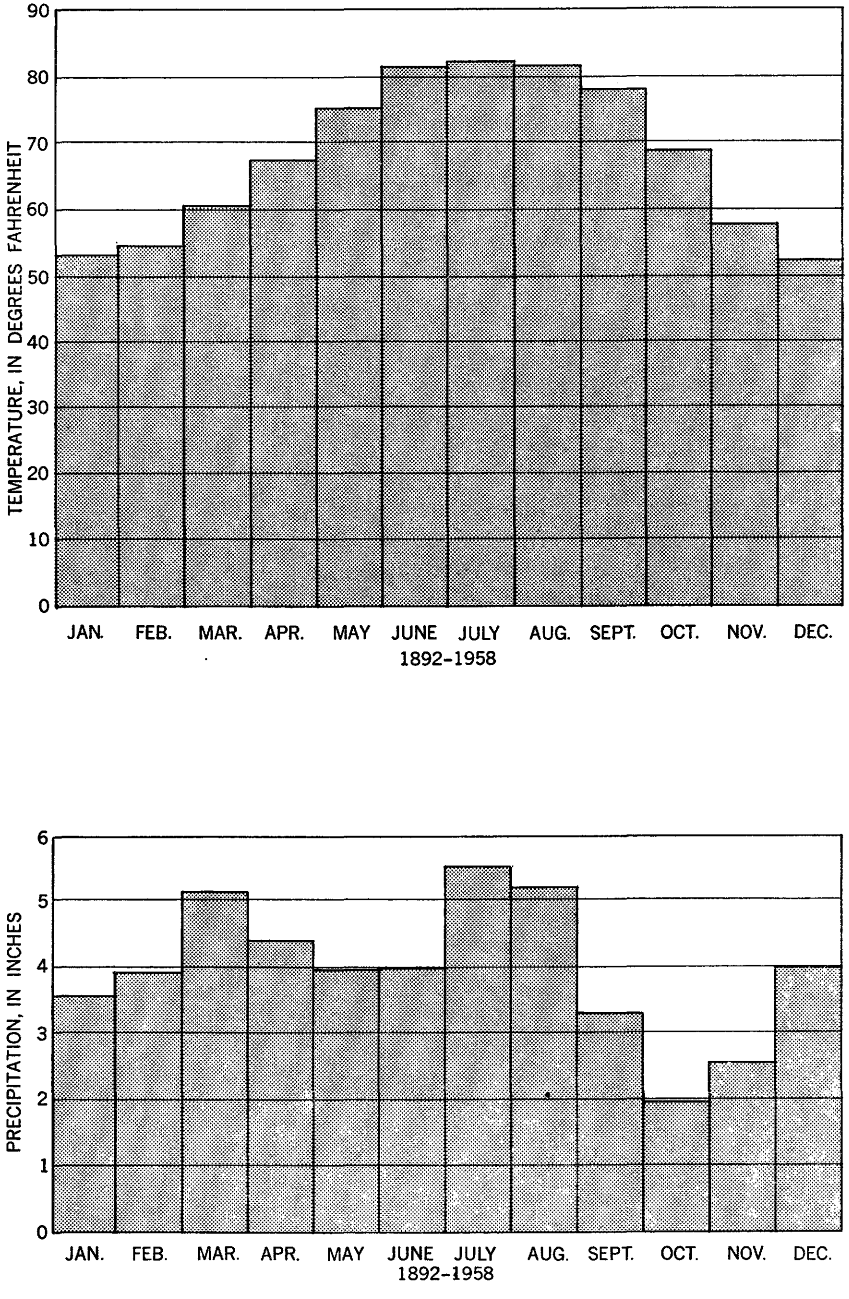


FIGURE 4.—Average monthly precipitation and temperature at Albany, Dougherty County. Ga.

ECONOMIC DEVELOPMENT

The 1960 U.S. Census of Population lists the population of Lee County as 6,204 and that of Sumter County as 24,652 (U.S. Dept. Commerce, 1960a). All of the population of Lee County and 53 percent of the population of Sumter County were classified as rural. The largest town in the region is Americus, the county seat of Sumter County, which had a population of 11,472 in 1960. Plains had a population of 572 and all other communities in Sumter had populations of less than 500. Leesburg, the county seat and largest town in Lee County, had a population of 774 in 1960. Smithville, the only other town of any size, had a population of 732.

AGRICULTURE

Agriculture is the leading occupation in Lee and Sumter Counties. According to the 1959 U.S. Census of Agriculture, about 174,900 acres in Lee County and about 231,200 acres in Sumter County were in farms (U.S. Dept. Commerce (1960 b and c)). This is 77 percent of the land area of Lee County and 74.5 percent of the land area of Sumter County. Also, according to the 1959 Census, 617 persons in Lee County and 1,580 persons in Sumter County were engaged in agriculture.

The principal crops in the two counties are corn, cotton, and peanuts. Numerous other crops are raised and beef cattle, hogs, poultry, and dairy products are important farm commodities.

INDUSTRY

Lee and Sumter Counties have a few small industries, the principal products of which are furniture, lumber, wood products, apparel and other fabricated textile products, food, and chemicals.

MINERALS

Sand and gravel are quarried at scattered localities throughout Lee and Sumter Counties. Bauxite and kaolin are mined on a small scale in the Andersonville area of northeastern Sumter County and limestone is quarried in southwestern Lee County.

TRANSPORTATION

Lee and Sumter Counties are adequately served by highways and railroads. U.S. Highways 19 and 280 traverse the area as do State Highways 3, 27, 30, 32, 45, 49, 50, 118, 153, and 195. The Central of Georgia, Seaboard Air Line, and Albany and Northern Railroads also serve the area.

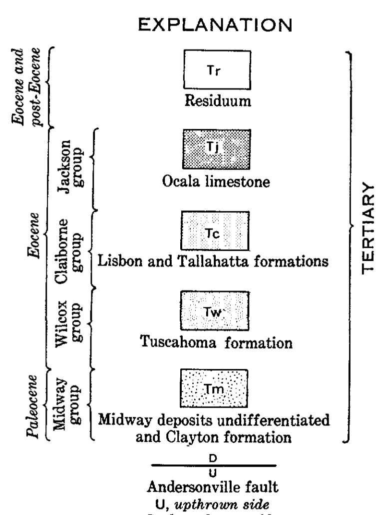
GEOLOGY

The exposed rocks in Lee and Sumter Counties range in age from Paleocene to Oligocene. Thin surficial deposits of Pleistocene and Recent ages may occur but these have not as yet been identified and mapped. The outcropping formations described in this report are, in ascending order, the Clayton formation, the undifferentiated deposits of the Midway group, the Tuscahoma, Tallahatta and Lisbon formations, the Ocala limestone, and the undifferentiated residuum.

Geologic mapping was not done during the course of this investigation. The geology of the area is shown in figure 5, which is an adaptation of a portion of a map by MacNeil (1947). As a result of preliminary geologic field investigations the writer is in general agreement with MacNeil concerning the surface geology of the region. MacNeil, however, recognized the presence of the Nanafalia formation and mapped it and the Clayton formation as one unit. In the present report this entire unit is referred to the Midway group in which the Clayton formation and overlying undifferentiated Midway deposits are recognized. The undifferentiated Midway deposits of the present report correspond to the Nanafalia formation of MacNeil.

STRATIGRAPHY

Lee and Sumter Counties are underlain by sedimentary rocks ranging in age from Early Cretaceous to Tertiary. The maximum thickness of the Tertiary deposits is about 1,000 feet and that of the Upper Cretaceous deposits about 2,300 feet. The thickness of the



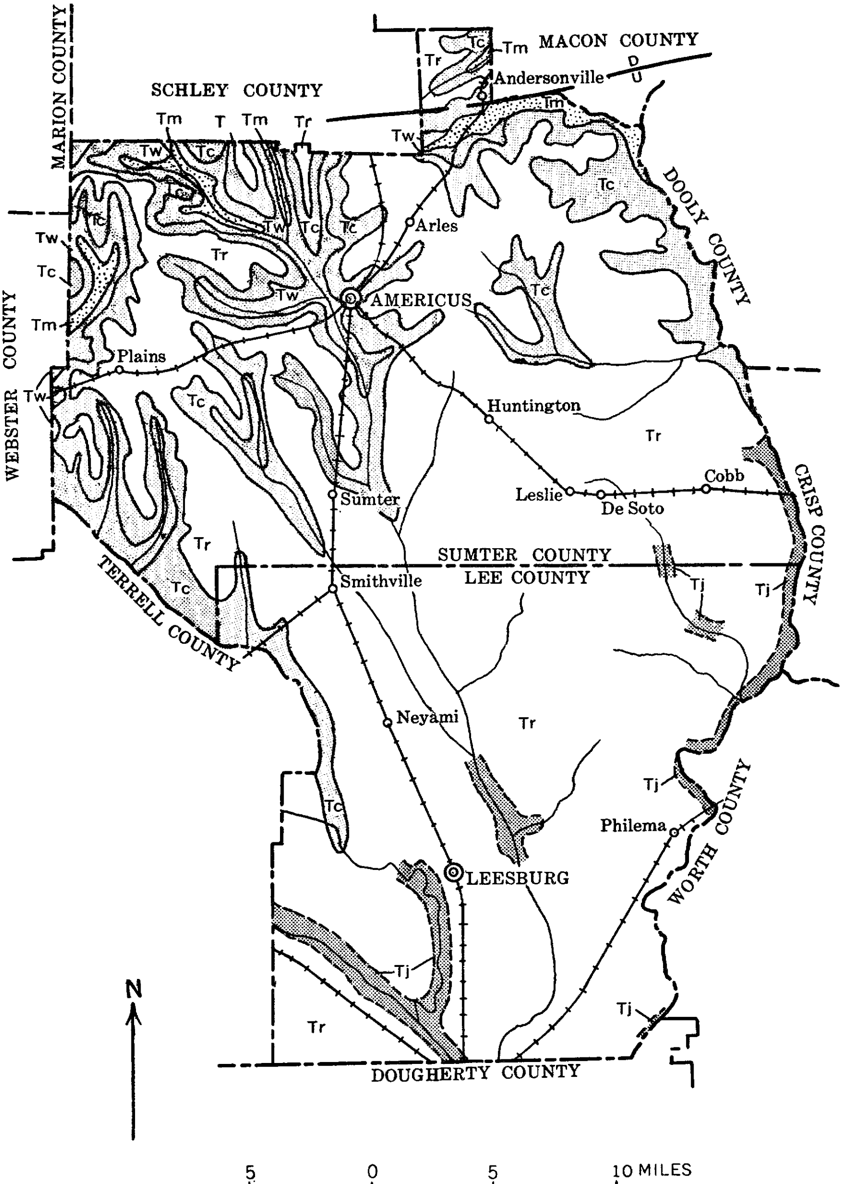


FIGURE 5.—Geologic map of Lee and Sumter Counties, Ga.

Lower Cretaceous deposits is not known but probably exceeds 1,000 feet. The Lower Cretaceous rocks are probably underlain by metamorphic and igneous rocks of pre-Cretaceous age. The discussion of stratigraphy in this report is limited to rocks of the Upper Cretaceous series and Tertiary system. The general stratigraphy of the area is illustrated in the geologic section on plate 2 and in tables 1 and 2.

In the discussion of stratigraphy which follows, occasional refererence is made to the structural belt because faulting or downwarping along the belt has influenced depositional conditions and stratigraphy in the region. The structural belt is shown on plate 1 and described in the section on structure.

UPPER CRETACEOUS SERIES

Cooke (1943, p. 5–39) recognized six formations in the Upper Cretaceous series of Georgia. In ascending order these are the Tuscaloosa, Eutaw, and Blufftown formations, the Cusseta sand, the Ripley formation, and the Providence sand. Eargle (1955) also used this classification in a more detailed study of the Upper Cretaceous rocks of Georgia. The work of Cooke and Eargle was based on lithology and assemblages of macrofossils in that part of Georgia where the Upper Cretaceous rocks crop out at the surface. According to S. M. Herrick (oral communication) it may not be practicable to use this classification in the subsurface of western Georgia. On the basis of lithology and microfauna of well cuttings it is difficult to distinguish the Eutaw from the Blufftown and the Cusseta from the Ripley. Thus, the subsurface Upper Cretaceous might be divided into four units. In ascending order these are the Tuscaloosa formation, the Eutaw and Blufftown formations, the Cusseta sand and Ripley formation, and the Providence sand. With the limited amount of subsurface data available in Lee and Sumter Counties it is practicable at the present time to use only two divisions of the Upper Cretaceous series—the Tuscaloosa formation and the undifferentiated Upper Cretaceous rocks, which includes all beds above the Tuscaloosa formation.

Lithology.—The rocks of the Upper Cretaceous series are more deeply buried than those of the Tertiary system and for this reason are less well known. Drill cuttings from deep in the Upper Cretaceous series are available from only two wells in the area. These are well 3200–8410–25 of the city of Americus and well 3200–8415–4, an oil-test well about 5.5 miles southwest of Americus.

Well 3200–8410–25, 1,005 feet deep, penetrated 732 feet of undifferentiated Upper Cretaceous rocks and bottomed in the Blufftown formation (pl. 2). The undifferentiated Upper Cretaceous in this well consists of, in descending order, 50 feet of arkosic sand and gravel; 361 feet of sandy marl, marly sand, thin beds of clean sand and gravel; widely spaced thin limestone and sandstone beds; and 328 feet of clean sand and gravel interbedded with dark-gray clay. Because of good sample recovery and an electric log it is possible to distinguish some of the Upper Cretaceous formations in this well. The upper unit probably corresponds to the Providence sand, the middle unit to the Cusseta sand and Ripley formation, and the lower unit to the Blufftown formation.

Well 3200–8415–4 penetrated the entire thickness of the Upper Cretaceous series and bottomed in the Lower Cretaceous. The rocks of the undifferentiated Upper Cretaceous are similar lithologically to those in well 3200–8410–25 and have a total thickness of about 1,300 feet. The Tuscaloosa formation consists of arkosic sand and gravel and lenses and stringers of clay and is about 900 feet thick.

An oil test (J. R. Sealy, Reynolds Brothers Lumber Co., no. 1) 4 miles south of Lee County in Dougherty County penetrated the entire thickness of the Upper Cretaceous series and bottomed in the Lower Cretaceous. The undifferentiated Upper Cretaceous at this location is about 1,600 feet thick and the Tuscaloosa formation is about 700 feet thick. Preliminary examinations indicate that the deposits are similar in lithology to those found in the Sumter County wells.

Cuttings from several scattered wells that penetrate the Upper Cretaceous to depths of 100 feet or less indicate that the uppermost bed of the Upper Cretaceous consists of 30 to 60 feet of arkosic sand and gravel throughout most of the region. In Dougherty County, immediately south of Lee County, the arkosic sand and gravel bed is underlain by 40 to 50 feet of marl, which is in turn underlain by 30 to 40 feet of coquina limestone. This coquina bed probably underlies southeasternmost Lee County, but cuttings indicate that it is not present in northern Lee County or in Sumter County. The coquina is a persistent bed which appears to underlie all of Dougherty County and an undefined area in southern Lee County.

Thickness.—The total thickness of the Upper Cretaceous series ranges from 2,200 to 2,300 feet throughout most of Lee and Sumter Counties.

PALEOCENE SERIES

The rocks comprising the Midway group in Georgia were long considered to belong to the basal part of the Eocene series. Cooke (1943, p. 39) placed the Midway group in the Paleocene series, stating that "The justification for classifying the Paleocene as a series apart

TABLE 1.—*Stratigraphic units in Lee County, Ga.*

Geologic unit	Thickness (feet)		Lithology	Yields from wells	Quality of water	Features of wells		
	Northwest corner of county	Southeast corner of county				Depth (ft)	Finish	Principal use
Residuum	40	40	Sandy, ferruginous, red clay containing disarranged masses of chert.	1 to 5 gpm.	Not known.	25	Open.	Domestic.
Ocala limestone	10	150	Underlies most of Lee County but is thin or absent in extreme northwest. Consists of pinkish white fossiliferous limestone underlain by 30 to 40 ft of calcareous sand.	Yields of 100 to 200 gpm might be expected in southeastern half of county. Maximum yields of 500 gpm might be expected in extreme southeast. Yields in northwestern half of county are as much as 100 gpm.	Moderately hard to hard but generally of good quality.	100	do	Domestic; limited use for irrigation.
Lisbon formation	5	100	Underlies most of Lee County but is thin or absent in extreme northwest. Consists mostly of dense earthy limestone and dense brownish-gray marl but contains thin beds of hard sandy glauconitic limestone.	Not known to be used as source of water. Could be expected to yield small quantities of water.	Probably moderately hard to hard.			
Tallahatta formation	110	240	Over most of county consists of massive, clean, phosphatic sand containing a 50- to 60-ft calcareous zone at top which ranges from sand containing abundant shells to coquina limestone. In extreme northwestern Lee County consists of interlaminated and cross-bedded sand, gravel, and clay.	Yields of 1,000 gpm might be expected from properly constructed wells in the southeastern half of the county. Yields of 200 to 1,000 gpm might be expected elsewhere.	Moderately hard to hard but generally of good quality.	50 to 400.	Open or screened.	Domestic; limited use for municipal and irrigation purposes.

Tuscahoma formation	100	100	Gray glauconitic silt and clay containing basal glauconitic sand.	Not known to be a source of water in Lee County.	Not known.			
Midway group	100	150	Consists mostly of light-gray fossiliferous limestone overlain by 40 to 50 ft of calcareous sand. Limestone is sandy and interbedded with fuller's earth in northwest, but is massive and pure in southeast. Sand is fine- to coarse-grained and interbedded with fuller's earth in northwest; but is fine-grained and interbedded with thin limestone in southeast.	Yields of 200 to 300 gpm might be expected from properly constructed wells in all parts of county.	Moderately hard to hard, locally very hard. Generally of good quality otherwise.	400 to 650	Open (screen would be required for wells producing large yields from sand).	Domestic; limited use for irrigation purposes.
Upper Cretaceous rocks, undifferentiated	1,600 (southern part of county)		Underlies all of Lee County but few records are available because of depth. Lithology probably is similar to that in Sumter County. Coquina bed 20 to 30 ft thick near top in parts of southern Lee County; 40-foot thick bed of course-grained feldspathic sand is persistent at top.	Few data available. Yields of 1,000 gpm might be expected from deep wells with many screens throughout the county.	Few data available. Probably moderately hard to hard. Water is likely to contain more than 0.3 ppm dissolved iron.	400 to 750	Open (screens would be required for wells producing large yields from sand).	Domestic; limited use for irrigation purposes.
Tuscaloosa formation	700 (southern part of county)		Underlies all of Lee County but few data are available because of depth. Lithology probably similar to that in Sumter County.	Yields large quantities in counties to north. Not used as source of water in Lee County because of great depth.	Quality of water not known in Lee County. Possibly contains some saline water.			

TABLE 2.—*Stratigraphic units in Sumter County, Ga.*

Geologic unit	Thickness (feet)		Lithology	Yields from wells	Quality of water	Features of wells		
	Northwest corner of county	Southeast corner of county				Depth (feet)	Finish	Principal use
Residuum	40	40	Sandy, ferruginous, red clay containing disarranged masses of chert.	1 to 5 gpm	Not known	25	Open	Domestic.
Ocala limestone	0	40	Definitely known only in southeastern Sumter County into which it extends from Lee County. At higher elevations near Leslie it consists of 100 feet of pinkish-white fossiliferous limestone underlain by 40 ft of clean, loose sand.	Few data available. Maximum yields might be as much as 100 gpm. Average yields probably would be less than 50 gpm.	Moderately hard to hard but generally of good quality.	75 to 150	do	Do.
Lisbon formation	0	40	Definitely known only in southeastern Sumter County. Consists of dense brownish-gray marl and thin beds of sandy glauconitic limestone.	Not known to be used as source of water. Could be expected to yield small quantities of water.	Probably moderately hard to hard.			
Tallahatta formation	40 (absent locally)	180	Consists of interlaminated, crossbedded phosphatic sand, gravel, and clay in northwestern part of county. Becomes less clayey downdip and in southeast corner consists of massive, clean phosphatic sand containing abundant shells in upper 40 to 50 ft.	Yields of 300 to 600 gpm reported from wells partly penetrating this unit in southeastern Sumter County. Maximum yields from properly constructed wells might reach 1,000 gpm in the southeastern part of county. Yields of 50 to 200 gpm could be expected in most other areas.	Moderately hard to hard, but generally of good quality in southeastern part of county. Water is soft in northwestern part of county, but iron content increases with age of well.	100 to 260 (southeastern part of county) 50 to 120 (rest of county).	Open (low-yield wells in southeastern part of county) screened (high-yield wells in southeastern part of county and both low- and high-yield wells in rest of county).	Domestic; limited use for industrial, municipal, and irrigation purposes.

Tuscahoma formation	30 (absent locally)	100	Gray glauconitic silt and clay containing basal glauconitic sand over most of county. Grades into reddish, cross-bedded micaceous sand containing clay balls in northwesternmost part. Not present in north easternmost part of county.	Few wells obtain water exclusively from the Tuscahoma; these tap the micaceous facies in the northwesternmost part. No data available concerning yields.	Not known	50 to 150	Screened	Domestic.
Midway group	70	150	Limestone, marl, sand, and clay. Lower 20 to 30 ft is limestone throughout most of county. Remainder of unit consists of interbedded marl, sand, clay and thin limestone beds. Limestone makes up most of thickness locally in southwest. Sand, lignitic clay, and kaolinic clay make up most of thickness in northeast. Lithology not known in southeast corner.	Few data available. Yields of 50 to 200 gpm probably could be obtained in most areas. Yields might be expected to be very small in northeastern part of county where clay makes up most of formation.	Mostly moderately hard to hard, some very hard. Generally of good quality.	200 to 400	Open	Domestic; limited use for municipal purposes.
Upper Cretaceous rocks, undifferentiated.	1,500 (central part of county)		Underlies all of Sumter County but few records are available because of depth. Upper 30 to 60 ft consists of clean arkosic sand and gravel. Remainder consists of marl, marly sand, and clay, and thin beds of sand and widely spaced thin limestone beds.	Reported yields of over 200 gpm from upper sand and gravel. Yields of 1,000 gpm are obtained from deep wells with many screens in Americus.	Moderately hard to hard. Contains more than 0.3 ppm dissolved iron.	200 to 400	Open (low-yield wells) screened (high-yield wells).	Municipal or domestic.
Tuscaloosa formation	900		Coarse-grained arkosic sand and gravel containing clay lenses and stringers.	Yields large quantities of water in counties north of Sumter. Not used in Sumter County because of depth.	Quality of water not known in Sumter County. Possibly contains saline water.	------	------	

from the Eocene lies in its fauna, which is, perhaps, as individual as that of any other series of the Cenozoic era * * *."

MIDWAY GROUP

The term "Midway" was first used by E. A. Smith (1886, p. 14) to describe exposures at Midway Landing on the west bank of the Alabama River in Choctaw County, Ala. Midway was then used in a restricted sense to refer to a zone now known as the Clayton formation of the Midway group.

Midway is now used in a broad sense and refers to a group of several formations. In Alabama, the formations are, in descending order, the Naheola, Porters Creek, and Clayton formations.

Langdon (1891) used the term "Midway or Clayton group" to describe exposures near Clayton, Barbour County, Ala. He was referring to the zone which Smith had termed Midway, and which is now regarded as the Clayton formation.

Veatch and Stephenson (1911, p. 216–226) mapped and described the Midway formation in Georgia. They recognized the Naheola formation, the Sucarnoochee clay (of former usage), and the Clayton formation of Alabama, but stated that the upper part of the Midway group appeared to be absent in Georgia.

Cooke (1943, p. 39–47) mapped and described the Clayton formation in Georgia. According to Cooke, the Clayton is the only formation of the Midway group which is present in Georgia. Zapp (1943) mapped the Clayton formation in the vicinity of Andersonville, including parts of Sumter, Schley, and Macon Counties, Ga. MacNeil (1947) mapped as one unit the Clayton and lower Eocene Nanafalia formations. MacNeil considered that beds of the Nanafalia and Clayton were intermixed over wide areas due to solution of limestone in the Clayton.

Zapp assigned the kaolin-bauxite zone in the Andersonville area to the Wilcox formation. MacNeil indicates that this zone should be referred to the Nanafalia formation of the Wilcox group. Veatch and Stephenson (1911) were apparently uncertain as to whether this zone belonged to the Clayton or Wilcox. No fossils, other than carbonized wood, have been found in the zone.

In this report the Nanafalia formation is not recognized and the kaloin-bauxite zone of the Andersonville area is referred to the Midway group. The zone dips southeastward beneath the Tuscahoma formation and is correlated with the Midway, because, in the subsurface of southern Lee County, fossiliferous Midway deposits directly underlie the Tuscahoma.

Lithology.—The Midway group of this report includes all beds above the Upper Cretaceous series and below the Tuscahoma formation. In northeastern Sumter County, where the Tuscahoma is overlapped, the Midway is overlain by the Tallahatta formation. The contact between the Midway group and the underlying Upper Cretaceous series is sharp and easily determinable throughout the region, the top of the Upper Cretaceous being marked by abundant feldspar which is absent or extremely rare in the Midway. In most cases the Midway is easily distinguishable from the overlying Tuscahoma by the abundance of glauconite in the Tuscahoma. In parts of northern Sumter County the contact is not as sharp as elsewhere because of glauconitic clay and sparsely glauconitic sand near the top of the Midway.

It is difficult to separate the Clayton formation from the overlying undifferentiated Midway deposits in some areas but general lithologic differences do exist. The Clayton formation is the product of an advancing sea and is mostly limestone and marl. The undifferentiated Midway is the product of a retreating sea and consists mostly of sand. In northern Sumter County the contact between the Clayton formation and the undifferentiated Midway deposits is very irregular, and there is evidence of a pronounced erosional unconformity on top of the Clayton.

In southernmost Lee County the Clayton formation consists of 100 feet of massive limestone. The limestone is typically very light gray (*N*8)[1] to yellowish gray (5*Y* 8/1), is aphanitic to fragmental in texture, and is slightly recrystallized. Commonly it contains abundant gastropods and pelecypods which are cemented by finer grained material. Many of the fossils are in the form of casts and molds. Fine to medium-grained quartz, glauconite, and pyrite are rare to common accessory minerals. The undifferentiated Midway deposits in southern Lee County consist of 50 feet of very fine- to fine-grained silty calcareous sand which is typically light olive gray (5*Y* 6/1) in color. Glauconite and pyrite are common to abundant accessory minerals. The sand contains thin beds of sandstone and sandy glauconitic limestone, some of which are composed almost entirely of Foraminifera. Among the Foraminifera in this zone are two large species recorded and described by Cole and Herrick (1953). These are *Operculinoides georgianus* Cole and Herrick, and *Pseudophragmina* (*Athecocyclina*) *stephensoni* (Vaughan). These Foraminifera were described from cuttings of wells in various locations in southwest Georgia including well 3135–8405–7, at Chehaw State Park in southernmost Lee County.

Cole and Herrick state that the presence of these Foraminifera substantiates the Midway age of the deposits. This fact is useful in

[1] Numbers refer to Rock-Color Chart, Goddard and others, 1948.

stratigraphic interpretation of unfossiliferous deposits in northern Sumter County. The Tuscahoma formation is a bed of rather distinctive and uniform lithology which may be traced from southern Lee County to northern Sumter County. The fact that fossiliferous Midway directly underlies the Tuscahoma in southern Lee County is considered to be strong supporting evidence that the unfossiliferous deposits underlying the Tuscahoma (underlying the Tallahatta where the Tuscahoma is overlapped) in northern Sumter County also are of Midway age.

Interpretation of the electric log of well 3140–8410–3, 1½ miles south of Leesburg, indicates about 96 feet of limestone of the Clayton and about 64 feet of undifferentiated Midway deposits. The Clayton formation and the undifferentiated Midway deposits are recognized in northwesternmost Lee County as shown in the following well log.

Generalized log showing Midway interval in well 3150–8410–7, Dixie Pines Plantation, 2.3 miles south-southeast of Smithville in northwestern Lee County

	Thickness (feet)
Undifferentiated Midway deposits:	
Silty calcareous sand: light-olive gray (5Y 6/1), fine- to medium-grained, interbedded with fuller's earth and thin sandy limestone beds; glauconite, Foraminifera, and shell fragments common	54
Clayton formation:	
Sandy limestone: yellowish-gray (5Y 8/1), and light-olive-gray (5Y 6/1); glauconite, pyrite and fine- to coarse-grained quartz sand abundant; iron oxide, fuller's earth shell fragments, and gastropod molds common	76

Cuttings from a well in Bronwood, Terrell County, about 7 miles southwest of Smithville, show a Midway interval similar to that at Dixie Pines Plantation. The Bronwood well penetrated 43 feet of undifferentiated Midway deposits and 60 feet of limestone in the Clayton formation. Other wells in Terrell County, west of Lee County, have penetrated Midway rocks of similar thickness and lithology as have numerous wells in Dougherty County to the south.

The Midway group throughout southern and western Lee County consists of the Clayton formation, composed of massive limestone, and the overlying undifferentiated Midway deposits, composed mostly of silty calcareous sand. The lithology of the Midway group in northeastern Lee County is uncertain owing to lack of geologic data but may be inferred by examination of cuttings from two wells a few miles to the east in Crisp County. In a well at Cordele, 9 miles east and slightly north of the northeastern corner of Lee County, the Clayton formation consists of 100 feet of marl containing thin limestone beds and many shell fragments; this is overlain by 45 feet of undifferentiated Midway deposits consisting of marly sand and gravel interbedded with light- and dark-gray clay. In a well at Arabi, about 7 miles south of the Cordele well, the Midway interval is about 170 feet thick and consists almost entirely of fine- to medium-grained calcareous sand interbedded with thin layers of light-gray clay; at this location there appears to be no lithologic distinction between the Clayton formation and the undifferentiated Midway deposits. If the lithology of the Clayton formation in the Crisp County wells is representative, the Clayton formation in that area consists mostly of marl and calcareous sand. Thus, it appears that the limestone, which is predominant in the Clayton formation of western Lee County, grades laterally into marl and calcareous sand in Crisp County. For this reason it is probable that the Clayton formation contains less limestone in northeastern Lee County than it does in other parts of the county.

Well 3200–8400–8 is located centrally on the eastern boundary of Sumter County and is approximately along the strike of the Midway from the well at Dixie Pines Plantation in northwestern Lee County. The Clayton formation in this well consists of 20 feet of sandy limestone overlain by 30 feet of marl. The undifferentiated Midway deposits consist of 50 feet of glauconitic sand and gravel containing varying amounts of calcareous material and lignite. Midway deposits of similar lithology occur as far north as Plains and Americus.

The base of the Midway group consists of interbedded limestone, marl, and fuller's earth throughout most of northern Sumter County and is referable to the Clayton formation on the basis of both macro- and micro-fauna. The basal beds are overlain, in scattered localities, by unfossiliferous sands and clays which are assigned in this report to the undifferentiated Midway deposits.

The lithology of the undifferentiated Midway is distinctive in the Andersonville area, where it consists chiefly of sand, much of which has no definite marine characteristics. The sand contains kaolin masses many acres in extent which, in turn, contain flat-shaped bodies of bauxite. The kaolin-bauxite zone is overlain in some localities by lenses of carbonaceous deposits consisting of a few feet of dark-gray to black silty sand and clay containing abundant glauconite, pyrite, and carbonized wood. The sand in the undifferentiated Midway is generally firm, massive to current-bedded, fine- to coarse-grained, and contains nodules of kaolinic clay. Most of the sand appears to be stratigraphically above the kaolin masses. It fills deep channels between them and overlies them unconformably in some localities. Elsewhere, it pinches out against their tops, and the kaolin masses and overlying carbonaceous beds make up the entire thickness of the undifferentiated

Midway. Although the kaolin masses are assigned to the undifferentiated Midway in this report, possibly they should be assigned to the Clayton formation and only the associated sand should be assigned to the undifferentiated Midway deposits.

A strongly crossbedded, loosely consolidated sand occurs above the stratigraphic level of the upper carbonaceous beds in the Midway in the Andersonville area. The upper sand is assigned in this report to the Tallahatta formation.

The lithology of the Midway group in northwestern Sumter County is illustrated in the cross section on plate 2 and in the measured section described below.

Measured section (MS-5), northwestern Sumter County

	Thickness (feet)
Undifferentiated residuum:	
Mudstone: brownish-red to reddish-brown, mostly silt and clay; fine- to coarse-grained quartz sand abundant; iron oxide pebbles common; weathers smooth to blocky; forms upland plain and gentle slope; base fairly sharp and regular	14
Total undifferentiated residuum	14
Middle Eocene series.	
Claiborne group.	
Tallahatta formation:	
Clayey sand and gravel; grayish-yellow to reddish-brown, fine-grained sand to pebble gravel, subangular to subrounded, poorly sorted to well-sorted, clear quartz, silt and clay abundant to rare; cross-bedded and interlaminated with vari-colored clay; 1 or 2 ft of medium- to coarse-grained, dark-olive-brown sand at top; weathers smooth; forms moderate slope; base sharp and flat	34
Total Tallahatta formation	34
Lower Eocene series.	
Wilcox group.	
Tuscahoma formation:	
Glauconitic sandy clay and silt; yellowish-gray to brownish-red; very fine- to fine-grained quartz sand and glauconite abundant; irregular laminations and iron crusts at top; caps small rise and extends down steep slope; weathers knobby to smooth; base irregular and gradational	15
Glauconitic sandy clay and silt: brownish-red, quartz abundant, fine-grained sand to granule gravel; glauconite and iron crusts common; weathers smooth; forms steep slope; base gradational and irregular	11
Total Tuscahoma formation	26

Measured section (MS-5), northwestern Sumter County—Continued

	Thickness (feet)
Paleocene series.	
Midway group.	
Undifferentiated Midway deposits:	
Sand and gravel: yellowish-gray, fine-grained sand to granule gravel, subangular to subrounded, poorly sorted to well-sorted, clear quartz, fairly clean and loose; kaolinic and kaolin clay balls abundant along base; weathers smooth; forms moderate slope; base fairly sharp but irregular and dipping in direction of creek	6
Kaolinic clay: light-gray with red splotches, crumbly when dry, sticky and plastic when wet; fine- to coarse-grained quartz sand common; irregular pods of white kaolin with sand and pebble gravel at top; weathers knobby; forms gentle slope; base fairly sharp but irregular and dipping in direction of creek	5
Total undifferentiated Midway deposits	11
Clayton formation:	
Fuller's earth clay: light-gray with yellow and red splotches, tough, non-plastic, breaks with conchoidal facture; muscovite abundant, very fine-grained; quartz sand rare to absent; weathers knobby; forms gentle slope; base concealed	5
Total Clayton formation	5

The Clayton formation in northwestern Sumter County consists of limestone and marl overlain by a persistent bed of fuller's earth, and the undifferentiated Midway deposits consist of a thin bed of kaolinic clay overlain by fine- to coarse-grained sand containing masses of white kaolin. The kaolinic clay grades laterally in some localities into abundantly glauconitic clay containing poorly preserved cherty fossils. The sand is of variable thickness and thickens eastward along the cross section shown on plate 2. It also thickens northward into southwestern Schley County where it contains sizeable masses of kaolin. At most outcrops the sand is firm, current-bedded, and lignitic and contains abundant coarse-grained muscovite.

Thickness.—The thickness of the Midway group ranges from 160 feet in southeastern Lee County to about 70 feet in northwestern Sumter County. The rate at which the Midway thins to the northwest is apparently constant without increase in rate of thinning along the structural belt. In most of the region south of the structural belt the Clayton formation is uniformly about twice as thick as the undifferentiated Midway deposits. North of the structural belt the average thickness of the Clayton formation is about 60 feet and that of the undifferentiated Midway about 40 feet, but the contact is very undulating and locally the undifferentiated Midway is thicker than the

Clayton. An example of the diversity of the relative thicknesses of the two units may be seen in a comparison of well 3200–8410–25, located just southeast of Americus, with well 3200–8415–3, located along the strike from well 3200–8410–25 and about six miles to the southwest. At well 3200–8410–25, a log of which is shown on plate 2, the Clayton consists of 30 feet of limestone and the undifferentiated Midway consists of 82 feet of sand. At well 3200–8415–3, a log of which is shown on plate 2, no undifferentiated Midway deposits are present. The well pentrates 80 feet into the Midway group, and the entire interval consists of limestone and marl of the Clayton formation.

The variability of relative thicknesses in northwestern Sumter County is illustrated on plate 2 in which the Clayton formation is that part of the Midway group below the fuller's earth horizon. The variability of relative thicknesses in the Andersonville area is shown in logs of two wells at the city of Andersonville (below). Well 3205–8405–3 did not penetrate any beds of the Clayton but was not drilled completely through the Midway group.

Generalized log showing Midway interval, Andersonville

City well 3205–8405–4

	Thickness (feet)
Undifferentiated Midway deposits:	
Dark-gray, lignitic, pyritiferous, sandy clay	20
Sandy kaolin	23
Clayton formation:	
Calcareous clay	10
Limestone	51

City well 3205–8405–3

Undifferentiated Midway deposits:	
Clayey, poorly sorted, very fine- to coarse-grained sand	10
Well-sorted, subangular, clean sand and gravel	68

EOCENE SERIES

The Eocene series in Georgia consists of the Wilcox group (lower Eocene), the Claiborne group (middle Eocene), and the Jackson group (upper Eocene).

WILCOX GROUP

The name Wilcox was first used by E. A. Smith in an unpublished report that described beds in Wilcox County, Ala., which had previously been called Lignitic by Hilgard. Crider and Johnson (1906, p. 5–9) were the first to use the term "Wilcox" in a published report, in which some of the strata in Wilcox County was described as belonging to the Wilcox formation.

The Wilcox is now regarded as a group consisting of several formations. In Alabama the Wilcox group is divided into, in descending order, the Hatchetigbee, Tuscahoma, and Nanafalia formations.

Veatch and Stephenson (1911, p. 227–235) mapped and described the Wilcox formation in Georgia stating that the formations recognized in Alabama could not be recognized in Georgia east of the Chattahoochee River. Cooke (1943, p. 48–53) also mapped and described the Wilcox as a formation in Georgia but noted that the equivalents of the Tuscahoma, and Nanafalia formations were known to be present there. MacNeil (1947) mapped the Wilcox in Georgia, showing the Hatchetigbee formation and the Tuscahoma sand as one unit and the Nanafalia formation and the Paleocene Clayton formation as another unit. MacNeil indicated that the Hatchetigbee formation does not crop out east of southeastern Stewart County.

TUSCAHOMA FORMATION

All of the Wilcox group in Lee and Sumter Counties is assigned in the present report to the Tuscahoma formation. The name Tuscahoma sand was first used in 1886 by E. A. Smith to describe deposits at Tuscahoma, on the Tombigbee River, Choctaw County, Ala. These deposits had previously been called Bells Landing series by Smith and Johnson (1887, p. 46–51). Cooke (1943) assigned individual outcrops in Georgia to the Tuscahoma sand and others to the Nanafalia and Bashi formations.

Lithology.—The Tuscahoma formation in this report includes all beds overlying the Midway group and underlying the Tallahatta formation. The Tuscahoma is remarkably uniform in thickness and lithology in the area southeast of the structural belt but becomes thinner and less homogeneous northwest of the belt. Southeast of the structural belt the Tuscahoma consists of about 70 feet of sandy glauconitic silt or very fine- to fine-grained silty glauconitic sand underlain by about 30 feet of silty to clean glauconitic sand and gravel. The color of the Tuscahoma is commonly light olive gray (5*Y* 6/1) but may be dark greenish gray (5*Y* 4/1) in zones where glauconite is particularly abundant. The abundance of glauconite is a distinguishing feature of the Tuscahoma, the concentration in some zones ranging as high as 50 percent. The glauconite of the lower sand is commonly coarse grained. The sand in the upper silt of the Tuscahoma is fairly well sorted and very fine to fine grained, but contains medium and coarse grains as well as granule gravel. The lower part of the Tuscahoma is poorly sorted and contains fine- to coarse-grained sand and granule to pebble gravel. Much of the quartz in the Tuscahoma is stained green. Pyrite and ferromagnesian minerals are abundant.

The uppermost part of the Tuscahoma locally contains thin beds of fine-grained sandy glauconitic limestone, and the limestone beds possibly should be assigned to the Bashi marl member of the Hatchetigbee formation. The Wilcox is 98 feet thick in Albany well 15, about 3 miles south of the Lee County line. The upper 23 feet of the Wilcox in this well contains abundant Foraminifera, which, according to Herrick (oral communication), are of Bashi age. The Foraminifera occur in a zone comprised of very fine- to fine-grained sand, interbedded with fine-grained sandy glauconitic limestone. The Wilcox is of similar thickness throughout Dougherty and Lee Counties, and the upper beds are, in many areas, lithologically similar to those in Albany well 15. Considerable limestone is present in the upper part of the Tuscahoma in a Bronwood well in Terrell County, 7 miles southwest of Smithville.

In western Sumter County the Tuscahoma crops out at the surface where it consists of glauconitic sandy clay and silt similar to that exposed at MS–5 (measured section no. 5) and described on pages 24 and 25. The geologic sections on plate 2 indicate that the Tuscahoma is overlapped near well 3205–8415–2 in northwestern Sumter County. Actually, the formation probably extends somewhat northeast of well 3205–8415–2, but it is thin, much weathered at outcrops, and difficult to recognize. The samples from which well 3205–8415–2 was logged were taken at intervals of 20 to 30 feet at the depth where the Tuscahoma should have been penetrated, and it is likely that, although the Tuscahoma was penetrated, it was very thin and no samples were collected from it.

The Tuscahoma is definitely overlapped in northeastern Sumter County, where, in numerous outcrops, recognizable beds of the Tallahatta formation directly overlie the Midway group. The overlap in this area is illustrated on plate 2.

The Tuscahoma overlies the Midway group with pronounced unconformity. In outcrops the contact is undulating and the base of the Tuscahoma contains balls and chips of kaolinic and fuller's earth clays derived from the underlying Midway.

Thickness.—The Tuscahoma is about 100 feet thick in the entire area southeast of the structural belt. It does not vary greatly in thickness except northwest of the structural belt where it thins markedly in a short distance and is overlapped by the Tallahatta formation.

CLAIBORNE GROUP

Conrad (1847, p. 280–282) first proposed the name Claiborne for outcrops at Claiborne Bluff and Claiborne Landing on the Alabama River, Monroe County, Ala.

In Alabama the Claiborne group, as now recognized, is divided into the Tallahatta formation, the Lisbon formation, and the Gosport sand, in ascending order. Veatch and Stephenson (1911, p. 235–296) mapped and described the Claiborne group in Georgia, stating that it was inappropriate to use the threefold division recognized in Alabama. They divided the Claiborne into the McBean formation, which contained a Congaree clay member, and the Barnwell sand. The McBean was defined as the equivalent of the Tallahatta and Lisbon formations and the lower part of the Gosport sand. Subsequent work has shown that the Congaree clay, now known as Twiggs clay member of the Barnwell formation, and the Barnwell sand are of Jackson age.

Cooke and Shearer (1918) restricted the McBean formation to deposits of Lisbon age along the Savannah River and tributaries and classified the Claiborne deposits in Georgia west of the Flint River as undifferentiated Claiborne. Cooke (1943, p. 54) classified all the Claiborne deposits of Georgia as McBean formation, but stated that some of the deposits west of the Flint River might be older than the typical McBean. MacNeil (1947) mapped the Claiborne group in Georgia. His map indicates that the McBean formation is present only in easternmost Georgia, and that the Tallahatta and Lisbon formations and the Gosport sand crop out from westernmost Georgia to central Georgia. The formations are not differentiated on the map, all being mapped as Claiborne.

In this report the Claiborne is divided into the Lisbon and Tallahatta formations. It is possible that the upper part of the Lisbon of this report is equivalent to the Gosport.

TALLAHATTA FORMATION

Dall (1898) was the first to use the name Tallahatta in a published report. Tallahatta is the local name of the hills containing the deposits. It is applied to the rough siliceous rocks that had previously been referred to as buhrstone.

The Tallahatta formation overlies the Tuscahoma formation in Lee and Sumter Counties except in northeastern Sumter County where it overlies the Clayton formation. The Tallahatta underlies the Lisbon formation in Lee County and southeastern Sumter County. In most of the remainder of Sumter County it underlies undifferentiated residuum from which it is difficult to distinguish owing to weathering. In parts of Sumter County it may underlie the Ocala limestone.

Lithology.—In southeastern Lee County the Tallahatta formation consists of about 20 feet of siliceous limestone overlain by about 220 feet of sand, marl, and limestone. The siliceous limestone is a dense, heavy rock and is an intricate mixture of limestone, detrital quartz grains, clear secondary silica, dark chert, and glauconite. The rock has been altered by orthogenic processes, and it is difficult to determine its original form. It probably was deposited as a sandy limestone or calcareous sandstone. The color of the siliceous limestone is typically medium light gray (*N*6) to medium gray (*N*5). This unit has not been found north of southern Lee County.

The beds overlying the siliceous limestone in southern Lee County are predominantly sand that is interbedded irregularly with sandy marl. The sand is fine to medium grained, subrounded, moderately to well sorted, and is typically clean and loose; colors are various shades of light gray. A characteristic feature of the sand is that it is closer to being well rounded than the sand of any other formation in the area. Another distinguishing feature is the presence of phosphate and fish teeth, which are more common than in other formations. Glauconite, garnet, and zircon are common accessory minerals. The sand contains abundant shell fragments and grades upward into a sandy coquina limestone near the top of the formation. The coquina zone is about 50 to 70 feet thick and is overlain generally by 20 to 30 feet of calcareous sand.

Cuttings from well 3150–8410–7 at the Dixie Pines Plantation, 2.3 miles south-southeast of Smithville, show 160 feet of Tallahatta. The Tallahatta there is composed mostly of fine- to medium-grained, clean phosphatic sand interbedded with thin layers of marl. Shell fragments are common to abundant near the top of the formation, but there is no coquina zone. A Tallahatta interval of similar thickness and lithology has been identified at well 3200–8400–8, near the center of the eastern boundary of Sumter County and approximately on strike with the Dixie Pines well. Cuttings from shallow wells in southeasternmost Sumter County indicate a coquina bed near the top of the Tallahatta. It is likely that the coquina is a widespread zone underling all of Lee County except for the northwestern corner and extending into southeasternmost Sumter County.

Northwest of the structural belt the Tallahatta contains less marine material and decreases somewhat in thickness. No fossiliferous or calcareous beds of the Tallahatta have been found in western Sumter County, where the formation consists mostly of fine- to coarse-grained, clean phosphatic sand, crossbedded and interlaminated with clay and gravel. Individual crossbedding laminae range in length from a few inches to 20 feet, and inclinations of slope vary from gentle to steep. The Tallahatta is of similar lithology in northeastern Sumter County but is finer grained and contains fossiliferous and calcareous material, at least as far north as Americus.

The log of well 3200–8410–4 (GGS 326), listed below, is of interest for several reasons. The well is near the updip limit of fossiliferous beds of the Claiborne, and, according to S. M. Herrick (oral communication), the microfauna is more indicative of a Tallahatta than of a Lisbon age. The sand overlying the Claiborne is lithologically similar to that occurring at the base of the Ocala and is here interpreted as being Ocala. This is considered to be substantiating evidence that beds of the Claiborne northwest of the structural belt are Tallahatta and not Lisbon.

Log of well 3200-8410-4 (GGS 326), located about 4.35 miles southeast of Americus. Elevation about 400 feet

	Thickness (feet)	Depth (feet)
Undifferentiated residuum:		
Mudstone: light-brown (5*YR* 5/6), moderate-yellowish-brown (10*YR* 5/4), and pale-red (5*R* 6/2), mostly silt and clay; quartz and iron-oxide pebbles common	30	30
Clayey sand and gravel: moderate-brown (5*YR* 4/4), fine-grained sand to pebble gravel, subrounded, poorly sorted, clear and milky quartz; silt and clay abundant; iron-oxide granules and pebbles common	10	40
Total undifferentiated residuum	40	
Upper Eocene series.		
Jackson group.		
Ocala limestone:		
Sand: grayish-orange (10*YR* 6/2), fine- to medium-grained, subrounded, fairly well sorted, clear quartz, clean; garnet and dark minerals rare	20	60
Total Ocala limestone	20	
Middle Eocene series.		
Claiborne group.		
Tallahatta formation:		
Calcareous sand: grayish-orange (10*YR* 7/4) to pale-yellowish-brown (10*YR* 6/2), very fine to fine grained, subrounded, well sorted, clear quartz; marl, glauconite, and limestone oolites abundant; Foraminifera common	20	80
Total Tallahatta formation	20	

Thickness.—The Tallahatta formation is about 240 feet thick in southeasternmost Lee County. It is about 150 feet thick along the southern edge of the structural belt and from 80 to 150 feet thick in the area of the structural belt. In northeasternmost Sumter County the maximum thickness is about 80 feet and in northwesternmost Sumter County it is about 50 feet. It is difficult to identify the top of the Tallahatta formation in northwestern Sumter County because, at weathered outcrops, the Tallahatta closely resembles the overlying undifferentiated residuum. Local thinning of the Tallahatta occurs along some of the stream valleys.

LISBON FORMATION

The Lisbon formation is named from exposures at Lisbon Bluff on the Alabama River, Clark County, Ala. The name Lisbon was first applied by Aldrich in 1886.

The Lisbon formation overlies the Tallahatta formation and underlies the Ocala limestone wherever it occurs in Lee and Sumter Counties. The Lisbon consists mostly of dense earthy limestone and marl. It contains thin beds of sandstone and hard sandy glauconitic limestone. Bryozoa are abundant and are predominant locally in some of the beds. Foraminifera and shell fragments are common throughout the formation. Glauconite is common in the Lisbon, and this, plus textural and color differences, serves to distinguish the Lisbon from the overlying Ocala limestone. The color of the Lisbon is commonly yellowish gray (5Y 8/1) to light olive gray (5Y 6/1).

The Lisbon formation underlies all of Lee County except perhaps the extreme northwestern corner. Only 10 feet of Lisbon was encountered in well 3150–8410–7 (Dixie Pines Plantation), 2 miles south-southeast of Smithville. The Lisbon underlies that part of eastern Sumter County south of the structural belt. It is believed that the Lisbon does not occur in western Sumter County either south or north of the structural belt. The Lisbon is about 40 feet thick at well 3200–8400–8, near the center of the eastern edge of Sumter County, and crops out in bluffs on the Flint River about 1.5 miles northeast of this well, particularly at MS–1—the bluff at Danville Ferry. North of this area the Lisbon appears to thin rapidly and pinch out near the structural belt. Danville Ferry is about 0.8 mile northwest of the Highway 27 crossing of the Flint River at a sharp bend of the river. (See pl. 1.) The following section was measured by the author in 1959.

Measured section (MS–1), Danville Ferry

	Thickness (feet)
Undifferentiated residuum:	
Mudstone: yellowish-gray and reddish-brown, mostly silt and clay, mottled and slightly laminated; thin irregular iron crusts common; fine- to medium-grained quartz sand and chert common; boulders of chert 1 ft in diameter locally common; sand locally more abundant than silt and clay; glauconite and pyrite rare; weathers knobby to smooth; base obscure but may be gradational	6
Total undifferentiated residuum	6
Upper Eocene series.	
Jackson group.	
Ocala limestone:	
Sand: light-brown (5*YR* 6/4), pale-yellowish-orange (10-*YR* 8/1), dark-yellowish-orange (10*YR* 6/6), and various shades of pink and white, fine- to medium-grained, angular	

Upper Eocene series—Continued	
Jackson group—Continued	
Ocala limestone—Continued	*Thickness (feet)*
to subangular, fairly sorted, clear quartz with iron stains, loose and clean; coarse-grained quartz sand common; dark minerals rare to common; massively bedded; forms steep slope where exposed in slides, moderate to steep slope where overgrown with vegetation; weathers smooth; base sharp and flat to slightly undulating	25
Total Ocala limestone	25
Middle Eocene series.	
Claiborne group.	
Lisbon formation:	
Sandy limestone: white (*N*9) to yellowish-gray (5*Y* 8/1). aphanitic; very fine- to medium-grained quartz sand abundant; coarse-grained quartz sand and quartz granules common throughout, abundant near base; glauconite and dark minerals common; garnet rare; bryozoa common; shell fragments rare; weathers smooth; forms almost vertical slope; base sharp and flat	6
Limestone: white (*N*9) to yellowish-gray (5*Y* 8/1) except brownish-gray where weathered, aphanitic, recrystallization common; very fine- to medium-grained quartz sand abundant, coarse-grained quartz sand and quartz granules common; glauconite and dark minerals common; shell fragments rare; weathers knobby; forms vertical cliff; base sharp, flat and overhanging	2.3
Marl: yellowish-gray (5*Y* 8/1) except brownish-gray where weathered; very fine- to coarse-grained quartz sand abundant; quartz granules common; glauconite abundant; dark minerals common; bryozoa and pelecypods abundant, particularly at very top; pelecypods include large *Ostrea sellaeformis;* Foraminifera and ostracods abundant; irregularly calcitized and containing hard calcareous nodules, forms almost vertical slope; weathers smooth to knobby; base obscure, probably flat and gradational	2
Marl: yellowish-gray (5*Y* 8/1) except brownish-gray where weathered; very fine- to coarse-grained quartz sand abundant; quartz granules common; garnet and dark minerals common; Foraminifera abundant; shell fragments and ostracods common; forms steep slope; mostly overgrown with vegetation; base obscure	3.5
Limestone: yellowish-gray (5*Y* 8/1), finely crystalline; very fine- to medium-grained quartz sand rare; other impurities rare or absent; mostly concealed; no topographic expression; base apparently sharp and flat	0.5
Marl: yellowish-gray (5*Y* 8/1); very fine- to medium-grained quartz sand abundant; coarse-grained quartz sand and quartz granules common; dark minerals abundant; shell fragments and ostracods common; Foraminifera abundant; mostly covered; forms moderate to steep slope; base concealed in river	5
Total Lisbon formation	19.3

MacNeil did not extend the residuum to the Flint River in the vicinity of Danville Ferry but it is evidently present in small patches along the tops of the highest bluffs. (See fig. 5.)

The Lisbon attains a maximum thickness of about 100 feet in southeastern Lee County. It thins to the north and west and is only about 10 feet thick in the vicinity of Smithville. It is about 50 feet thick in southeastern Sumter County and about 40 feet thick just south of the structural belt in eastern Sumter County.

JACKSON GROUP

The Jackson group was first named by Conrad (1856, p. 257–258) when he described a group of rocks as older Eocene Jackson. Cooke and Shearer (1918) described the Jackson formation of Mississippi and divided it into the Yazoo clay member above and the Moodys marl member below. The Jackson group is named for deposits at Jackson, Miss., along the Pearl River and Moodys Branch.

In eastern Georgia the Jackson group consists of the Ocala limestone, the Barnwell formation (believed to be a shoreward facies of the Ocala), and the Cooper marl. In western Georgia only the Ocala limestone is present.

OCALA LIMESTONE

Dall and Harris (1892, p. 103, 157, 331) first described the Ocala limestone near Ocala, Fla., and assigned it to the Eocene or Oligocene. Cooke (1915) established the Jackson age of the Ocala limestone and first applied the name in Georgia to rocks exposed near Bainbridge, Decatur County. Veatch and Stephenson (1911, p. 306–324) placed some of these rocks in the Jackson formation and some in the Vicksburg formation with which the Ocala limestone of Florida was then correlated.

The Ocala occurs in Lee and Sumter Counties wherever the Lisbon formation does. It appears to overlap the Lisbon and to occupy a slightly larger area. The Ocala rests on the Tallahatta formation where the Lisbon is overlapped and is overlain by residual clay and sand derived from the solution of limestone. The residuum is partly of Ocala origin but is not discussed here with the Ocala.

Lithology.—The Ocala is divisible into a lower sand and an upper limestone. The lower sand is about 40 feet thick in most areas, is generally fine to medium grained, and contains shell fragments. Locally it grades into calcareous sand, in which limestone oolites are abundant, or into firmly cemented calcareous sandstone. The lower sand is well exposed at Danville Bluff on the Flint River in Sumter County. (See p. 32.) In some areas, particularly in southernmost Lee County, the lower sand is absent, and the entire Ocala interval is limestone.

The limestone of the Ocala varies considerably in texture. Commonly it is composed mostly of shell and bryozoa fragments and has a fragmental texture. Oolitic and aphanitic textures also are common. Calcite rhombs are common to abundant, but saccharoidal textures are not common in Lee and Sumter Counties. The limestone is irregularly interbedded with thin beds of calcareous sand similar to that at the base of the formation. Quartz sand is rare to common in the limestone itself and, with the exception of iron oxide and manganese, other impurities are rare. Dendritic manganese occurs throughout the limestone and was observed in most well cuttings and outcrops. Pellets of iron oxide are common locally, especially near the top of the limestone, but are absent in many localities.

Both the sand and limestone of the Ocala commonly are very pale orange (10*YR*, 8/2). The occurrence of limestone appears to be continuous in Area II (plate 1), but is spotty and discontinuous north of this area, the limestone having weathered to residual clay. In well 3200–8405–6, about 4.8 miles southeast of Americus, 50 feet of limestone and sandstone appears to be Ocala. In well 3200–8410–4, about 4.35 miles southeast of Americus and 1 mile west of the preceding well, 20 feet of sand also appears to be Ocala. These two wells are located within the structural belt, near its northern margin. Sand of the Ocala occurs in well 3200–8400–8 near the center of the eastern boundary of Sumter County and at Danville Bluff on the Flint River about 1.5 miles to the northeast. The Ocala has not been identified north of the structural belt, and it is believed that the northern edge of the structural belt is its extreme updip limit. In western Sumter County the Ocala, like the Lisbon, appears to pinch out south of the structural belt.

Thickness.—The Ocala has an average thickness of 30 to 60 feet along the northern boundary of Area II (pl. 1). The average thickness increases south and east of this line, but the thickness is also dependent upon land-surface elevation. A greater thickness is present in interstream areas than in adjacent stream valleys. The Ocala has a maximum thickness of about 150 feet at higher elevations in southeastern Lee County and is about 100 feet thick at higher elevations in southeasternmost Sumter County.

OLIGOCENE SERIES

The Oligocene series includes all rocks overlying the Upper Eocene series and underlying the Miocene series. As currently recognized by the U.S. Geological Survey the Oligocene series in Georgia includes all rocks younger than the Cooper marl and older than the Tampa limestone.

The Oligocene series is most completely developed in Mississippi where it includes the Vicksburg group. Only two Oligocene formations are known in Georgia, the Flint River formation and the Suwannee limestone. According to Cooke (1943, p. 77) the Suwanee limestone is restricted to a small area along the Withlacoochee River near the Florida State line.

FLINT RIVER FORMATION

The name Flint River formation was proposed by Cooke (1935) for deposits in Georgia and southeastern Alabama that are exposed above the Ocala limestone along the Flint River, between Hales Landing and Red Bluff near Bainbridge. The beds previously had been assigned to the Chattahoochee formation by Veatch and Stephenson (1911). Cooke (1923) correlated these beds with the Glendon limestone of Alabama. Later Cooke (1935) changed his opinion and correlated these beds with the Chickasawhay marl of Mississippi, thereby assigning them an age younger than that of the Glendon limestone.

Cooke (1943) mapped large areas of Lee and Sumter Counties as Flint River formation and discussed the presence of lumps of chert in the Flint River in Sumter County.

Beds of Flint River formation were not found in place by the author. The former presence of what is described as the Flint River formation in Sumter County is attested by scattered masses of chert containing Oligocene fossils. The chert occurs in disarranged masses near the top of the material described in this report as undifferentiated residuum. The exposures of chert are not continuous and appear to be scattered remnants of a once widespread formation. From the disarranged condition of the chert it appears that it has been reworked or that it has collapsed downward into solution cavities in the underlying Ocala limestone.

In Lee and Sumter Counties the chert is of widespread occurrence, but it is most common in Sumter County northwest of the structural belt. There appears to be a particularly heavy concentration of chert along the north edge of the structural belt.

UNDIFFERENTIATED RESIDUUM

MacNeil (1947) mapped large areas of southwestern Georgia, including parts of Lee and Sumter Counties, as residuum. He indicated that the residuum included beds of Eocene, Oligocene, and Miocene ages, and possibly some Pleistocene terrace material. According to MacNeil the various formations have been disarranged and intermixed to such an extent that it is not possible to separate their residues.

The undifferentiated residuum of this report includes all beds overlying the Ocala limestone or, where the Ocala is missing, overlying the Tallahatta formation.

The undifferentiated residuum is not separated into formations. It consists of residual clay of the Ocala limestone and chert of the Flint River formation and possibly includes some Pleistocene terrace material. Northwest of the structural belt chert of the flint River is more abundant than elsewhere, particularly along the northern margin of the structural belt. It is believed that residuum derived from the Ocala is thin or absent northwest of the structural belt.

The undifferentiated residuum is heterogenous in lithology. In most places it consists of reddish, fine- to coarse-grained, poorly sorted, clayey sand or very sandy clay and contains abundant pellets of iron oxide. Locally it contains disarranged masses of chert. The residuum at Danville Ferry (MS–1) is south of the structural belt and probably was derived from the Ocala. (See p. 32.)

The undifferentiated residuum has an average thickness of about 40 feet throughout Lee and Sumter Counties.

STRUCTURE

REGIONAL STRUCTURE

The formations in Lee and Sumter Counties strike slightly east of northeast and dip slightly south of southeast. Tertiary formations strike about N. 46° E. and dip southeast. The Upper Cretaceous rocks strike about N. 48° E. and dip southeast.

The Upper Cretaceous rocks dip about 22 feet per mile. The dip decreases upward in the section. The dip of the Midway group is slightly greater than 20 feet per mile; that of the Tuscahoma formation is slightly less than 20 feet per mile; that of the Tallahatta formation is about 13 feet per mile; and that of the Lisbon formation is about 12.8 feet per mile. The dip of the Ocala limestone is probably somewhat less than that of the Lisbon. It is not possible to determine accurately the dip of the Ocala, however, because the top of the Ocala is very irregular owing to erosion and solution. The general structural features of the various rock units are shown by structural contour maps (pls. 3, 4, 5, and 6).

On plate 3 no contours were plotted on top of the Upper Cretaceous in northwestern Sumter County because of the lack of subsurface data. On plate 4 the contours on top of the Midway group are tentatively alined with the contours on the base of the Andersonville bauxite zone as determined by Zapp (1943). According to Zapp the bauxite zone is about 40 feet thick, and, for this reason, each contour on top of the Midway roughly corresponds with a contour 40 feet lower on Zapp's map. (In this report the top of the bauxite zone is considered to be the top of the Midway.) On plate 6 no contours were plotted on top of the Claiborne group in northwestern Sumter County because, in this area, the top of the Claiborne is difficult to distinguish from the overlying residuum.

STRUCTURAL BELT

The structural belt is a zone in which the regional southeast dip of formations is greater than elsewhere. Its exact nature cannot be fully determined until more geologic data are available, but it may be a monoclinal flexure, a fault, or a series of faults. Its approximate position is shown on plate 1. In the structural belt area the dips of the Upper Cretaceous series, the Midway group, and the Tuscahoma formation are about twice as great as elsewhere. The dip of the Tallahatta formation also appears to be greater than elsewhere. The steep dips in the structural belt are illustrated on the structural contour maps on plates 3, 4, 5, and 6.

The structural belt apparently marks the updip limit of occurrence of the Lisbon formation and the Ocala limestone. The Flint River formation, represented by disarranged masses of chert, appears to overlap the Lisbon formation and the Ocala limestone and to extend north of the structural belt.

ANDERSONVILLE FAULT

The Andersonville fault (pls. 1, 2) is an east-west fault having a maximum displacement of about 100 feet; its upthrown side is on the south. The Andersonville fault was located by Zapp (1943) during an investigation of the Andersonville bauxite district. The fault was found by extensive test drilling and analysis of core samples from the test holes. The existence of the fault has been corroborated by geologic field work during the present investigation. On geologic section *A–A′* (pl. 2), the top of the Midway is about 100 feet higher at the outcrop south of the Andersonville fault than in the Andersonville city well, just north of the fault. The existence of the fault is also strongly suggested by exposures along Flint River east of Andersonville. Limestone and marl of the lower part of the Midway are exposed at Dripping Bluff on the Flint River about 5 miles east of Andersonville and just south of the Andersonville fault (pl. 1). Lignitic and kaolinic clay of the upper part of the Midway are exposed along the river in an unnamed bluff less than a mile north of Dripping Bluff and just north of the Andersonville fault. The lower calcareous beds of the Midway are buried beneath land surface at the unnamed bluff indicating that beds of the Midway at that point have been displaced down in relation to beds of the Midway at Dripping Bluff.

FAULTS IN WESTERN SUMTER COUNTY

Three probable faults in western Sumter County are located on plates 1, 3, 4, 5, and 6. The faults are an interpretation of structure and are located on the basis of altitudes on top of the Midway group and Tuscahoma formation at various points. In contouring the top of the Midway and Tuscahoma in this area from available data, as shown on plates 4 and 5, it is necessary either to make the contours diverge greatly from the general strike and spacing pattern or to assume the presence of faults. Faulting is considered to be the most likely explanation.

The Andersonville fault has been well established by extensive test drilling, and the presence of similar faults in western Sumter County is not unlikely. It is not possible to determine the exact nature and position of the faults without test drilling. It is believed, however, that they are similar in origin and nature to the Andersonville fault and that they are, perhaps, part of an en echelon system of faults parallel to and north of the structural belt. The maximum displacement along the faults appears to be about 100 feet but may be somewhat less. Like the Andersonville, the faults in western Sumter County are upthrown on the south side.

GROUND WATER

Open spaces of various types occur in almost all rocks at the earth's surface and at depths of a few hundred feet in some areas to several thousand feet in others. Only a part of the total rainfall penetrates the earth's surface, but it is sufficient to fill all openings from the lowest depths upward to a surface known as the water table, with water under hydrostatic pressure.

The zone of saturation in Lee and Sumter Counties is several thousand feet thick and the rock units or formations in this zone are chiefly alternating beds of sand, clay, marl, and limestone. Ground water in each formation is to some degree interconnected with that in the overlying and underlying formations, and in this sense the zone of saturation may be thought of as one continuous reservoir of ground water. However, each formation has definite hydrologic properties among which is its ability to yield water to wells. Formations that readily yield usable quantities of water are known as aquifers.

Limestone and sand are the principal aquifers in southwest Georgia because they commonly have a combination of high porosity and high permeability, and therefore yield the largest quantities of water to wells. Porosity is the ratio of open space in a rock to its total volume; it commonly is expressed as a percentage. Permeability. which defines a rock's ability to transmit water, is determined by the size, shape, and the degree of interconnection of the open spaces. Marls and clays are poor aquifers because, although they may be even more porous than limestone or sand, they have low permeability. The amount of water that may be obtained from a formation also depends on its thickness.

Frequent reference is made to Areas I and II (pl. 1) in the discussion of ground water that follows because the two areas differ in ground-water conditions. Area II is downdip from Area I and is characterized by a more complete stratigraphic section and thicker individual units.

ARTESIAN CONDITIONS

Artesian water is ground water that is confined between beds of low permeability and is under sufficient pressure to rise above the level at which it is encountered in a well; it does not necessarily have to flow at the surface. Most ground water in Lee and Sumter Counties is artesian and enters aquifers where they crop out at the surface. The formations dip to the southeast at a rate slightly greater than that of the land surface. Water moves downdip under the force of gravity and eventually becomes confined between beds of low permeability; it is then under hydrostatic pressure. This pressure is caused by the weight of water in updip parts of the aquifer and is also affected by the degree of confinement of the overlying beds. Generally speaking, the hydrostatic pressure in the Lee-Sumter County area increases with the depth of the aquifer because the deeper aquifers and their confining beds crop out farther to the northwest at higher altitudes.

UPPER CRETACEOUS SERIES

Most wells that obtain water from the rocks of the Upper Cretaceous series are located in ground-water Area I (pl. 1), which includes the northwest corner of Lee County and all of Sumter County except the southeast corner. Within Area I the Upper Cretaceous is used as a source of domestic and muncipal supplies of water. South of Area I there are few wells in the Upper Cretaceous because other aquifers are available at shallower depth. Recharge to the Upper Cretaceous rocks occurs northwest of Sumter County where the formations crop out at the surface.

Water-bearing beds.—The principal water-bearing zones in the undifferentiated Upper Cretaceous series are relatively thin beds of sand and gravel which are interbedded with clay, marl, sandstone, and limestone. Possibly the most persistent water-bearing zone is the clean arkosic sand and gravel that occurs at the top of the series directly under the Clayton formation. Another water-bearing zone is the coquina limestone that occurs near the top of the series and underlies an indefinite area in southern Lee County.

The Tuscaloosa formation is an important aquifer in counties to the north but is not used as a source of water in Lee and Sumter Counties because of its depth. On the basis of limited geologic data it consists, in Lee and Sumter Counties, mostly of arkosic sand and gravel and is probably water bearing. However, it is possible that because of its depth and the slow circulation of water, the Tuscaloosa formation in Lee and Sumter Counties may contain saline water which would be unsuitable for most purposes. An oil-test well drilled in Marion County, near the northwest corner of Sumter County, is reported to have struck saline water at an unknown depth. Because no saline water has been reported from the undifferentiated Upper Cretaceous series and the beds underlying the Tuscaloosa are mostly impermeable, it is possible that the saline water was encountered in the Tuscaloosa formation.

Water levels.—Little information is available on water levels in wells which penetrate rocks of the Upper Cretaceous series. In Area I the fact that most such wells are equipped with piston or turbine pumps, prevents measurement, and in Area II few wells tap the Upper Cretaceous. In Area I, however, numerous reported water-level measurements are available from drillers. Most measured wells are relatively deep, commonly ranging from 50 to 150 feet and, in some instances, as deep as 200 feet below land surface.

The deep water levels are attributed mainly to two factors: (a) wells tapping the Upper Cretaceous series in Area I are usually located on the relatively high ground of interstream divides where most of the inhabitants live, and (b) the Upper Cretaceous is deeply buried and does not receive recharge from local rainfall. If recharge were furnished by local rainfall it might be expected that water levels beneath hilltops would be significantly higher.

Flowing wells probably could be constructed in the Upper Cretaceous series in deeper stream valleys throughout Area I. Well 3200–8410–22, in a creek valley in Americus, taps the Upper Cretaceous and is reported to have flowed about 5 gpm (gallons per minute) when drilled in May 1946. The water level is reported to have dropped, however, to 127.5 feet below land surface after the well was pumped at a rate of 800 gpm for about 24 hours. Well 3210–8405–1 in Andersonville had a reported water level of 21 feet below land surface when drilled in 1946. It obtains all its water from the Upper Cretaceous and is located near a creek bottom.

Few water-level data are available from wells in the Upper Cretaceous in Area II. However, because of the relatively lower land surface and smaller relief, water levels in wells constructed in the Upper Cretaceous probably would be much nearer land surface than in Area I and the area of flowing wells would be much more extensive than in Area I. Well 3145–8400–8 at Philema in eastern Lee County had a water level of 13.9 feet above land surface when measured in 1958. This well is reported to be 700 to 800 feet deep and probably obtains most of its water from the Upper Cretaceous. The well, about 0.7 mile west of Flint River, is at an altitude of about 236 feet, about 46 feet above the river, thus the water surface is about 60 feet above that of the river.

Well 3140–8410–5 in southwestern Lee County is reported to have flowed until 15 or 20 years ago. The water level was only 2.8 feet below land surface when measured in June 1958. The depth and construction details of this well are not known, but the water has a sulfur taste indicating that it may be from the Upper Cretaceous series. Most wells in the Lee-Sumter County area that yield sulfurous water tap the Upper Cretaceous. Veatch and Stephenson (1911) reported several flowing wells in this vicinity at the time of their investigation, but no wells in the area were known to flow in 1958. Several flowing wells have been constructed in the Upper Cretaceous series a few miles south of Lee County in Dougherty County. Some of these, however, have ceased flowing owing to heavy pumpage in and near the city of Albany. This pumpage may also be responsible for loss of flow in well 3140–8410–5 in southwestern Lee County.

Seasonal fluctuations of water levels in the rocks of the Upper Cretaceous series are very slight as indicated by measurements in well 3200–8410–21—an observation well constructed in the Upper Cretaceous. From the spring of 1958 to the spring of 1959 the lowest water level was 48.9 feet below land surface on November 21, 1958 and the highest was 35.1 feet below land surface on January 4, 1959. This fluctuation of only 13.8 feet was due mostly to pumpage; the well is within 500 feet of four city wells that tap the Upper Cretaceous and which are pumped heavily and seasonally.

MIDWAY GROUP

Most wells that obtain water from rocks of the Midway group are distributed over the same general area (Area I, pl. 1) as are wells that obtain water from the Upper Cretaceous series. South of Area I there are few wells in the Midway group because of the availability of water from other aquifers at shallower depth. Water from the Midway group is used for domestic, municipal and irrigation purposes.

Recharge to the Midway group occurs in its outcrop belt, a portion of which is in northern Sumter County. It is likely, however, that most recharge occurs north of Sumter County because the occurrence of artesian springs in northern Sumter County indicates that water is being discharged there rather than recharged. Probably considerable recharge to the Midway occurs from the underlying Upper Cretaceous rocks also. The artesian pressure in the sand and gravel at the top of the Upper Cretaceous probably is greater than in the overlying deposits thus enabling water to move upward into the basal limestone of the Midway group.

Water-bearing beds.—The Midway group contains two water-bearing zones—the limestone of the Clayton formation and various sand beds in the undifferentiated Midway deposits overlying the Clayton. The limestone is a relatively thick and continuous aquifer in southern and western Lee County and in southwestern Sumter County but is thin and discontinuous elsewhere. The undifferentiated Midway deposits contain water-bearing sand beds throughout most of the region, but locally, as in northeastern Sumter County, the deposits consist entirely of clay.

Water levels.—Water-level conditions in the rocks of the Midway group are similar to those in the Upper Cretaceous series. Reported water-level measurements in Area I are commonly 50 to 150 feet below land surface in the interstream areas, but the presence of artesian springs indicates that flowing wells probably could be constructed in the deeper stream valleys. The few data available for Area II indicate that water levels are much nearer land surface than in Area I and that the area of potential artesian flow is much greater.

Seasonal water-level fluctuations appear to be very slight in both areas. Well 3155–8415–11 in Area I, 5.8 miles southwest of Americus, taps the Midway group. During the period September 2, 1958 to June 2, 1959, water levels in this well ranged from a low of 80.9 feet below land surface on September 30, 1958 to a high of 72.6 feet below land surface on March 6, 1959—a fluctuation of only 8.4 feet. Well 3140–8410–3, 1.4 miles south of Leesburg in Area II, penetrates rocks of the Midway group and the Upper Cretaceous series, but the electric log of the well indicates that most of the water is produced from the Clayton formation of the Midway group. During the period June 10, 1958 to July 6, 1959, water levels in the well ranged from a high of 5.9 feet below land surface on April 13, 1958 to a low of 12.2 feet below land surface on January 7, 1959—a fluctuation of only 6.2 feet.

TUSCAHOMA FORMATION

The Tuscahoma is not an important aquifer in Lee and Sumter Counties and very few wells obtain water from it. However, some open-hole wells that obtain most of their water from the rocks of the Midway group or the Upper Cretaceous series probably obtain some water from the Tuscahoma where the open-hole interval begins in the Tuscahoma.

Water-bearing beds.—The glauconitic sand which forms the basal 20 to 30 feet of the Tuscahoma over most of the area is probably water bearing but is not known to be used as a source of water except in conjunction with rocks of the Midway or Upper Cretaceous.

Water levels.—There are no data available concerning water levels in the Tuscahoma formation.

TALLAHATTA FORMATION

The Tallahatta formation is one of the most widely used aquifers in Lee and Sumter Counties. It is a principal source of domestic supplies in Area I and a principal source of municipal and irrigation supplies in Area II. Wells may be constructed in the Tallahatta almost anywhere in the region except in the deeper stream valleys of central and northern Sumter County where it has been thinned or removed by erosion. Because of its comparatively gentle dip the Tallahatta may be encountered by drilling at relatively shallow depths throughout the region. Wells obtaining water from the Tallahatta in Area I range in depth from 60 to 120 feet. A depth of only about 200 feet is required for wells constructed in the Tallahatta formation as far south as central Lee County, and a depth of no more than 300 feet is required in extreme southeastern Lee County.

Water-bearing beds.—The principal water-bearing beds in the Tallahatta formation consist of sands which are interbedded with clay and marl. The sands predominate and therefore, the formation as a whole is mainly water bearing. The coquina limestone which occurs at the top of the formation in Lee County and southeastern Sumter County is also a water-bearing zone.

Water levels.—The fact that most wells constructed in the Tallahatta formation are equipped with piston or turbine pumps prevents measurement of water levels in them. However, some wells may be measured and numerous water-level records are available from drillers. Water levels in wells in Area I range from 15 to 90 feet below land surface and average about 50 feet below land surface. Water levels in wells in Area II range from 17 feet above land surface to 50 feet below and average about 25 feet below land surface.

Flowing wells.—Numerous flowing wells have been constructed in the Tallahatta formation in Area II along Lake Blackshear. Most of these are at altitudes below 250 feet and are generally no more than 20 feet above the lake. Water levels in wells 3155–8355–10 and 3200–8355–3 were reported to be 16.5 feet and 7 feet above land surface respectively in May 1952. Well 3155–8355–7 had a measured water level of 12.5 feet above land surface in May 1958. Flowing wells from the Tallahatta formation are not found along the Flint River south of Lake Blackshear, probably because flows can be obtained at shallower depth from the Ocala limestone; however, flows probably could be obtained from the Tallahatta formation at low altitudes along the river from Lake Blackshear south. No flowing wells are known to tap the Tallahatta formation in other parts of Lee and Sumter Counties. However, flows might be obtained at low altitudes along Kinchafoonee and Muckalee Creeks in Area II. It is not likely that flows could be obtained in Area I even at low altitudes because the Tallahatta in that area is much dissected by erosion and the artesian head is dissipated through numerous springs.

The range of seasonal water-level fluctuations in the Tallahatta is not known. Such fluctuations probably are much greater, however, in Area I than in Area II. The relatively shallow depth of the Tallahatta in Area I makes it more subject to rapid recharge from local rainfall, and the numerous springs make possible rapid discharge of excess water.

LISBON FORMATION

The Lisbon formation is not an important aquifer in Lee and Sumter Counties. The earthy limestone and marl of the Lisbon are relatively impermeable and the formation does not yield water readily. The Lisbon probably furnishes some water to wells constructed in the Tallahatta formation in which an open-hole section has been left in the Lisbon interval and to some wells constructed in the Ocala limestone in which an open-hole section extends down into the top of the Lisbon.

OCALA LIMESTONE

The Ocala limestone is the principal source of domestic supplies of water throughout Area II, which includes most of Lee County and part of southeastern Sumter County. Wells constructed in the Ocala are especially suitable for providing domestic supplies because they are of shallow depth, are simple and inexpensive, and have water levels relatively near the surface.

Recharge to the Ocala apparently is mainly from local rainfall because water levels in wells respond quickly to local rainfall or to lack of it. Most recharge is believed to occur in the relatively flat

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interstream areas where surface drainage is poor and sinks and areas of interior drainage are most common. Figure 6 illustrates the similarity of water-level trends in a dug and a drilled well about 60 feet apart in an interstream area of southeastern Sumter County. Well 3155–8400–10 is a dug well that taps residuum, and well 3155–8400–9 is a drilled well that taps the Ocala limestone. Continuous records from the dug well show an almost immediate response to local rainfall. The hydrograph of the drilled well, prepared from weekly and monthly measurements, shows a close similarity to that of the dug well.

Water-bearing beds.—Both the limestone and the basal sand of the Ocala are water bearing; however, data are not available as to whether certain zones in the Ocala yield more water than others.

Water levels.—Water levels were measured in 117 wells penetrating the Ocala limestone during May and June of 1958. The measurements ranged from 53.3 feet below land surface to 13.9 feet above land surface and averaged about 18 feet below land surface. The measurements were made during a period of above average rainfall when water levels were relatively high and stable.

Ground water flows down the hydraulic gradient from areas of high artesian pressure to areas of low artesian pressure at right angles to the lines of equal pressure. A general pattern of pressure decrease

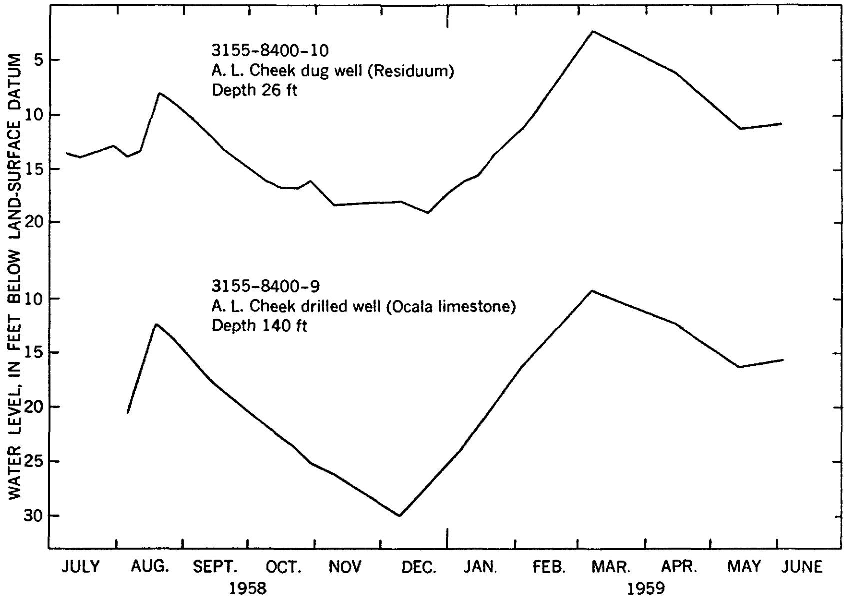

FIGURE 6.—Hydrographs showing water-level fluctuations in dug and drilled wells in Sumter County, Ga.

to the southeast indicates a gross movement of water in that direction. This general pattern is modified, however, and there is a direct correlation between the piezometric surface and the topography of the region.

The cause of relatively high artesian pressure in interstream areas and relatively low artesian pressure in stream valleys is not fully understood. However, local recharge probably occurs mainly in the interstream areas causing mounding of water in these areas and drainage to the nearby streams. Solution channels may be much more numerous in the subsurface beneath stream valleys than beneath interstream areas. Most springs in the region are in the valleys of streams that have cut down into the Ocala limestone, as along Flint River and the lower courses of Kinchafoonee and Muckalee Creeks.

The area of artesian flow from the Ocala limestone appears to be limited to a strip along Flint River from a point slightly north of the Lee-Sumter County line south to a point near the Dougherty County line. It is possible to construct flowing wells in the Ocala at least locally along this strip, sometimes at considerable elevations above the river. Well 3145–8400–7 at Philema, for example, had a water level of 10.3 feet above land surface when measured in May 1958. This well is about 0.7 mile west of the river at an altitude of 238 feet, about 40 feet above the river.

Few wells in the valleys of Muckalee and Kinchafoonee Creeks flow constantly from the Ocala though it is possible that such wells could be constructed at some places near the creeks. Several wells in Dougherty County, within a mile of Lee County, obtain flows from the Ocala. They are on the Muckalee Creek arm of Lake Worth, which is formed by an impoundment of Flint River and Kinchafoonee and Muckalee Creeks. Land-surface elevations at the wells are less than 10 feet above the mean level of Lake Worth. Well 3135–8405–1, in Lee County at the edge of Lake Worth, is about 0.5 mile north of the nearest flowing well in Dougherty County. The water level in this well in June 1958 was even with the top of the casing, which was 0.6 foot above land surface. The altitude of the well is 188 feet, 6 feet above the level of Lake Worth. Well 3145–8410–6 is 7 miles north of Leesburg within the V formed by the confluence of Muckalee and Muckaloochee Creeks and is believed to tap the Ocala, although details of construction are not known. The water level in this well was only 0.2 foot below land surface in May 1958, and the well is reported to have flowed briefly earlier in the spring of that year.

Artesian pressure in the Ocala limestone varies yearly and seasonally within each year, the variations being closely related to rainfall. Annual water-level fluctuations of 35 or 40 feet have been reported in a few wells at higher altitudes, but such fluctuations probably are much above average. During the period May 1958 to May 1959 the water level in well 3155–8400–9 fluctuated from a low of 29.4 feet below land surface on December 8, 1958 to a high of 9.2 feet below land surface on March 6, 1959 (fig. 6). This well is on a relatively high interstream area at an altitude of 350 feet, and the water level probably is subject to greater than average fluctuations. During the period from June 1958 to June 1959 the water level in well 3140–8410–2 fluctuated from a high of 4.6 feet below land surface on July 17, 1958 to a low of 12.0 feet below land surface on December 30, 1958 (fig. 7). This shallow well is in a relatively low area near Kinchafoonee Creek at an altitude of 232 feet, and the water level probably is subject to less than average fluctuation. A comparison of water-level trends with those in a deep well 3 feet away is shown in figure 7. During the period August 1958 to August 1959 the water level in well 3140–8410–9 (fig. 8) fluctuated from a low of 31.3 feet below land surface on December 30, 1958 to a high of 19.9 feet below land surface on July 23, 1959, a total fluctuation of 11.4 feet (fig. 8).

WATER-TABLE CONDITIONS

Ground water is said to occur under water-table conditions when it is unconfined and is in hydraulic connection with the atmosphere through the soil zone. The water table is the top of the zone of satura-

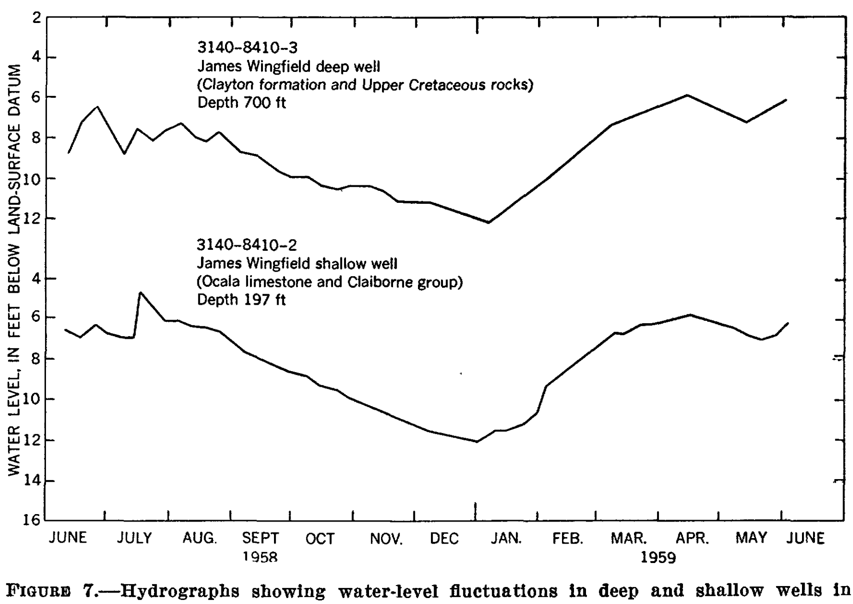

FIGURE 7.—Hydrographs showing water-level fluctuations in deep and shallow wells in southern Lee County, Ga.

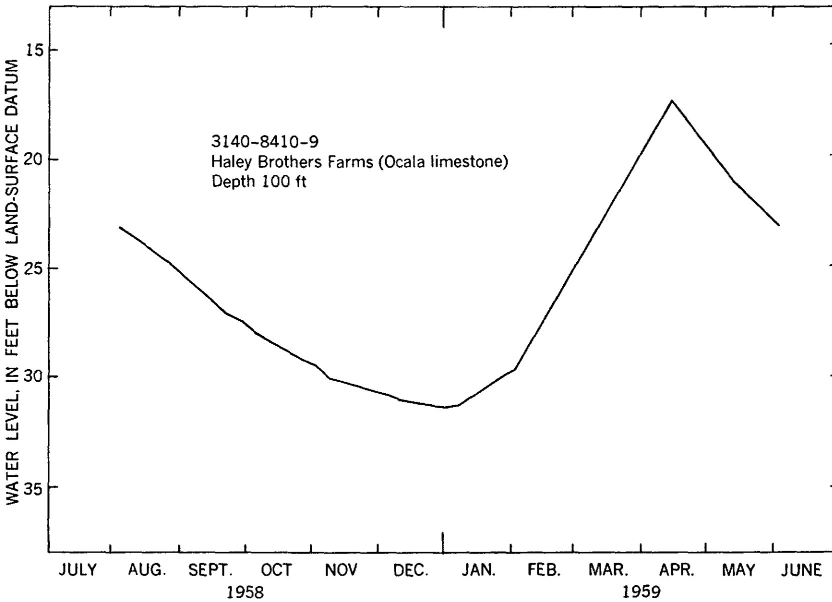

FIGURE 8.—Hydrograph of well in Ocala limestone in southern Lee County, Ga.

tion. It tends to conform with the topography of the land but has less relief; generally it is deepest under hills and ridges and closest to the land surface in valleys. Under water-table conditions, in humid areas, nearly all recharge is the result of local rainfall which penetrates down to the water table; discharge is by numerous springs and seeps, by vegetative use in low areas, or by artificial withdrawal by wells. In humid climates fluctuations of the water table generally show a close correlation with local rainfall. The fact that the water table is near the surface makes the water subject to rapid replacement by rainfall and rapid withdrawal by natural causes. Ground-water levels under water-table conditions are usually subject to more rapid fluctuations than under artesian conditions except where fluctuations are artificially induced by heavy pumpage.

UNDIFFERENTIATED RESIDUUM

Ground water in the residuum occurs under water-table conditions. The water is in contact with the atmosphere and receives recharge from local rainfall. The residuum serves, at least in certain localities and at certain seasons, as a confining bed for the artesian water in the Ocala limestone. A demonstration of this has been observed at well 3155–8405–2, which was constructed in the residuum in 1858 and is still in use. The well was dug to the top of the Ocala limestone and has been bailed and cleaned several times. When the well is bailed water reportedly spouts up in fountains from the underlying Ocala.

Water-bearing beds.—The residuum is relatively impermeable and contains no known productive water-bearing beds. It yields small quantities of water very slowly to wells and is used as an aquifer only because of its shallow depth.

Water levels.—Water levels in wells constructed in residuum average about 10 to 15 feet below land surface. Large annual water-level fluctuations are reported from most wells with levels in individual wells generally ranging from 1 to 20 feet below land surface. Many of the wells go completely dry during the summer and fall. A hydrograph of well 3155–8400–10, a dug well constructed in the residuum, is shown in figure 6. From June 1958 to June 1959 the water level in this well ranged from a low of 19.1 feet below land surface on December 25, 1958 to a high of 2.5 feet below land surface on March 6, 1959, a total fluctuation of 16.6 feet.

WELLS

Almost all the water used for domestic, municipal, industrial, and agricultural purposes in Lee and Sumter Counties is obtained from wells. Wells are the logical source of water supplies in this area because of the widespread occurrence of ground water and the special advantage of using ground water. Wells may be constructed at any given locality and thus may be located conveniently at owners' homes, city waterworks plants, factories, or irrigated fields. Moreover, well water generally is bacteriologically pure, fairly uniform in temperature, and suitable for most purposes without expensive treatment.

The early settlers in the region constructed dug wells with hand tools. These were commonly 3 to 4 feet in diameter and 20 to 30 feet deep. Dug wells are easily constructed and usually furnish sufficient water for domestic use. However, they are subject to pollution and sometimes go dry. Many are still in use but they are rapidly being replaced by deeper drilled wells. Most wells today are drilled by gasoline-powered machinery. The two most common methods of drilling wells are the cable-tool method and the hydraulic-rotary method. In the cable-tool method, drilling is accomplished by raising and dropping a heavy bit, suspended from a steel cable, into the hole and removing the crushed and broken material by means of a bailer or sand pump. In the hydraulic-rotary method, drilling is accomplished by a rotating bit, and the abraided rock material is removed continuously by circulating mud. The mud is pumped down through the drill stem, and broken rock fragments are brought up to the surface in the hole outside the drill stem.

DOMESTIC SUPPLIES

Domestic supplies of water in Lee and Sumter Counties are obtained almost entirely from drilled wells, although a relatively small number of dug wells are still in use. Domestic wells are constructed to furnish 10 to 25 gpm, are generally 2 to 4 inches in diameter, 60 to 400 feet deep, and are equipped with small ¼- to ½-hp (horsepower) jet or piston pumps.

Domestic wells are of two general types—open hole and screened. Wells which obtain water from limestone aquifers are almost always of the open-hole type. When a well is drilled in limestone, casing is driven or cemented into the top of the limestone and the lower portion of the hole is left open. An example of this is well 3195–8405–11 (table 3). Open-hole wells also are constructed in sand if the sand is overlain by a firm caprock such as limestone, clay, or marl. In such a well the casing is driven or cemented into the caprock and a cavity is created by pumping sand out from beneath the caprock. Water may then be pumped from the cavity without bringing up sand. Well 3155–8405–7 (table 4) is an example of this type.

Under certain conditions an open-hole well may be constructed in sand without the necessity of pumping out a cavity. Such a well generally is cased all the way to the bottom, which is left open and through which water enters the well. If the artesian pressure is great enough to provide a continuously high water level there is no need for a screen. The intake pipes on the pump may be set high enough above the bottom of the well so as not to cause enough agitation at the bottom to bring up sand. Wells which are constructed in sand that is not overlain by a firm caprock or in which the artesian pressure is not high generally must have screens. The screen allows water to enter the well and at the same time keeps out sand.

Area I.—Throughout Area I domestic supplies of water are obtained from screened wells that tap the Tallahatta formation or from open-hole wells tapping the Midway group and Upper Cretaceous series. Screened wells constructed in the Tallahatta formation are generally 50 to 120 feet deep and have a 5- or 10-foot screen at the bottom with casing extending upward from the screen to land surface. Open-hole wells constructed in the Midway group and Upper Cretaceous series are usually 200 to 400 feet deep and vary considerably in construction details. They obtain water from the portion of the hole below the casing. Casing may extend all the way down to the Upper Cretaceous, or to various depths in the Midway, or only to the top of the Tuscahoma. Some of the wells penetrate limestone of the Clayton formation and for this reason are of the open-hole type. Open-hole wells that obtain water from sand reportedly may be con-

TABLE 3.—*Records of selected wells, Lee County, Ga.*

Well	Owner	Date drilled	Location	Date tested	Aquifer	Rock type	Depth of well (ft)	Well construction: Casing size (in.)	Casing from (ft)	Casing to (ft)	Screens size (in.)	Screens from (ft)	Screens to (ft)	Open hole size (in.)	Open hole from (ft)	Open hole to (ft)	Reported yield (gpm)	Static water level (ft below land surface)	Drawdown (ft)
3140-8400-3	Marietta Hubbard.	1954	7.5 miles east of Leesburg.		Ocala limestone.	Limestone and sand.	160	4	0	63				4	63	160		26	18
3195-8405-11	J. M. Roach, Jr.	1950	4 miles northeast of Leesburg.		do	Limestone	98	3	0	45				3	45	98		5	
3145-8405-15	Max B. Hardy	April 1954	4.5 miles northeast of Leesburg.	April 1954	do	do	105	8	0	79				8	79	105	214		18
3150-8405-9	Robert Snead	1952	7.7 miles east of Smithville.		do	Limestone and sand.	139	3	0	80				3	80	139		25	
3145-8400-7	Mac Eubanks		At Philema		do	do	135	3	0	42				3	42	135		+9.8	
3140-8410-2	James Wingfield	1952	1.5 miles south of Leesburg.	1952	Ocala limestone and Claiborne.	do	197	6	0	60				6	60	197	167	7	
3140-8410-3	do	1952	do	1952	Clayton formation and Upper Cretaceous series.	do	700	8	0	555				8	555	700	200	7	
3140-8410-11	City of Leesburg.	May 1938	Leesburg		Tallahatta formation.	Sand	320	8	0	320							180	28	
3145-8410-9	J. S. Dobson	January 1955.	2 miles north of Leesburg.	January 1955.	Ocala limestone and Tallahatta formation.	Limestone and sand.	212	10	0	32				10	32	212	2200		
3140-8415-4	W. H. Fryer	1957	8.5 miles southwest of Leesburg.	1957	Tallahatta formation.	Sand	213	10	0	143				10	143	213	850		
3150-8415-4	City of Smithville.	December 1950.	Smithville	December 1950.	do	do	180	8 4	0 140	105 170	8 4	105 170	140 180				187	33	15
3150-8410-7	Dixie Pines Plantation.	March 1955.	2.3 miles SE of Smithville.	March 1955.	Midway group	Limestone	400±	8									300		
3150-8415-1	R. C. McCree	1957	1.5 miles southwest of Smithville.	1957	Midway group and Upper Cretaceous series.	Limestone and sand.	400	6	0	250				6	250	400	200		

structed by pumping out cavities beneath beds of limestone, clay, and marl.

Area II.—Almost all domestic wells in Area II are of the open-hole type and most of them obtain water from the Ocala limestone. Wells constructed in the Ocala limestone are commonly 75 to 150 feet deep, 3 to 4 inches in diameter, and have about 40 feet of casing which is driven or cemented into the top of the limestone. In Area II–A the Ocala limestone has been thinned by erosion and solution and most domestic wells tap sand of the Tallahatta formation. Open-hole construction is possible because, in this area, the Lisbon formation forms a firm caprock above the Tallahatta and because artesian pressure is great enough to keep water levels continuously high. Many of the wells which obtain water from the Tallahatta formation are at low elevations near Lake Blackshear and flow throughout the year.

LARGE-YIELD WELLS

Large supplies of water are often needed to meet the requirements of municipalities, industries, and irrigation projects and almost all such supplies in Lee and Sumter Counties are obtained from drilled wells. Wells yielding 100 gpm and more are commonly 6 to 10 inches in diameter and are equipped with turbine pumps of from 10 to 100 hp. Such wells vary considerably in depth but are generally deeper than domestic wells and may be as much as 1,000 feet deep. In order to obtain large yields in some areas it is necessary for wells to have many screens so that water may be gotten from several water-bearing zones.

Area I.—The largest supplies of water in Area I are obtained from rocks of the Upper Cretaceous series. The city of Americus is by far the largest user of water in the area and obtains most of its water from seven drilled wells in the Upper Cretaceous, which range in depth from 300 to 900 feet. The wells furnish as much as 2,750,000 gpd (gallons per day) during periods of maximum water consumption, and each of the four newest wells has a reported yield ranging from 800 to 1,000 gpm. Three of these wells are included in table 4 (nos. 3200–8410–22, 3200–8410–23, and 3200–8410–25).

Because most of the water from the Americus wells is produced from thin sand beds, the placement of many screens is required in each well. The general steps in construction are as follows: (a) a 20-inch hole is drilled down to limestone or marl of the Clayton formation or the Upper Cretaceous series; (b) casing is seated in the limestone or marl; (c) a smaller test hole is drilled below the 20-inch cased hole into the Upper Cretaceous and samples are collected; (d) an electric log is run to determine the best water-bearing zones; (e)

TABLE 4.—*Records of selected wells, Sumter County, Ga.*

Well	Owner	Date drilled	Location	Date tested	Aquifer	Rock type	Depth of well (ft)	Well construction: Casing size (in.)	Casing from (ft)	Casing to (ft)	Screens size (in.)	Screens from (ft)	Screens to (ft)	Open hole size (in.)	Open hole from (ft)	Open hole to (ft)	Reported yield (gpm)	Static water level (ft. below land surface)	Drawdown (ft)
3155-8400-14	Deseret Farms Inc.	7-7-58	4.7 miles southeast of Leslie.	7-7-58	Tallahatta formation.	Sand, sandstone, limestone shell.	175	12 8	0 0	34 120	---	------	------	8	120	175	638	43	54
3155-8400-15	....do....	7-7-58	....do....	7-7-58	....do....	....do....	179	12 8 8	0 0 0	30 122 313	---	------	------	---	------	---	350	------	---
3205-8410-11	Dayton Veneer & Lumber Co.	1-22-48	At Arles 4 miles northeast of Americus.	2-5-52	Upper Cretaceous rocks.	Sand and gravel.	386				8	313	333	8	333	386	254	------	---
3200-8410-22	City of Americus	5-6-46	Americus	5-17-46	....do....	....do....	693	20 10	0 0	160 693	10	180 200 330 345 450 460 565 617 650 688	185 210 335 350 455 465 575 622 655 693	---	------	---	800	12	139
3200-8410-23	....do....	7-3-47	....do....	8-6-47	Clayton formation, Upper Cretaceous rocks.	Sand gravel; some limestone at top.	590	20 10	0 200	190 590	10	260 475 495 570	290 485 515 590	?	190	200	800	74	191
3200-8410-25	....do....	9-57	....do....	9-57	....do....	....do....	890	20 10	0 190	190 900	10	210 255 275 310 370 385 428 455 520 630 668 740 775 807 885	220 260 280 315 375 390 433 460 525 635 673 745 780 812 890	---	------	---	935	60	106

3200-8420-3	City of Plains	6-10-52	Plains	6-10-52	Clayton formation Upper Cretaceous rocks.	Sand, gravel, limestone.	514	18 8	0 65	86 247	8	170 197	180 202	8	202	514	125	143	37
3200-8420-5	do	About 1954	do		Tallahatta formation.	Sand	100+	8	0	90 appr	8	90 appr	100 appr				100		
3200-8420-7	Thad Jones	1958	do	1958	do	do	78	6	0	68	6	68	78				135		
3200-8420-2	Southwest Ga. Experiment Sta.	9-58	1.3 miles east of Plains.	5-58	do	do	88	4	0	68	4	68	88				95	50	
3155-8405-12	Howell Harris	4-15-57	1 mile northwest of Leslie.		Ocala limestone	Limestone	90	3	0	60				3	60	90		6.99	
3155-8405-7	V. C. Cummings	1939	3.7 miles southwest of Leslie.		Tallahatta formation.	Sand	168	3	0	160+				3	160+	168		18.44	
3155-8415-11	Roy Cartledge	6-52	6.7 miles southwest of Americus.		Clayton formation, Upper Cretaceous rocks.	Limestone, sand.	250	3	0	121				3	121	250		81.1	

the test hole is reamed to the desired diameter in the Upper Cretaceous; (f) an inner casing consisting of well screens separated by blank casing is inserted; (g) gravel packing is placed around the inner casing throughout the reamed portion of the hole. Well 3205–8410–11 (table 4), which is about 4 miles northeast of Americus, was constructed this way and is reported to yield 254 gpm. All of the water from this well is produced through a single screen from the uppermost sand and gravel bed of the Upper Cretaceous.

Wells that obtain large yields from the Clayton formation in Area I are restricted mostly to the southwestern part of the area. Most are open-hole wells constructed in limestone and range in depth from about 300 to 450 feet. Well 3150–8410–7 (table 3), 2.3 miles southeast of Smithville, is reported to yield 300 gpm from the Clayton formation. Well 3150–8415–1 (table 3), 1.5 miles southwest of Smithville, which also taps the Clayton, reportedly yields 200 gpm. No wells of large yield in Sumter County obtain water exclusively from the Clayton formation, but yields of 100 to 200 gpm probably could be obtained from the Clayton in parts of southwestern Sumter County where the formation is composed mostly of limestone.

Several wells in Area I obtain moderately large quantities of water from the Tallahatta formation. Three such wells in and near Plains, in western Sumter County (table 4, nos. 3200–8420–5, 3200–8420–7, and 3200–8420–2), have reported yields ranging from 95 to 135 gpm. Well 3150–8415–4 (table 3) in Smithville is reported to yield 187 gpm from the Tallahatta formation. Almost all wells that obtain water from the Tallahatta formation in Area I have a single screen and range in depth from 80 to 180 feet.

Area II.—The largest supplies of water in Area II are obtained from wells that tap the Tallahatta formation. Most existing wells that obtain large yields from the Tallahatta are 6 to 8 inches in diameter, 175 to 320 feet in depth, and may or may not have screens.

Wells 3155–8400–14 and 3155–8400–15 (table 4) in southeastern Sumter County have reported yields of 638 and 350 gpm from the Tallahatta formation. When originally drilled these wells were of open-hole construction, but under heavy pumping sand was produced and screens and gravel packing were installed to eliminate the sand. Well 3145–8410–9 (table 3), an open-hole well in central Lee County, has a reported yield of 2,200 gpm. Most of the water is obtained from the Tallahatta formation though some is obtained from the Ocala limestone. Well 3140–8415–4 (table 3), another open-hole well in southwestern Lee County, has a reported yield of 850 gpm, all of which is from the Tallahatta formation. The Tallahatta formation is an important aquifer in the city of Albany, about 3 miles south of

Lee County. The water supply for Albany is obtained from several wells about 1,000 feet deep. Several aquifers are tapped but the principal water-bearing zones are in the Tallahatta formation, which yields up to 1,200 gpm.

Comparatively few wells of large yield obtain all their water from the Ocala limestone. Well 3145–8405–15 (table 3), in central Lee County, has a reported yield of 214 gpm, all of which is from the Ocala. A well 2 miles north of Philema, in eastern Lee County, which obtains all of its water from the Ocala, reportedly flows at a rate of 220 gpm. Well 3140–8410–2 (table 3), in southern Lee County, has a reported yield of 167 gpm, most of which is from the Ocala. Several wells a few miles south of Lee County in Dougherty County yield about 500 gpm from the Ocala; possibly wells of comparable yield could be constructed in parts of southeastern Lee County.

Very few wells of large yield tap the Midway group or Upper Cretaceous series in Area II because of the availability of other aquifers at shallower depth. Well 3140–8410–3 (table 3), in southern Lee County, reportedly yields 200 gpm. This well has casing extending down into the top of the Clayton formation and an open-hole interval extending down into the top of the Upper Cretaceous. Electric log data suggests that the Clayton may be more permeable than the Upper Cretaceous, and it is reasonable to assume that most of the water is produced from the Clayton. Yields of 200 to 300 gpm probably could be obtained from properly constructed wells in the Clayton formation throughout the western half of Area II. The productivity of rocks of the Upper Cretaceous series in Area II is not known.

SPRINGS

Area I.—Small springs are numerous in Area I, particularly in the hilly northern section, and most have their source in either the Tallahatta formation or the Midway group. Springs issuing from the Tallahatta formation are of the contact gravity type and commonly occur near the contact of the Tallahatta and the underlying Tuscahoma formation. Some springs occur near the contact of the Tallahatta and the upper clays of the Midway in areas where the Tuscahoma is overlapped. When water seeping downward through the permeable sands of the Tallahatta reaches the impermeable beds at the top of the Tuscahoma or Midway, its direction of movement changes to almost horizontal. Springs occur in many places where the contact is exposed or is near land surface. A well-known example of this type is Providence Spring, which is half a mile east of Andersonville and within Andersonville National Cemetery, site of the Civil War Andersonville Military Prison. The spring, which flows from the Tallahatta formation, is located on the lower slopes of a hill that borders a small creek. The Tallahatta underlies the hill and the creek valley, but, owing to erosion, it is thin along the valley and lower hillslopes where clays of the Midway are only a few feet below land surface and conditions are favorable for the development of springs. However, the hill is covered with thin surficial clay that has not been dissected by erosion, and water tends to seep out along the base of the hill instead of emerging in distinct springs.

During part of the time Union soldiers were imprisoned at Andersonville only diffuse seeps were present, and they used water from the creek. One day during a rainstorm, a gully was eroded on the hill slope and Providence Spring formed. The formation of the spring probably was due to downcutting of the gully that removed the surficial clay, exposed sand of the Tallahatta formation, and allowed water to come to the surface in a distinct spring. The prisoners regarded the formation of the spring as providential and thus the name.

The city of Americus formerly obtained part of its water from a group of springs of the contact gravity type known as One-hundred springs, which issue from near the base of the Tallahatta formation. In October 1950 the measured flow of the springs was 125 gpm; however, they are no longer utilized for municipal supply.

Most of the springs issuing from the Midway group are artesian. Myrtle Springs, about 5 miles northwest of Americus, is an example of this type. Water boils to the surface through sands in the upper part of the Midway at a point where the overlying Tuscahoma formation has been removed by erosion. The measured flow of Myrtle Springs was 29.6 gpm in October 1950.

Area II.—All the important springs in Area II are artesian and have their source in the Ocala limestone. They occur in low areas adjacent to streams, most commonly where the streams are downcutting and have removed most or all of the overlying residual material. Most of the springs occur along Flint River and its tributaries from the northern limit of the Ocala limestone south and along Kinchafoonee and Muckalee Creeks and their tributaries from a point about 2 miles north of Leesburg south.

Graves Springs, near Muckalee Creek, had a measured flow of 222 gpm in November 1950. Palmyra Springs, near Kinchafoonee Creek, had a measured flow of 716 gpm in November 1950. Several large springs at Mossy Dell, 2 miles northeast of Leesburg, probably have a combined yield of more than 1,000 gpm.

QUALITY OF WATER

Chemical quality is one of the most important factors that determine the suitability of water for various uses. General limits are recognized for dissolved constituents in drinking water (Welsh and Thomas, 1960) and in industrial and agricultural supplies (California Water Pollution Control Board, 1952). Water may be rendered unsuitable for a particular use if any one of these limits is exceeded. Fortunately, various modern methods of water treatment can be used to remove the undesirable constituents from water and to make the chemical quality acceptable.

Table 5 lists data obtained from the chemical analysis of 14 water samples from various aquifers in Lee and Sumter Counties. Five samples were collected from wells that yield water from the Clayton formation and rocks of the Upper Cretaceous series, but most of the water is believed to come from the Upper Cretaceous. These five water samples had an average hardness of 86 ppm (parts per million) and an average dissolved solids content of 154 ppm. Three samples are primarily from the Clayton formation; their average hardness is 127 ppm and their average dissolved solids content is 175 ppm. Two samples are from the Tallahatta formation in Area II; their average hardness is 116 ppm and their average dissolved solids content is 140 ppm. Two water samples were collected from wells in the Tallahatta formation in Area I; the average hardness is 24 ppm and the average dissolved solids content is 56 ppm. Two samples were collected from wells in the Ocala limestone; the average hardness is 92 ppm and the average dissolved solids content is 120 ppm. Three of the samples that were primarily from the Upper Cretaceous series had an iron content of greater than 0.3 ppm. This is objectionable in some cases because water containing more than 0.3 ppm iron will stain laundry, plumbing fixtures, and containers. Water from the rocks of Upper Cretaceous series typically contains more than 0.3 ppm iron in southwest Georgia.

In Area II, the occurrence of iron in water from the Tallahatta formation does not appear to be a problem. However, it is a problem locally in Area I. Water samples from the Tallahatta in Area I normally have low iron content immediately and for awhile after a well is drilled, but after 2 or 3 years the iron content increases. This may occur when recharge to the formation is relatively rapid and much dissolved organic material, oxygen, and carbon dioxide move into the formation with downward percolating rainwater. Conditions may be favorable for iron-producing bacteria, or carbon dioxide may increase to form carbonic acid (H_2CO_3), which corrodes well casing and forms a brown ferruginous coating on sand grains.

Some of the chemical constituents from each of the water samples shown in table 5 are plotted graphically in figure 9 and expressed in

TABLE 5.—*Chemical analyses, in parts per million, of ground water, Lee and Sumter Counties, Ga.*

[All analyses by U.S. Geological Survey]

Well	Owner	Location	Year drilled	Date sampled	Temperature (°F)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids Residue at 180°C	Hardness as ($CaCO_3$) (Calcium, Magnesium)	pH
Water from Clayton formation and Upper Cretaceous rocks																				
3200-8410-19	City of Americus [1]	Americus	1928	4- 1-58	69	25	0.37	42	3.2	2.7	2.6	133	0.0	17	2.2	0.2	0.0	175	118	7.4
3200-8410-18	do	do	1914	1-21-38	----	50	.36	30	3.1	3.3	3.0	96	.0	14	2.0	.0	.1	155	88	------
3200-8410-23	do	do	1947	12- 1-51	72	62	.38	27	3.0	2.0	2.0	85	.0	9.2	3.2	.1	.1	154	80	7.7
3200-8410-25	do	do	1957	1- 9-59	73	58	.05	28	1.2	2.5	2.8	91	.0	11	1.0	.1	.1	157	75	7.3
3200-8420-3	City of Plains [2]	Plains	1952	4- 1-58	68	49	.11	22	3.6	2.4	3.1	76	.0	12	2.2	.1	.5	131	70	7.3
Water chiefly from Clayton formation																				
3140-8410-3	James Wingfield	1.5 miles south of Leesburg.	1952	1- 9-59	66	34	0.16	52	1.6	2.6	0.8	164	0.0	0.4	1.5	0.0	0.1	184	136	7.5
3200-8415-3	Mr. Bowen	5.2 miles southwest of Americus.	1957	1- 9-59	68	33	.69	48	3.6	3.5	1.5	149	.0	18	1.0	.1	.1	194	135	7.3
3205-8420-7	Howard Dupree	9.2 miles northwest of Americus.	1958	1- 9-59	66	26	.09	40	2.2	1.3	2.2	125	.0	10	1.0	.2	.1	147	109	7.6
Water from Tallahatta formation in Area II																				
3140-8410-11	City of Leesburg	Leesburg	1938	4- 1-58	----	15	0.01	44	2.2	2.6	0.4	144	0.0	1.5	3.0	0.2	2.1	144	119	7.5
3155-8405-20	City of Leslie	Leslie	1927	4- 1-58	68	21	.06	43	1.6	1.0	.2	134	.0	3.2	2.0	.2	.1	137	114	7.6

Water from Tallahatta formation in Area I																		
3150-8415-4	City of Smithville	Smithville	1950	4- 1-58	68.5	15	0.02	16	0.5	5.7	0.4	48	0.0	0.0	8.2	0.0	5.3	81	42	6.6
3200-8420-2	Ga. Experiment Station.	1.3 miles east of Plains	1958	1- 9-59	69	7.8	.11	2.0	.5	2.5	.8	2	.0	.4	4.2	.0	7.2	31	7	5.1
Water from Ocala limestone																		
3145-8405-15	Max Hardy	4.5 miles northeast of Leesburg.	1954	1- 9-59	----	12	0.00	38	0.2	1.2	0.3	114	0.0	0.4	2.0	0.0	2.5	122	96	7.6
3155-8410-3	A. A. Ellis	5.2 miles northwest of Smithville	1952	1- 9-59	66	12	.00	34	.7	2.2	.3	99	.0	.4	4.0	.1	6.7	117	88	7.5

[1] Sample obtained after chlorination.
[2] Caustic soda added.

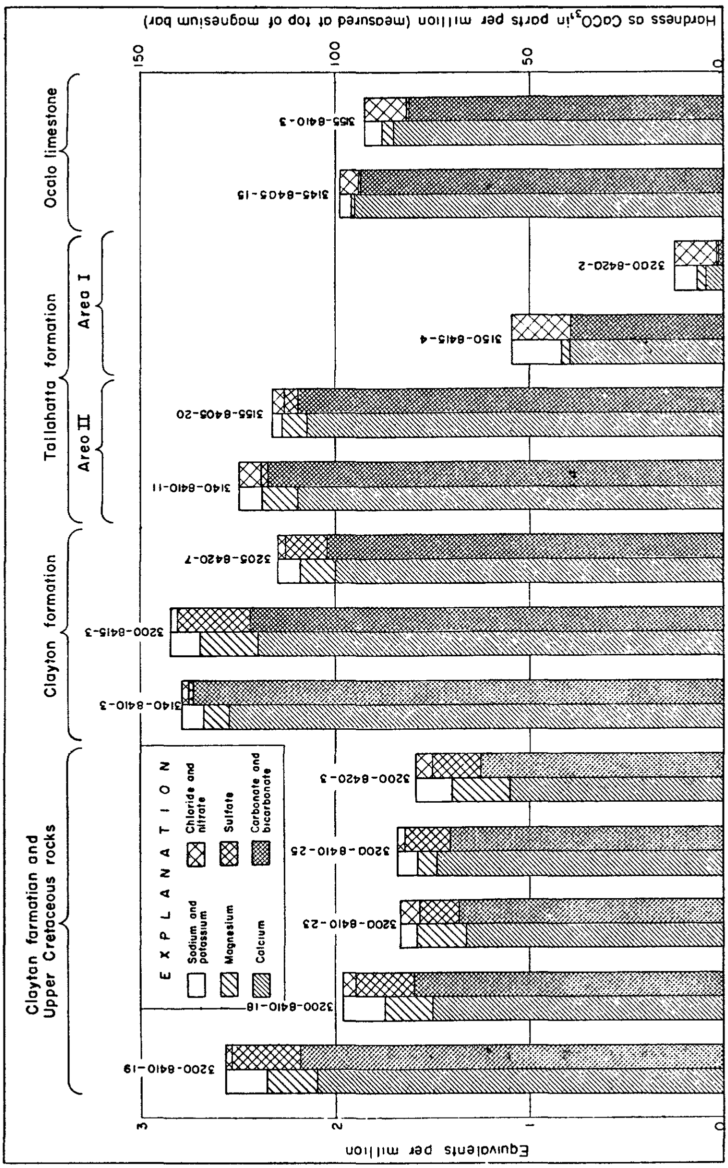

FIGURE 9.—Quality of water from selected wells in Lee and Sumter Counties, Ga.

equivalents per million. Chemical equivalents per million (numerical expressions of parts per million) are computed by multiplying the reported concentration of the individual constituents in parts per million by the reciprocal of their combining weights.

All chemical data for water samples shown in table 5 and figure 9, with the exception of the sample from well 3200–8420–2, are of the calcium bicarbonate type. Well 3200–8420–2 taps the Tallahatta formation in an updip area where the Tallahatta deposits contain little calcareous material.

SUMMARY

Lee and Sumter Counties have important ground-water resources that could be developed on a larger scale, particularly for municipal, irrigation, and industrial use.

Water for domestic use usually can be obtained from drilled wells 60 to 150 feet deep, though in parts of Sumter County hydrologic conditions are such that it is necessary or desirable that such wells be 200 to 400 feet deep.

Water for municipalities, industries, or irrigation may be produced from properly constructed wells throughout Lee and Sumter Counties. Rocks of the Upper Cretaceous series should furnish 1,000 gpm to properly constructed wells throughout Area I and possibly throughout Area II. The Clayton formation should yield 200 to 300 gpm in most of Area II and the southwestern portion of Area I. Yields from the Clayton probably would not exceed 100 gpm in the remainder of Area I and the portion of Area II in northeastern Lee and southeastern Sumter Counties. Yields from the undifferentiated deposits of the Midway group probably would be less than 100 gpm throughout the two counties. The Tallahatta formation should yield 1,000 gpm throughout Area II and possibly 300 to 400 gpm along the southern margin of Area I. Throughout most of Area I, yields of less than 100 gpm could be expected from the Tallahatta, although yields of 100 to 200 gpm might be obtained locally. The Ocala limestone should yield 25 to 50 gpm in most of Area II, and yields of 200 to 300 gpm could be expected locally in southeastern Lee County.

Ground-water conditions are decidedly more favorable in Area II than in Area I. Domestic supplies of water may be obtained throughout Area II from wells 75 to 150 feet deep, and because they are constructed in the Ocala limestone, inexpensive open-hole construction may be used. Domestic supplies of water may be obtained in most of Area I from wells 60 to 120 feet deep constructed in the Tallahatta formation, but these wells generally must be equipped with screens. Open-hole wells in Area I may be constructed in the Clayton formation or Upper Cretaceous rocks, but these wells generally must be from 200 to 400 feet deep.

Yields of 500 to 1,000 gpm may be obtained throughout Area II from wells 175 to 400 feet deep constructed in the Tallahatta formation. Because of the thickness and continuity of the water-bearing beds, the relatively shallow water levels, and the relatively small drawdowns, wells may be of open-hole construction or require few screens. Comparable yields may be obtained from the Upper Cretaceous series in Area I, but such wells must generally be 500 to 1,000 feet deep and they would require many screens. In addition to the Tallahatta formation other important aquifers occur in Area II. Yields of 200 to 300 gpm may be obtained from the Clayton formation in a large part of Area II and from the Ocala limestone in southeastern Lee County. If necessary, large yields possibly could be obtained from the Upper Cretaceous series from wells deeper than 400 feet. In Area I the only aquifers other than the Upper Cretaceous from which large yields could be expected are the Tallahatta and Clayton formations. Yields of 300 to 400 gpm could conceivably be obtained from the Tallahatta along the southern margin of the area, but elsewhere maximum yields would be less than 100 gpm. Yields of 200 to 300 gpm from the Clayton formation would be restricted to a small area in the southwest portion of Area I. Elsewhere maximum yields from the Clayton would be less than 100 gpm.

The Tallahatta formation is the principal aquifer in Area II, and it furnishes water that is of generally good quality. The hardness ranges from 114 to 119 ppm. Iron frequently becomes a problem in water from the Tallahatta formation in Area I. Excessive iron occurs also in rocks of the Upper Cretaceous series, which is the principal aquifer in Area I.

Water from all aquifers in Lee and Sumter Counties, within economic depths of drilling, appears suitable for irrigation use without treatment. Industries that require water of less than 75 ppm hardness might have to use water-softening equipment to treat water from most aquifers, particularly from the Clayton formation and the Ocala limestone. Also, certain industries would require iron-removal equipment to treat water from the Upper Cretaceous rocks or from the Tallahatta formation in Area I.

SELECTED REFERENCES

Aldrich, T. H., 1886, Preliminary report upon the Tertiary fossils of Alabama and Mississippi: Alabama Geol. Survey Bull. 1, p. 15–60.

Applin, P. L., 1951, Preliminary report on buried pre-Mesozoic rocks in Florida and adjacent States: U.S. Geol. Survey Circ. 91, 28 p.

Applin, P. L., and Applin, E. R., 1947, Regional subsurface stratigraphy, structure, and correlation of middle and early Upper Cretaceous rocks in Alabama, Georgia, and north Florida: U.S. Geol. Survey Oil and Gas Inv. Prelim. Chart 26.

Brantley, J. E., 1916, A report on the limestone and marls of the Coastal Plain of Georgia: Georgia Geol. Survey Bull. 21, 289 p.

California Water Pollution Control Board, 1952, Water quality criteria: Sacramento, Calif., Pub. 3, 512 p.

Cole, W. S., and Herrick, S. M., 1953, Two species of larger Foraminifera from Paleocene beds in Georgia: Bull. Am. Paleontology, v. 35, no. 148, p. 3–14, pls. 4, 5.

Conrad, T. A., 1847, Observations on the Eocene formations and description of one hundred and five new fossils of that period, from the vicinity of Vicksburg, Miss.: Philadelphia Acad. Nat. Sci. Proc., v. 3, p. 280–299.

——— 1856, Observations on the Eocene deposit of Jackson, Miss., with descriptions of 34 new species of shells and corals: Philadelphia Acad. Nat. Sci. Proc., v. 7, p. 257–268.

Cooke, C. W., 1915, The age of the Ocala limestone: U.S. Geol. Survey Prof. Paper 95, p. 107–117.

——— 1923, The correlation of the Vicksburg group: U.S. Geol. Survey Prof. Paper 133, p. 1–9.

——— 1935, Notes on the Vicksburg group: Am. Assoc. Petroleum Geologists Bull., v. 19, p. 1170–1171.

——— 1943, Geology of the Coastal Plain of Georgia: U.S. Geol. Survey Bull. 941, 121 p., 1 pl.

Cooke, C. W., and Shearer, H. K., 1918, Deposits of Claiborne and Jackson age in Georgia: U.S. Geol. Survey Prof. Paper 120–C, p. 41–81.

Crider, A. F., and Johnson, L. C., 1906, Summary of the underground-water resources of Mississippi: U.S. Geol. Survey Water-Supply Paper 159, 86 p.

Dall, W. H., 1898, A table of North American Tertiary formations correlated with one another and with those of western Europe, with annotations: U.S. Geol. Survey 18th Ann. Rept., pt. 2, p. 323–348.

Dall, W. H., and Harris, G. D., 1892, Correlation papers. Neocene: U.S. Geol. Survey Bull. 84, 349 p.

Eargle, D. H., 1955, Stratigraphy of the outcropping Cretaceous rocks of Georgia: U.S. Geol. Survey Bull. 1014, 101 p.

Georgia Division Mines, Mining, and Geology, 1939, Geologic map of Georgia, prepared in cooperation with U.S. Geol. Survey. Scale 1:500,000.

Goddard, E. N., and others, 1948, Rock-color chart: Natl. Research Council, Washington, D.C.

Harris, G. D., 1894, On the geological position of the Eocene deposits of Maryland and Virginia: Am. Jour. Sci., ser. 3, v. 47, p. 301–304.

Herrick, S. M., and LeGrand, H. E., 1949, Geology and ground-water resources of the Atlanta area, Ga.: Georgia Geol. Survey Bull. 55, 124 p.

Hilgard, E. W., 1860, Report on the geology and agriculture of the State of Mississippi: 391 p.

——— 1867, On the Tertiary formations of Mississippi and Alabama: Am. Jour. Sci., ser. 2, v. 43, p. 29–41.

LaForge, Laurence, Cooke, C. W., Keith, Arthur, and Campbell, M. R., 1925, Physical geography of Georgia: Georgia Geol. Survey Bull. 42, 165 p.

Lamar, W. L. 1942, Industrial quality of public water supplies in Georgia: U.S. Geol. Survey Water-Supply Paper 912, 83 p.

LaMoreaux, P. E., 1946, Geology and ground-water resources of the Coastal Plain of east-central Georgia: Georgia Geol. Survey Bull. 52, 173 p.

Langdon, D. W., 1891, Variations in the Cretaceous and Tertiary strata of Alabama: Geol. Soc. America Bull., v. 2, p. 589–605.

LeGrand, H. E., and Furcron, A. S., 1956, Geology and ground-water resources of central-east Georgia: Georgia Geol. Survey Bull. 64, 174 p.

McCallie, S. W., 1898, A preliminary report on the artesian well system of Georgia: Georgia Geol. Survey Bull. 7, 214 p.

——— 1908, A preliminary report on the underground water of Georgia: Georgia Geol. Survey Bull. 15, 376 p.

——— 1913, A preliminary report on the mineral springs of Georgia: Georgia Geol. Survey Bull. 20, 190 p.

MacNeil, F. S., 1947, Geologic map of the Tertiary and Quaternary formations of Georgia: U.S. Geol. Survey Oil and Gas Inv. Prelim. Map 72.

Meinzer, O. E., 1923, The occurrence of ground water in the United States, with a discussion of principles: U.S. Geol. Survey Water-Supply Paper 489, 321 p.

Owen, Vaux, 1958, Summary of ground-water resources of Lee County, Ga.: Georgia Mineral Newsletter, v. 11, no. 4, p. 118–121.

——— 1959, A summary of the ground-water resources of Sumter County, Ga.: Georgia Mineral Newsletter, v. 12, no. 2, p. 42–51.

Smith, E. A., 1886, Summary of the lithological and stratigraphical features and subdivisions of the Tertiary of Alabama: Alabama Geol. Survey Bull. 1, p. 7–14.

Smith, E. A., and Johnson, L. C., 1887, Tertiary and Cretaceous strata of the Tuscaloosa, Tombigbee, and Alabama Rivers: U.S. Geol. Survey Bull. 43, 189 p.

Spencer, J. W., 1891, First report of progress, 1890–91: Georgia Geol. Survey, Admin. Rept., p. 5–10.

Stephenson, L. W., and Veatch, J. O., 1915, Underground waters of the Coastal Plain of Georgia, and a discussion of the quality of the waters, by R. B. Dole: U.S. Geol. Survey Water-Supply Paper 341, 539 p.

Thomson, M. T., Herrick, S. M., Brown, Eugene, and others, 1956, Availability and use of water in Georgia: Georgia Geol. Survey Bull. 65, 416 p.

U.S. Dept. Commerce, 1950, The 1950 census of population, v. 2, pt. 11, 350 p.

——— 1956. The 1954 census of agriculture, v 1. pt. 17, 380 p.

——— 1960a, The 1960 census of population, advance report of final population counts: 12a series, 27 p.

——— 1960b, The 1959 census of agriculture, preliminary reports in Lee County, Ga.: v. 1, pt. 28, 379 p.

——— 1960c, The 1959 census of agriculture, preliminary report on Sumter County, Ga.: v. 1, pt. 28, 379 p.

U.S. Weather Bureau, 1958, Climatological data, annual summary, Georgia: v. 62, no. 13, 11 p.

Vallely, J. L., and Peyton, Garland, 1954, The mineral industry of Georgia: U.S. Bur. Mines and Minerals Yearbook, preprint, 17 p.

Vaughan, T. W., 1900. The Eocene and lower Oligocene coral faunas of the United States, with descriptions of a few doubtfully Cretaceous species: U.S. Geol. Survey Mon. 39, 263 p.

Veatch, J. O., and Stephenson, L. W., 1911, A preliminary report on the geology of the Coastal Plain of Georgia: Georgia Geol. Survey Bull. 26, 466 p.

Wait, R. L., 1957, History of the Albany, Ga., water supply: Georgia Mineral Newsletter, v. 10, no. 4, p. 143–147.

——— 1963, Geology and ground-water resources of Dougherty County, Ga.: U.S. Geol. Survey Water-Supply Paper 1539–P, p. P1–P102.

Warren, M. A., 1944, Artesian water in southeastern Georgia with special reference to the coastal area: Georgia Geol. Survey Bull. 49, 140 p.

Warren, W. C., and Thompson, R. M., 1943, Bauxite and kaolin deposits of Wilkinson County, Ga.: U.S. Geol. Survey Strategic Minerals Inv. Prelim. Map.

Welsh, G. B., and Thomas, J. F., 1960, Significance of chemical limits in USPHS drinking water standards: Am. Water Works Assoc. Jour., v. 52, no. 3, p. 289–300.

Wilmarth, M., 1938, Lexicon of geologic names of the United States including Alaska: U.S. Geol. Survey Bull. 896, Pts. 1 and 2, 2,396 p.

Zapp, Alfred D., 1943, Andersonville Bauxite District, Ga.: U.S. Geol. Survey Strategic Minerals Inv. Prelim. Map.

INDEX

[Major references are in italic]

	Page
Acknowledgments	5
Agriculture	11
Americus	3, 11
Andersonville fault	38
Aquifers	39, 64
See also particular rock units.	
Artesian conditions	40, 47
See also particular rock units.	
Barnwell formation	34
Barnwell sand	29
Bashi marl	27
Carbonic acid, in ground water	59
Chattahoochee formation	36
Chemical analyses	60
Chickasawhay marl	36
Claiborne group	*28*, 37
Clayton formation	20, *21*, *25*, 60, 63
Climate	8
Coastal Plain of Georgia, physiographic divisions	6
reports on	5
Congaree clay	29
Cooper marl	34
Domestic water supplies	51
Dougherty County, ground water	3
Dougherty Plain unit	3, 6
Drainage	7
Economy	11
Eocene series	26
Fall Line Hills unit	7
Faults	38
Flint River	7
Flint River formation	36
Foraminifera	21, 28
Fossils, Clayton formation	21
Geography, physical	6
Geologic map	13
Geology, summary	12
Glauconite, in Tuscahoma formation	27
Glendon limestone	36
Gosport sand	29
Graves Springs	58
Ground-water areas I and II, domestic water supplies	51, 53
large-yield wells	53
springs	57
topography	7
Ground water, general features	39
quality	59
Hatchetigbee formation	27
Hydrographs	46, 48, 49
Industry	11
Introduction	2
Investigation, area of, location and extent	3
previous	4
purpose and scope	3
Iron, in water	59
Irrigation	2
Jackson group	34
Kaolin-bauxite zone	20
Kinchafoonee Creek	7
Lake Blackshear	45
Lake Worth	47
Leesburg	11
Lisbon formation	*32*, 37, *45*
McBean formation	29
Measured section	24, 32
Midway group	15, *20*, 37, 38, *42*, 63
Minerals	11
Moodys marl	34
Mossy Dell, springs at	58
Muckalee Creek	7
Myrtle Springs	58
Naheola formation	20
Nanafalia formation	20
Ocala limestone	*34*, 37, *45*, 49, 57, 61, 63
Oligocene series	35
Paleocene series	15
Palmyra Springs	58
Permeability, definition	40
Plains	11
Population	11
Porosity, definition	40
Precipitation	8
Providence Spring	57
Quality of water	59
Rejuvenation of streams	8
Saline water	41
Selected references	64
Smithville	11
Springs	57
Stratigraphy, summary	12, 16
Structural belt	38

	Page
Structure, regional	37
Sucarnoochee clay	20
Summary	63
Suwanee limestone	36
Tallahatta formation	*29*, 37, *44*, 56, 58, 60, 63
Temperature	8
Transportation	11
Tuscahoma formation	*27*, 37, *44*
Tuscaloosa formation	41
Twiggs clay	29
Undifferentiated residuum	36, 49
Upper Cretaceous series	*14*, *40*, 53, 60, 63
Water-table conditions	48
Wells, construction	50
domestic, types	51
large-yield	53
log, showing Jackson and Claiborne intervals	31
showing Midway interval	22, 26
numbering of	5
quality of water from	62
records	52, 54
Wilcox group	26
Yazoo clay	34