GEORGIA

STATE DIVISION OF CONSERVATION

DEPARTMENT OF MINES, MINING AND GEOLOGY
GARLAND PEYTON, Director

THE GEOLOGICAL SURVEY
Information Circular 18

SOURCE AND QUALITY OF GROUND WATER IN SOUTHWESTERN GEORGIA

by
Robert L. Wait

1776

ATLANTA
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Prepared in cooperation with the United States
Department of the Interior, Geological
Survey, Water Resources Division,
Ground Water Branch

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INTRODUCTION

A quality-of-water sampling program was begun in 1957 in Georgia by the U. S. Geological Survey in cooperation with the Georgia Department of Mines, Mining and Geology. The purpose of this program is to determine the quality of water in various aquifers and the changes in quality of ground water that occur with time. The sampling program will be continued in the future. However, the analyses made during the first year of the program are valuable to those who are concerned with the planning of city, industrial, and irrigation supplies who may require water of a certain quality. It is intended to present this portion of the first year's work as an aid to those people who have need for such data.

The analytical program carried out in southwestern Georgia included municipal supplies in 28 cities located in 25 counties, and one sample from an industrial well. A municipal supply in each of the counties in the area was sampled. The wells from which water samples were obtained were usually those for which drill cuttings are available. The drill cuttings are filed in the sample library of the Georgia Geological Survey. By sampling wells for which a record of the geologic formations penetrated is available, the quality of the water from the well can be related to the rock type and to the geologic formation.

Constructional data for each well were obtained so far as records and memories permitted. The depth of a well alone is not indicative of the zone or zones from which water is obtained. It is also necessary to know the location of open hole or screened zones and other constructional features. The construction data are listed with the chemical analyses.

Data are presented to show the amount of water pumped by each municipal supply. In cities where the water was not metered, an estimate of water consumption was made, based on the population served by the supply and a conservative per capita consumption of 100 gallons per day.

Location of area

The area discussed in this report is in the Coastal Plain of Georgia and includes 25 counties covering an area of approximately 9,800 square miles (fig. 1). The topographic divisions of the Coastal Plain in the area include parts of the Fall Line Hills and the Tifton Upland, and the Dougherty Plain.

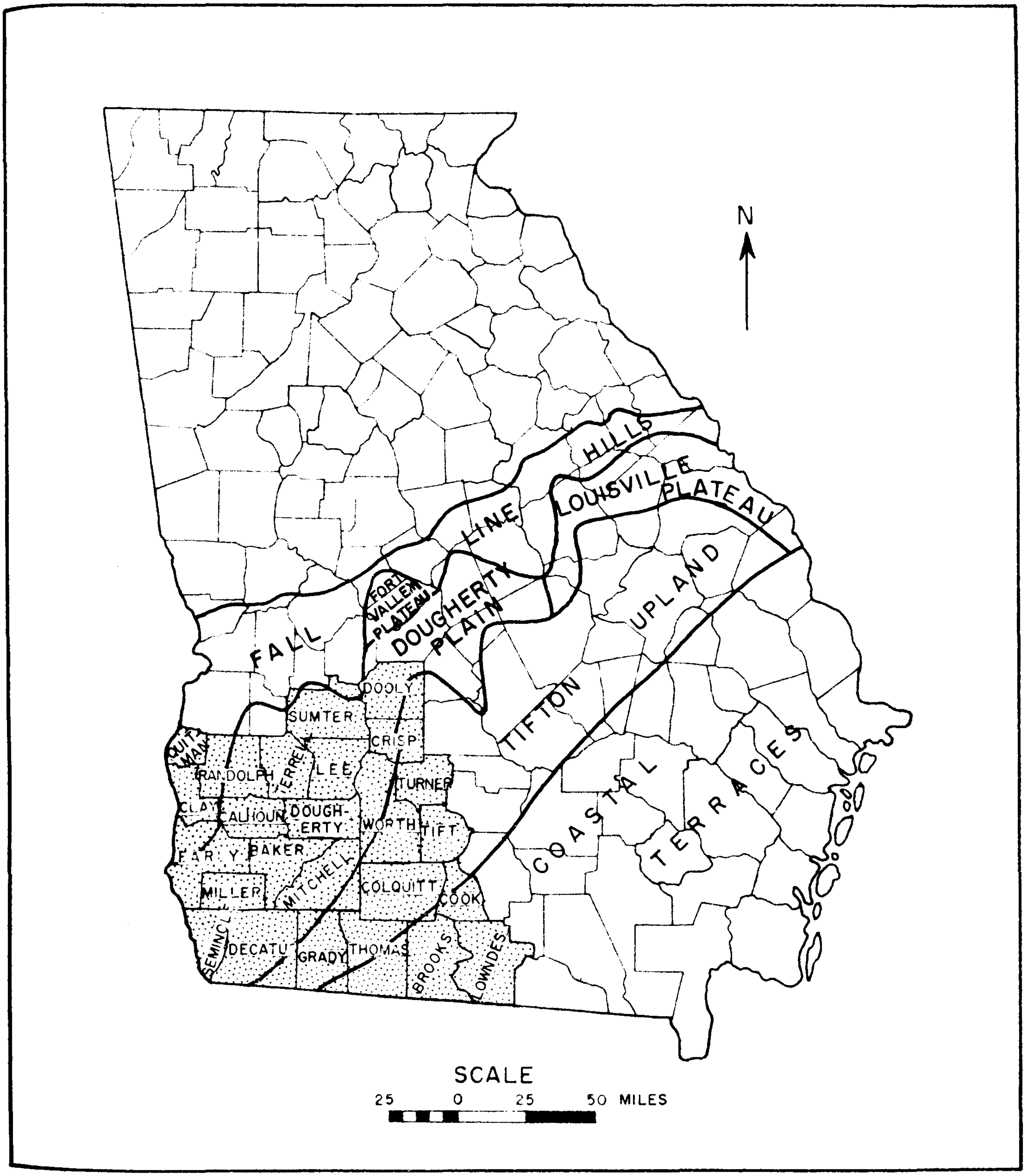

Figure 1 - Map showing location of area and physiographic provinces

Previous investigations

The first ground-water investigation in Georgia was that of McCallie (1898). Several chemical analyses of waters from springs and wells are listed in his report. A second report by McCallie (1908) also listed chemical analyses of ground waters. The most comprehensive ground-water report on the Coastal Plain is that of Stephenson and Veatch (1915). One or more chemical analyses of water are listed for most of the counties of the Coastal Plain, and an entire section is devoted to a discussion of the quality of both ground and surface waters. A comprehensive report (Collins and others, 1934) on the quality of water in the United States contains analyses of 14 municipal supplies in Georgia. Lamar (1942) discussed the quality of water in Georgia and listed analyses of the supplies of most of the larger cities of the State. A more recent report of the same nature is Water-Supply Paper 1299 (1954), which contains analyses of the supplies for many of the larger cities in Georgia. Chemical analyses of ground waters are found in all the Georgia Geological Survey bulletins concerning the ground-water resources of the State. Many of these reports may be consulted at libraries throughout the State. A list of selected references is at the end of this report.

Supervision and acknowledgments

This report was prepared by the U. S. Geological Survey in cooperation with the Georgia Department of Mines, Mining and Geology, Garland Peyton, Director. Ground-water investigations in the United States are under the general supervision of P. E. LaMoreaux, Chief, Ground Water Branch, and in Georgia are under the direct supervision of J. T. Callahan, District Geologist. The chemical analyses were made by the Quality of Water Laboratory of the U. S. Geological Survey, Ocala, Fla., under the supervision of J. W. Guerin, District Chemist. S. M. Herrick, Staff Stratigrapher, Atlanta, Ga., furnished much of the information regarding the geologic formations penetrated by various wells. The cooperation of the superintendents of the various water systems, who assisted in obtaining water samples and who furnished pumpage and well-construction data, is gratefully acknowledged. Thanks are also due Messrs. John David and Jack Carlson of the Layne-Atlantic Co., Albany, Ga., who kindly furnished well-construction data for several of the wells that were sampled.

GEOLOGY AND GEOCHEMICAL PROPERTIES OF AQUIFERS

The Coastal Plain of Georgia is the part of the State south of the Fall Line, a line or zone extending from Columbus through Macon, Milledgeville, and Augusta. It includes nearly 35,000 square miles and is the largest of the three geologic provinces of Georgia. The rocks exposed in the Coastal Plain range in age from Late Cretaceous to Recent. They consist of alternating layers of sand, clay, and limestone, of which the sand and limestone are the principal aquifers. The sedimentary rocks of the Coastal Plain crop out beginning at the Fall Line, and dip gently to the south and southeast. The rocks form a wedge which thickens in the direction of dip.

Upper Cretaceous Rocks

Immediately to the south of the Fall Line, the sand and clay beds of the upper Cretaceous series crop out. This series has been divided into six formations in Georgia, some of which are aquifers. The rocks and aquifers of the Upper Cretaceous and younger rocks are presented in table 1 with a summary of the lithology, thickness, and water-bearing properties. The four main aquifers in the Upper Cretaceous series are the Providence sand, the Cusseta sand, a sand near the base of the Eutaw formation, and the Tuscaloosa formation. The Upper Cretaceous rocks are used as a source of ground water in a wide area in southwestern Georgia, beginning at the Fall Line, extending as far south as Blakely in Early County, and extending eastward as far as Americus in Sumter County, where some of the new city wells obtain water from these sands. Municipal wells at Arlington and Leary obtain water from the Upper Cretaceous and from some of the overlying formations as well. Several of the city wells in Albany, Dougherty County, obtain water from a coquina limestone near the top of the series in that area.

Table 1.--Generalized table of deposits in southwestern Georgia

System	Series	Stratigraphic unit	Thickness (feet)	Lithology	Water-bearing properties
Quaternary	Recent and Pleistocene	River terrace deposits	0- 30	Sand, fine to very coarse grained, and gray to yellow gravel; silt, clay, and boulders.	Present along major rivers in area but generally too high above rivers to be recharged by them. Are non-water-bearing, except where flooded.
Tertiary	Miocene	Hawthorn fm. and Tampa ls.	50-350	Pale- to dark-green phosphatic sandy clay, brown phosphatic sand, and phosphatic sandy recrystallized limestone.	Sand present in Hawthorn yields water to domestic wells. Tampa limestone yields abundant water where present as part of principal artesian aquifer, as at Valdosta.
	Oligocene	Suwannee ls. and Flint River fm.	100±	Limestone, soft to chalky to dense recrystallized, saccharoidal; unfossiliferous to fossiliferous; contains large flint boulders.	Major aquifer, yields of up to 2,100gpm obtained from Miocene and Oligocene in Valdosta area. Water of calcium bicarbonate type.

Table 1.--Continued

System	Series	Stratigraphic unit	Thickness (feet)	Lithology	Water-bearing properties
Tertiary	Eocene	Ocala ls.	0-300	Limestone, white to pink, pure to sandy, aphanitic, fossiliferous; contains brown dolomitic limestone in Valdosta area.	Major aquifer throughout much of area. Yields as much as 1,700 gpm obtained in Dougherty County. Water of calcium bicarbonate type, generally low in sulfate. Water in Valdosta area contains much magnesium and sulfate.
		Claiborne gp. (Lisbon and Tallahatta fms.)	280-400	Yellowish-gray to olive-gray sand and sandstone, coquina limestone with fine-grained sand; siliceous limestone near base.	Major aquifer, yields up to 1,200 gpm obtained in Dougherty County. Principal source of water at Albany and Cordele. Contains saline water at Thomasville.
		Wilcox gp. Bashi marl member of Hatchetigbee fm. Tuscahoma fm. and Nanafalia fm.	200	Light-gray fine-grained calcareous glauconitic sand and sandy clay. Medium-grained sand near base.	Basal sand may be water-bearing. Yields water to domestic wells near area of outcrop. Not an important aquifer in area.

Table 1.--Continued

System	Series	Stratigraphic unit	Thickness (feet)	Lithology	Water-bearing properties
Tertiary	Paleocene	Midway group (Clayton fm.)	150-300	Light-gray fine-grained sand near top, white crystalline fossiliferous limestone in middle, light-gray conglomeratic feldspathic sand near bottom.	Major aquifer in Clay, Randolph, Terrell, Lee, Calhoun, Dougherty and Early Counties. Yields 250 to 1,700 gpm. Water of calcium bicarbonate type; may be of sodium calcium bicarbonate type in basal sand.
Cretaceous	Upper Cretaceous	Includes Providence sd. Ripley fm. Cusseta sd. Blufftown, Eutaw and Tuscaloosa fms.	2,000+	Light-gray brown and white fine- to very coarse-grained feldspathic sand, sandy clay, and silt. Coquina near top of series in Albany area.	Yields from Providence and Cusseta sands and Tuscaloosa formation range from 50 to 1,200 gpm. Water mostly of sodium bicarbonate type but contains increasing amounts of chloride with depth i southern part of area. Connate water present at great depth. May contain excessive amounts of iron. In Albany area coquina near top an excellent aquifer.

The quality of water from rocks of the Upper Cretaceous series is variable in southwestern Georgia, but in the Chattahoochee Valley is usually of the sodium bicarbonate type. Eastward and downdip the chloride content of water from the Upper Cretaceous rocks increases. An oil test well in Dougherty County produced sodium chloride water from a depth of 1,200 feet.

Two water samples reported here were obtained from rocks of the Upper Cretaceous series, one from the city well at Georgetown, Quitman County, and one from well 3, Fort Gaines, Clay County. Both waters are of the sodium bicarbonate type. The well at Georgetown obtains water from the sand at the base of the Eutaw formation. The well at Fort Gaines obtains water from the Providence sand.

The water from the Upper Cretaceous, which is high in sodium chloride, is not considered suitable for irrigation. However, if wells are constructed to obtain water from the Upper Cretaceous and from the overlying formations in the Tertiary, most of which yield water of the calcium bicarbonate type, the resulting mixture is generally suitable for irrigation (Wait, 1958).

Clayton Formation

The Clayton formation consists of a cemented sand at the top, which is underlain by a thick bed of fossiliferous white limestone, and a feldspathic sand below the limestone which contains much sodium feldspar. The limestone is the main aquifer, although small quantities of water can be obtained from the sands above and below it. The first flowing artesian well in Georgia, drilled in 1881 near Albany, obtained water from the limestone of the Clayton formation. Since that date many wells have been drilled which obtain water from this aquifer in southwestern Georgia. The Clayton is the source of municipal supplies in Terrell, Randolph, Clay, and Calhoun Counties and the northern part of Early County. Much water is obtained for domestic use from the Clayton formation in northwestern Lee County and in adjoining southwestern Sumter County. The Clayton is present in Webster County, but usually is found only under hills where the protective cover of the overlying formations has prevented erosion and solution of the limestone. Several wells in Webster County (immediately west of Sumter County) are known to obtain water from the Clayton, including a well about 6 miles northeast of Preston. The Clayton is used in Dougherty County in combination with the sand and coquina of the Claiborne group. Some of the old city wells at Cordele, Crisp County, obtain water from the Clayton formation. The well sampled at Americus obtains water from the Clayton, although as previously mentioned the new wells there obtain water from the Upper Cretaceous rocks.

Although the analyses presented here show the water from the Clayton to be of the calcium bicarbonate type, the quality of water from the Clayton formation varies throughout the area. Wells that obtain water from the upper sand and limestone produce calcium bicarbonate water, and wells that penetrate the feldspathic sand beneath the limestone produce water of the sodium calcium bicarbonate type. The increase in sodium is attributed to the sodium feldspar in the basal sand.

Wilcox group

The Wilcox group consists of clay, sandy clay, and fine sand, most of which are dark gray in color. Rocks of the group produce little ground water, but enough water for domestic supplies can be obtained in the area of outcrop. A medium-grained sand near the base of the group also may yield some water in downdip areas. A city well at Plains obtains water from the Wilcox group.

Claiborne group

The Claiborne group consists of sandy limestone, coquina, sandstone, and loose sand. In Dougherty County the upper part of the group (Lisbon formation) is a cemented sandstone and yields only small quantities of water. In Sumter County many domestic wells obtain water from an unconsolidated sand which is probably a part of the Tallahatta formation. The coquina and loose sand of the lower part of the Claiborne group (Tallahatta formation) constitute a major aquifer in southwestern Georgia. Municipal wells at Albany, Cordele, and Vienna obtain water from it. City well 17 in Albany obtains water from the Tallahatta and has been pumped at the rate of 1,200 gpm. Most of the wells developed in this formation are screened and gravel packed. The water obtained from the Claiborne group is of the calcium bicarbonate type and is moderately hard to hard and alkaline.

At Thomasville, near the edge of the Tallahassee syncline, the water in the Claiborne group is high in mineral content. A test well was drilled by the city of Thomasville in 1949 to determine the water-bearing properties of the rocks below a depth of 600 feet. The test well was drilled to a depth of 1,635 feet. A water sample obtained from the Claiborne at a depth of 1,630-1,635 feet contained 11,900 ppm of chloride, 1,420 ppm of sulfate, and 22,200 ppm of dissolved solids, (analysis reported by Law and Co.).

Ocala limestone

The Ocala limestone is near the land surface throughout most of the Dougherty Plain (fig. 1), including the southern part of Lee and Terrell Counties, the area west of the Flint River in Dougherty County, most of Calhoun and all of Baker and Miller Counties, the southern and eastern parts of Early County, the western half of Crisp County, and the northern half of Seminole County. It extends eastward under the Tifton Upland (fig. 1), where it is overlain by sediments of Oligocene and Miocene ages. The Ocala is thinnest in the Dougherty Plain and thickens to the southeast where overlying formations prevent erosion and solution. The Ocala is probably too thin to be used as a source of ground water in the extreme updip portion of the area in western Calhoun and in northern Terrell and Lee Counties.

Yields from the Ocala limestone are known to range from about 200 to 1,700 gpm in Dougherty County. Similar yields may be expected throughout most of the Dougherty Plain. In the Tifton Upland, yields from the Ocala are higher because the limestone is thicker.

The quality of water from the Ocala in the Dougherty Plain is usually excellent. The water is of the calcium bicarbonate type and is moderately hard to hard and slightly alkaline. Sulfate is very low near the area of outcrop. However, in the Tifton Upland area the Ocala is somewhat dolomitic at places, and the water also contains greater amounts of sulfate.

At Valdosta, Lowndes County, a well was drilled for the city in 1954 to a depth of 400 feet and penetrated dolomitic limestone of the Ocala from about 350 to 400 feet. The water obtained was reported to be excessively high in magnesium and sulfate. When the bottom 50 feet of the well was plugged, the quality of water improved, but the yield of the well dropped substantially, and the well was abandoned. Wells of similar depth in the general area produce water of good quality. Therefore, it might have been possible to pump this well for a long enough period to remove the high-sulfate water and obtain water of good quality.

The well sampled at Moultrie was drilled in 1949 to a depth of 1,000 feet. The Ocala is dolomitized in this area and yields water high in sulfate. The well produced water that was reported to be extremely high in magnesium and sulfate. It was plugged back to 752 feet and produced water of good quality. However, the sample reported here is high in magnesium and sulfate which probably indicates that some water is being obtained from the Ocala limestone. This analysis indicates that some water may leak upward from the portion of the well below 752 feet.

Oligocene series

Rocks of Oligocene age are present in the subsurface of the Tifton Upland. These rocks range from hard flinty recrystallized limestone to soft sandy limestone and sand. Although no water was obtained exclusively from the Oligocene limestone, it is known that it yields water of the calcium bicarbonate type which is moderately hard to hard, and alkaline. Several of the wells sampled obtain water largely from the Oligocene limestones.

Miocene series

The Tampa limestone is present in the Tifton Upland area. At most places it is a sandy limestone but it ranges from a hard fossiliferous to a soft earthy limestone. The water from the Tampa is probably of the calcium bicarbonate type. None of the wells sampled during this investigation obtained water exclusively from the Tampa, although several of the wells presumably obtain some water from it.

The Hawthorn formation is at the land surface in the Tifton Upland of southwestern Georgia. It is the source of much domestic water, chiefly from sand and gravel. In the southern tier of counties, especially in Decatur, Grady,and Thomas Counties, fullers earth makes up much of the Hawthorn, and little ground water can be derived from it. None of the water samples obtained during this investigation came from the Hawthorn formation.

Principal artesian aquifer

The Ocala limestone and the limestones of Oligocene and Miocene age together constitute what is known as the principal artesian aquifer in Georgia. According to Warren (1944, p. 17), "***the principal artesian aquifer consists of limestones of Oligocene and Upper Eocene ages". "***Within a strip about thirty miles in width that borders the seacoast ***sediments of Oligocene age are thin or absent, and that the Hawthorn formation of Miocene age rests directly on the Ocala limestone." It is now known that limestones of Miocene and Oligocene age are present in the Coastal area of Georgia where the principal artesian aquifer was defined by Warren. Accordingly, the principal artesian aquifer, redefined, is now considered to be composed of limestones of late Eocene, Oligocene,and Miocene age.

Wells that produce water from the principal artesian aquifer are shown on figure 2. Analyses from Sylvester, Tifton, Moultrie, Cairo, Thomasville, Quitman, and Valdosta illustrate the chemical quality of ground water from the principal artesian aquifer, as wells in these cities obtain ground water from part or all of it.

River-terrace deposits

Terrace deposits are present along most of the major rivers of the state, but are too far above the rivers in most places to be recharged by them. It is possible, however, that in the areas above dams, adjacent to ponded water, the sand and gravel of the terraces may yield water to wells. In the area above the Jim Woodruff dam the terraces are flooded by ponded water along both the Chattahoochee and Flint Rivers. Terraces along the Flint River are flooded to the vicinity of Bainbridge, Decatur County. No wells are known to derive water from the terrace deposits, but the possibility that they may be a source of ground water should not be overlooked.

Pumpage

Figure 2 shows the location of municipal supplies sampled and the aquifer from which the water was obtained. In the northwestern part of the area, ground water is usually obtained from the Upper Cretaceous rocks. Throughout most of the Dougherty Plain ground water is obtained from the Ocala limestone, the Claiborne group, and the Clayton formation. In the Tifton Upland the principal artesian aquifer is the main source of ground water.

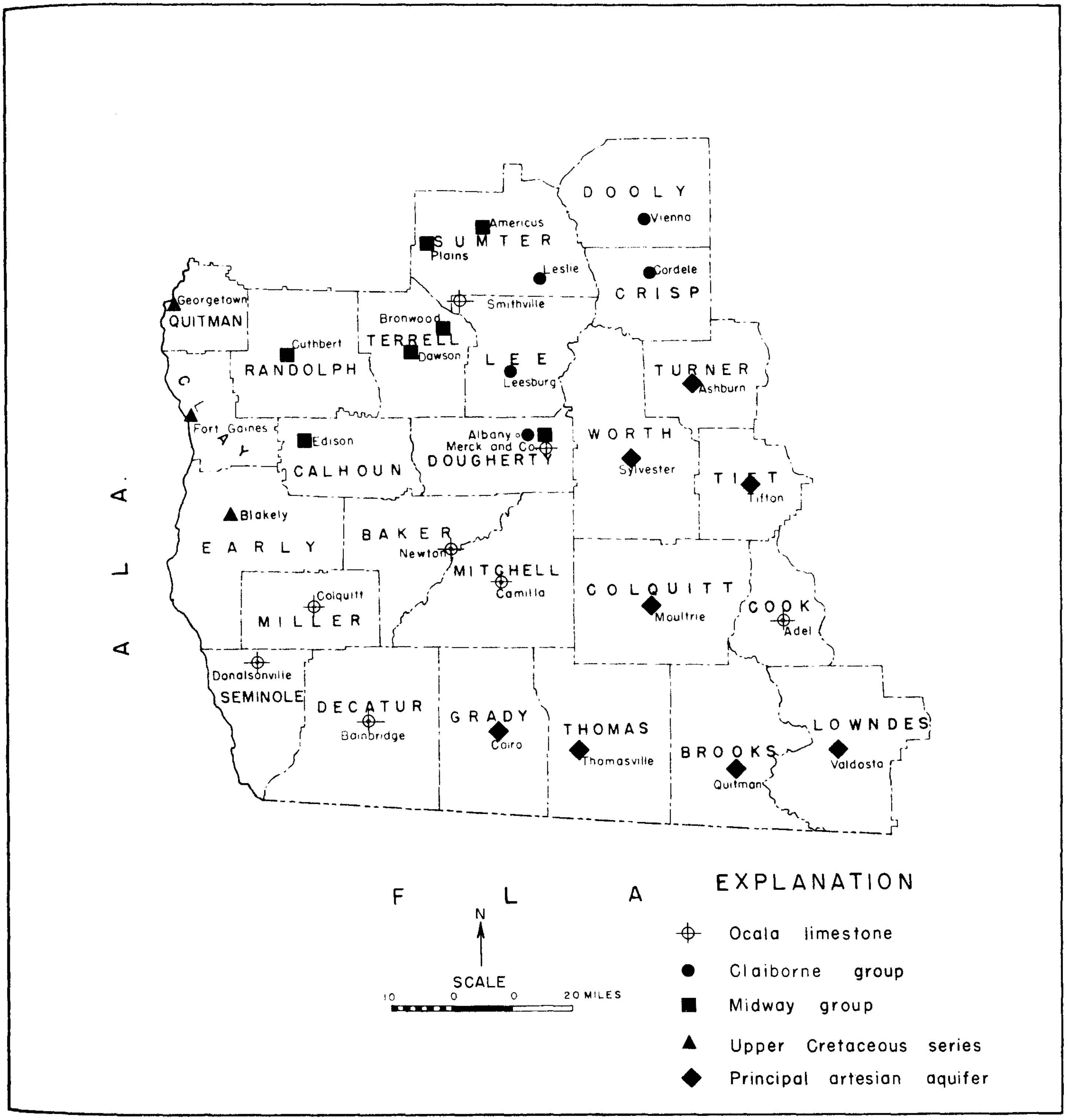

Figure 2 — Map showing locations of wells sampled and aquifers which they tap.

Because the quality of ground water may vary with the amount of water pumped, data on pumpage of individual cities are included in this report. The total municipal pumpage for the 28 cities is estimated to be about 20 mgd (million gallons per day). Albany is the largest municipal user of ground water in southwestern Georgia. Average daily pumpage in Albany during 1957 was 6.0 mgd. Other large municipal users of ground water are Moultrie, Bainbridge, Camilla, Thomasville, Tifton, and Americus.

Table 2.--Municipal pumpage in southwestern Georgia

City	Municipal pumpage, 1957 (mgd)	City	Municipal pumpage, 1957 (mgd)
Adel	0.30 a/	Fort Gaines	.13 d/
Albany	6.00 b/	Georgetown	.05 d/
Amercus	1.53 c/	Leesburg	.06 a/
Ashburn	.20 a/	Leslie	.04 d/
Bainbridge	1.25 a/	Moultrie	1.37 b/
Blakely	.60 a/	Merck and Co.	.51 b/
Bronwood	.20 d/	Newton	.04 a/
Cairo	.50 a/	Plains	.05 d/
Camilla	1.30 a/	Quitman	.04 a/
Colquitt	.50 a/	Smithville	.06 d/
Cordele	1.01 e/	Sylvester	.23 a/
Cuthbert	.45 a/	Thomasville	2.12 b/
Dawson	.53 a/	Tifton	1.5 b/
Donaldsonville	.25 d/	Valdosta	2.1 b/
Edison	.03 a/	Vienna	.22 a/

a. Estimated by superintendent of waterworks.

b. Metered pumpage.

c. Estimated on basis of partial records of individual wells.

d. Estimate based on per capita consumption of 100 gpm.

e. Based on 7 months of record.

Quality of water

The source of most ground water is rainfall. It enters the aquifers where they are exposed at or near the land surface and moves downward and laterally under the influence of gravity to join the ground-water body. As the water moves it dissolves some of the rock materials. Thus the water obtained from a limestone may be expected to contain much calcium bicarbonate, for calcium carbonate composes the bulk of most limestones. If the limestone has been dolomitized that is, contains much calcium magnesium carbonate, the water may be expected to contain greater than usual amounts of magnesium. Gypsum (calcium sulfate) likewise contributes calcium and sulfate to the water. If the aquifer is a sand, the water may be either a soft sodium bicarbonate water or a calcium bicarbonate water, according to the minerals other than silica that are present. The sand of the Upper Cretaceous series contains much feldspar, and the water is usually characterized by sodium dissolved from the feldspar. Sand in the Tertiary formations contains little feldspar, but usually has abundant calcium carbonate in the form of shell fragments, or calcium carbonate cementing material. The water obtained from these sands is usually of the calcium bicarbonate type.

Aquifers that change in lithologic character may be expected to yield water of different quality in different places. It has been noted that some formations become progressively finer grained in a downdip direction. A formation composed of coarse sand in the outcrop area may grade into fine sand downdip, then to clay, and eventually to limestone. A formation that exhibits these changes in lithology is said to have changed facies. Ground water obtained from a formation that exhibits such facies changes will reflect these changes in the quality of water.

Warping or bending of the sediments also may cause a change in the quality of water. In an area where the sediments are downwarped, like a long plank that has sagged in the middle, there may be restricted circulation of ground water. The resulting slower movement results in an increased dissolved-solids content in the water. The concentration of dissolved solids may increase to a point where the water is no longer suitable for some purposes. Connate water - sea water that was present in formations at the time they were deposited - is found in some downwarped areas, for there has been insufficient circulation of ground water to flush the connate water from the rocks. One such area of saline water is believed to exist in Georgia along the western flank of the so-called Withlacoochee anticline, in the vicinity of Thomasville.

Most of the waters analyzed contain a total of 4 to 6 epm (equivalents per million) of dissolved constituents, regardless of the location of the well in relation to the area of outcrop of the aquifer from which the water was obtained. This small range would seem to be somewhat anomalous. It can be shown that, in general, ground waters tend to increase in dissolved solids as the water moves from the area of outcrop to areas where the water is confined in deeply buried formations, in this instance in a southeasterly direction. The time the water has been in the rocks and the distance it has traveled are considered to be major factors in the increase of dissolved solids. However, it is apparent from figure 3 that no such pattern exists in southwestern Georgia. The principal reason for the lack of increase in dissolved solids is thought to be local recharge to the water-bearing formations through sinkholes, which are characteristic of that part of the Coastal Plain underlain by limestones, and the influence of structural features in southwestern Georgia.

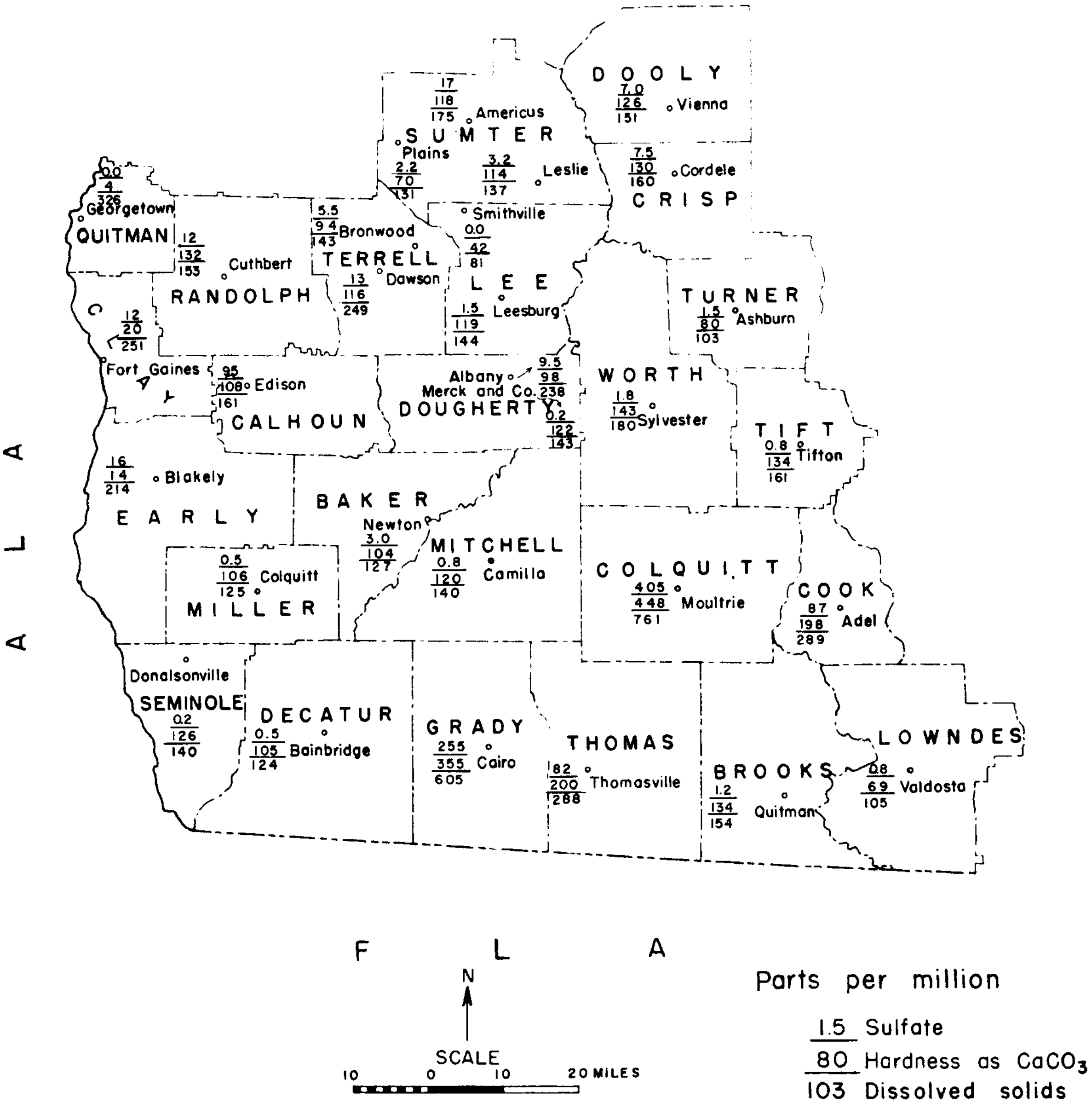

Figure 3 – Well locations, showing the amounts of certain chemical constituents in ground water.

Suitability of ground water for irrigation

The suitability of water for irrigation is determined by the amount and kind of mineral matter dissolved in the water and by the sodium-adsorption-ratio (SAR). (See table 3.) The mineral matter in the water is indicated roughly by the electrical conductivity of the water. In general the conductivity of water increases with increased amounts of dissolved material. The amount of increase depends upon the kind and amount of material that is added to the solution. Not all substances increase the conductivity by the same amount for an equal amount of the substance added. The conductivity can be used in a general way to indicate the amount of material dissolved in the water but cannot be used to determine any individual constituent present. The conductivity of water varies according to the temperature, and for this reason all conductivity measurements are referred to a standard temperature of 25°C.

The sodium-absorption-ratio (SAR) is (a ratio) related to the amount of sodium adsorbed by soil to which the water is added and is determined according to the following formula:

$$SAR = \frac{Na}{\sqrt{\frac{Mg + Ca}{2}}}$$

where the concentration of the constituents is given in equivalents per million.

Of the 30 water samples analyzed, only 3 appear to be unsuitable for irrigation. These are the waters from wells at Cairo, Moultrie, and Georgetown. The waters from Cairo and Moultrie have a low sodium hazard but a high salinity hazard (fig. 4). The water from the Georgetown well has a medium salinity hazard and a very high sodium hazard.

The water sample from the Fort Gaines well has a medium salinity hazard and a medium sodium hazard. This type of water can be used in coarse-textured, moderately well leached soils.

Table 3 lists the SAR and specific conductance for each of the water samples. These data may be used to determine the suitability of each water sample for irrigation. Figure 4 shows the suitability of 9 water samples. The remaining values of SAR and specific conductance were not plotted on this diagram, as they are very closely grouped in the range "low" to "medium" salinity hazard, and "low" sodium hazard. The values that are plotted give the extreme range of ground waters sampled during the investigation.

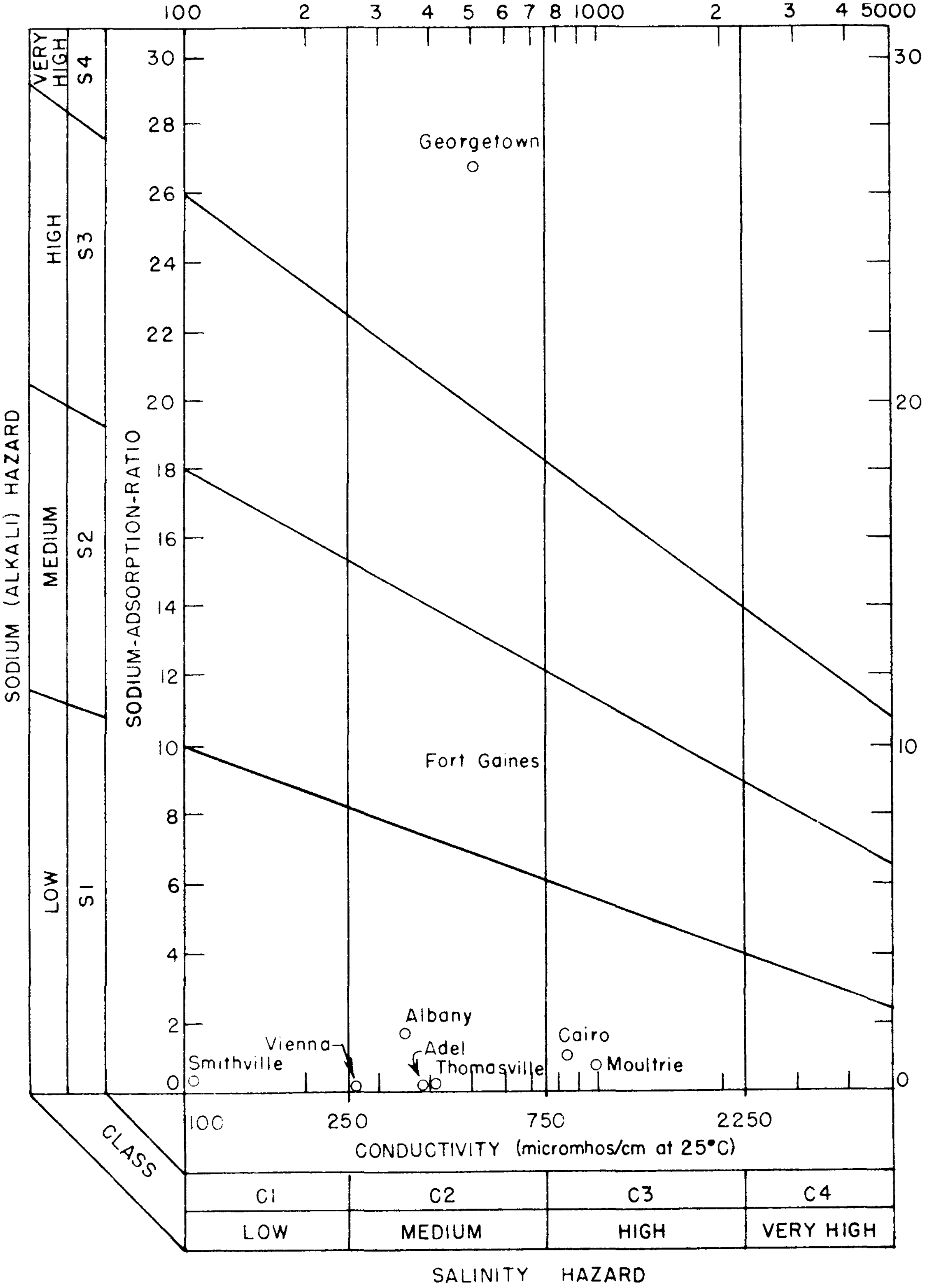

Figure 4 – Suitability of selected ground waters for irrigation in southwestern Georgia

Table 3.--Sodium-adsorption-ratio and specific conductance of ground waters in southwestern Georgia

City	Sodium-adsorption-ratio (SAR)	Specific conductance (micromhos at 25°C)
Adel	.1	399*
Albany	2.0	362*
Americus	.1	240
Ashburn	.1	164
Bainbridge	.1	201
Blakely	.9	342*
Bronwood	.4	222
Cairo	1.1	829*
Camilla	.1	249
Colquitt	.1	219
Cordele	.1	261
Cuthbert	.1	254
Dawson	.3	249
Donaldsonville	.1	250
Edison	.5	251
Fort Gaines	8.7	403*
Georgetown	27	497*
Leesburg	.1	240
Leslie	.0	214
Moultrie	.8	966*

Table 3.--continued

City	Sodium-adsorption-ratio (SAR)	Specific conductance (micromhos at 25°C)
Merck and Company	.1	239
Newton	.3	218
Plains	.1	150
Quitman	.1	268
Smithville	.4	113*
Sylvester	.1	294
Thomasville	.2	418*
Tifton	.1	146
Valdosta	.0	149
Vienna	.1	254*

* These values plotted in figure 4.

Table 4 lists a classification of irrigation waters according to the U. S. Salinity Laboratory staff (1959). This classification can be used to determine the suitability for irrigation of the ground waters listed in the appendix and in table 3.

The water obtained from the Miocene, Oligocene, and Eocene limestones and sands and from limestone of the Clayton formation appears to be the best suited for irrigation. The water from the Upper Cretaceous series is high in sodium but may be used with caution in some areas. In the vicinity of the Withlacoochee anticline the ground waters appear to be too saline for irrigation. However, it is possible that suitable water can be obtained at a shallower depth.

Method of sampling

The samples taken during this investigation were collected in pyrex glass bottles. It has been found that if water samples are collected in ordinary glass jugs, the reaction of the water with the glass tends to increase the amount of silica present in the sample (Collins and Riffenburg, 1923). A separate 6-ounce sample was collected for the determination of iron. This sample bottle was filled completely and capped tightly to prevent oxidation of the iron in the water. The sample was filtered into the bottle through a fiber-glass fiter to remove all solid particles. The iron reported by the analyst represents that which was in solution in the water at the time of collection.

Table 4.--Classification of irrigation waters*

Conductivity

Low-salinity water, (C-1) can be used for irrigation with most crops on most soils with little likelihood that soil salinity will develop. Some leaching is required, but this occurs under normal irrigation practices except in soils of extremely low permeability.

Medium-salinity water, (C-2) can be used if a moderate amount of leaching occurs. Plants with moderate salt tolerance can be grown in most cases without special practices for salinity control.

High-salinity water, (C-3) cannot be used on soils with restricted drainage. Even with adequate drainage, special management for salinity control may be required and plants with good salt tolerance should be selected.

Very high salinity water, (C-4) is not suitable for irrigation under ordinary conditions, but may be used occasionally under very special circumstances. The soils must be permeable, drainage must be adequate, irrigation water must be applied in excess to provide considerable leaching, and very salt-tolerant crops should be selected.

Table 4.--continued

Sodium

Low-sodium water, (S-1) can be used for irrigation on almost all soils with little danger of the development of harmful levels of exchangeable sodium. However, sodium-sensitive crops such as stone-fruit trees and avocados may accumulate injurious concentrations of sodium.

Medium-sodium water, (S-2) present an appreciable sodium hazard in fine-textured soils having high cation-exchange-capacity, especially under low-leaching conditions, unless gypsum is present in the soil. This water may be used on coarse-textured or organic soils with good permeability.

High-sodium water, (S-3) may produce harmful levels of exchangeable sodium in most soils and will require special soil management--good drainage, high leaching, and organic matter additions. Gypsiferous soils may not develop harmful levels of exchangeable sodium, except that amendments may not be feasible with waters of very high salinity.

Very high sodium water, (S-4) is generally unsatisfactory for irrigation purposes except at low and perhaps medium salinity, where the solution of calcium from the soil or use of gypsum or other amendments may make the use of these waters feasible.

* United States Department of Agriculture, 1954, Agriculture Handbook No. 60

The water samples are thought to be representative of the waters usually yielded by the wells from which they are drawn. It has been shown, however, (Sayre and Livingston, p. 81-83; Piper and Garrett, p. 41) that wells which produce water from several zones yield a mixture of waters that may change in chemical composition as the well is pumped. This is especially true if such a well is gravel packed. When the well is idle, water from the zone of highest head flows into the zones of lower head. Consequently when the well is pumped after being idle for a time it produces water that is native only to the zone of highest head. After this water has been discharged from the well, the quality of water changes as each water-bearing zone begins to yield water that is native to it, and the resulting mixture from the well is a combination of the types of waters in the various water-bearing zones. The mixture produced at a particular pumping rate is proportional to the ability of each of the zones to yield water under the head conditions in the different zones at that rate.

Accordingly, to be sure to obtain a representative water sample for analysis, it is necessary to know the normal routine of pumping, when and for how long the well was last pumped, and the constructional features of the well.

Constituents

The concentration of the constituents in water are expressed in parts per million (ppm) and equivalents per million (epm) to show the relative and absolute concentrations of the materials present. The concentration of any constituent in grains per U. S. gallon (gpg) can be obtained by multiplying values in parts per million by 0.058. The following discussion of the constituents is adapted largely from Water-Supply Paper 658 (Collins, Lamar, and Lohr, 1934).

Silica (SiO_2).--Silica is dissolved from practically all rocks. Its state in natural water is not definitely known, but it is assumed to be in the colloidal state, and to take no part in the equilibrium of water. Silica in water forms scale in boilers. All the samples taken for analysis were collected in pyrex bottles to avoid an increase in silica due to the action of water on ordinary glass.

Iron (Fe).--Iron is dissolved from practically all rocks and is often dissolved from iron pipes, pumps, and iron storage tanks. Separate 6-ounce bottles of water were collected and analyzed for iron. These samples were filtered through a fiberglass filter at the time of collection to remove most of the iron particles suspended in the water. When iron is present both in solution and suspension and has been precipitated by oxidation it is not possible to determine how much was in solution at the time the sample was collected. The iron reported here is that which was in solution at the time of collection.

Water that contains excessive iron stains objects with which it remains in contact, turning them red or reddish brown. Excessive iron may also interfere with the efficient operation of exchange-silicate water softeners. Iron may be removed from water by aeration of the water, followed by settling, or filtration. The pH of the water may require adjustment to reduce its corrosiveness.

Calcium (Ca) and magnesium (Mg).--Calcium and magnesium cause hardness in water. They make up most of the dissolved mineral matter in hard waters. Both calcium and magnesium are dissolved from limestone. Dolomitic limestone is a source of much of the magnesium dissolved in water in some parts of the Coastal Plain of Georgia. Gypsum (calcium sulfate) also may contribute considerable amounts of calcium to water. Some other effects of calcium and magnesium are discussed under "Hardness".

Sodium (Na) and potassium (K).--Sodium and potassium are dissolved from most of the rocks of the earth. These two elements make up a small percentage of the dissolved constituents in water from the Tertiary formations of Georgia but are found in increasing amounts in water from the Upper Cretaceous rocks. These latter rocks contain much feldspar which is the source of some of the sodium. Sodium may also be in water as a result of contamination by sea water. Sea water that was present in rocks at the time of deposition and has not been flushed out is a source of sodium in ground water. Sodium and potassium in water have little effect on the use of the water for most domestic purposes. Water that is high in sodium is usually not suitable for irrigation.

Bicarbonate (HCO_3) and carbonate (CO_3).--The bicarbonate present in natural waters is the result of the action of carbon dioxide dissolved in water upon the carbonate rocks with which it comes in contact. A small amount of carbonate reported in some waters may be the result of the action of the water sample upon the bottle (Collins and Riffenburg, 1923). However, this was avoided here by the use of pyrex glass bottles.

Bicarbonate is the principal acid radical in most ground waters from the Tertiary formations of Georgia, and also in most of the Upper Cretaceous formations.

Sulfate (SO_4).--Sulfate is dissolved from many rocks of the earth. Some of the main sources are sulfides of iron, such as pyrite and marcasite, and gypsum. Pyrite is common in many of the limestones of Georgia and also in some of the sands. Water that has dissolved gypsum may contain more sulfate than bicarbonate. Sulfate in hard water affects the formation of scale in boilers. Sulfate is usually low or absent in the Ocala limestone in the area of outcrop and for some distance downdip from the outcrop. The maximum amount of sulfate determined in this study was 405 ppm in one of the well waters of the supply of Moultrie. However, water from the abandoned well in Valdosta was reported to contain more than 1,000 ppm.

Chloride (Cl).--Chloride is dissolved in small quantities from rocks of the earth. Water that is contaminated by sea water may contain large quantities of chloride. Sewage and industrial wastes may increase the quantity of chloride in some waters. Large quantities of chloride salts in water make the water corrosive. Water that contains excessive amounts of chloride is not suitable for irrigation.

Fluoride (F).--Fluoride is present in rocks of the earth in small quantities. In some areas of the eastern United States ground waters contain concentrations of as much as 15 ppm of fluoride, as in parts of the Atlantic Coastal Plain in Virginia and the Carolinas and of the Gulf Coastal Plain in Texas and Arkansas. Only small quantities of fluoride, generally less than 1 ppm, are present in the ground waters of the Coastal Plain in Georgia.

According to the U. S. Public Health Service (Dean and others, 1941) about 1.0 ppm in water inhibits dental caries (decay) in the teeth of children. In an evaluation of the fluoridation program of Athens, Ga., Chrietzberg and Lewis (1957) stated, "***A dramatic reduction in dental caries of the permanent teeth can be observed in children up to 13 years of age, with the younger ages showing the greatest benefit".

Nitrate (NO_3).--The presence of nitrate in water may result from pollution of water by organic substance, or to solution of nitrate from rocks. Nitrate in small amounts usually can be considered a natural constituent of water, but if it is present in unusual amounts it may indicate pollution of the water. Nitrate is one of the oxidation products of organic matter such as sewage. Nitrate is commonly high in water from dug wells, which are rapidly becoming a thing of the past in some parts of Georgia. Excessive amounts of nitrate in drinking or formula water of infants may cause methemoglobinemia ("blue babies") (Waring, 1949).

Hardness.--Hardness of water is the characteristic that is most noticed by all users. It prevents soap from lathering. Hardness is caused principally by calcium and magnesium and is reported in terms of equivalent calcium carbonate ($CaCO_3$). The hardness of a water may be calculated by multiplying the parts per million of calcium by 2.5 and that of magnesium by 4.1, the sum of which products represents the hardness as $CaCO_3$ in parts per million. The hardness caused by calcium and magnesium equivalent to bicarbonate and carbonate in water is called "carbonate hardness". Hardness in excess of that amount is called "noncarbonate hardness". Hardness of water is objectionable, as it increases consumption of soap and causes scale in boilers which reduces their heat-exchange efficiency. Hardness may be decreased by the addition of lime and soda ash in treatment of water, such as is done at Thomasville, where the hardness in the water is reduced from slightly more than 200 ppm to about 85 ppm (Lohr and Love, 1954). It has been shown (Thomson, Herrick, and Brown, 1956, pl. 3) that hardness of ground waters in Georgia generally increases southward from the Fall Line. Ground waters are classified by the U. S. Geological Survey according to the following scale of hardness:

Water class	Hardness (ppm)
Soft	Less than 60
Moderately hard	61 to 120
Hard	121 to 180
Very hard	More than 180

The hardness of ground waters in this area ranges from 4 to 448 ppm. The waters from the Upper Cretaceous series are usually very soft, and those from the Tertiary formations are moderately hard to very hard.

Dissolved solids.--The dissolved-solids content represents the amount of solid mineral matter remaining from a given quantity of water after the water has been evaporated to dryness at 180°C. It is approximately equal to the amount of mineral matter dissolved in the water, but may include some water of crystallization or occlusion. According to the U. S. Public Health Service, waters containing less than 500 ppm of dissolved solids are generally suitable for domestic and industrial purposes. Water containing more than 1,000 ppm of dissolved solids generally is not suitable for domestic purposes and many industrial purposes, but may be used for irrigation under certain conditions.

Specific conductance (K x 10^6 at 25°C).--The specific conductance of water, expressed as micromhos at 25°C, is an indication of the dissolved-solids content, which generally is approximately equal to the specific conductance multiplied by a factor of 0.6 to 0.7.

Temperature.--The temperatures reported here were taken at the well as the water sample was collected, and are thought to be representative of the temperature of the water in the aquifer from which it was obtained. The temperature of water samples collected from a main or storage tank is affected by the weather and does not represent the temperature of the water in the formation. Temperature of ground water does not vary much throughout the year. The average temperature of ground water in formations near the land surface is usually about the same as the average annual air temperature of the area. Temperature of ground water increases with depth, usually at about 1°F for each 50 to 100 feet of increased depth. The temperature of water collected during this investigation ranged from 67° to 77°F.

Hydrogen-ion concentration (pH).--The hydrogen ion concentration of water is expressed as the pH. Technically it is the negative exponent of the concentration of hydrogen ions in gram atoms per liter. Water having a pH of 7.0 is neutral on the pH scale. Values less than 7 indicate acidity and values greater than 7 indicate alkalinity. According to Collins, Lamar, and Lohr (1934, p. 8), "***determination of pH must be made almost as soon as samples are collected." The pH values reported here were determined in this laboratory at varying times after the samples were collected and may not, therefore, be strictly representative of the water at the well.

Conclusions

Ground water of excellent quality may be obtained throughout southwestern Georgia. The water from the Tertiary formations is chiefly of the calcium bicarbonate type and is moderately hard to very hard and alkaline. That from the Upper Cretaceous rocks is of the sodium bicarbonate type and is soft and slightly alkaline. Dissolved solids are usually moderate and consist mostly of calcium or sodium and bicarbonate. Ground water from the Ocala limestone usually is low in sulfate near the area of outcrop, but the sulfate increases downdip and in the Valdosta area sulfate is reported to be extremely high. In the vicinity of the Withlacoochee anticline near Thomasville water from a depth of about 1,600 feet was too saline for most uses. The temperature of ground waters in the area ranged from 67° to 77°F.

The quality of ground water in southwestern Georgia is generally suitable for municipal, industrial, and irrigational uses of the water, though some softening of the very hard waters is desirable for domestic uses.

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APPENDIX

Records of chemical analyses and well-construction information.

Location: Adel, Cook County
Owner: Municipal
Well No.: City Well 4
Date drilled: June, 1957
Yield: 1,200 gpm

G.G.S. No.: --

Color: 2
Temperature (°F): 71
Date of collection: April 18, 1958

pH: 7.7
Specific conductance (micromhos 25°C): 399

Constituents	Parts per million	Equivalents per million
Silica (SiO_2)	33	
Iron (Fe)	.26	
Calcium (Ca)	53	2.64
Magnesium (Mg)	16	1.32
Sodium (Na)	4.6	.20
Potassium (K)	1.4	.04
Bicarbonate (HCO_3)	144	2.36
Carbonate (CO_3)	0	.00
Sulfate (SO_4)	87	1.81
Chloride (Cl)	4.0	.11
Fluoride (F)	.3	.02
Nitrate (NO_3)	.1	.00
Dissolved solids	289	
Hardness as $CaCO_3$		
Total	. . 198	
Noncarbonate	. . 80	

Casing record					Aquifer
Size (inches)	From (feet)	To (feet)	Depth of well (feet)	Screen setting (feet)	
16	0	46			
12	46	276	500	276-500[a]	Ocala limestone

a/ Open hole in limestone

Location: Albany, Dougherty County
Owner: Municipal
Well No.: City Well 13
Date drilled: December, 1951
Yield: 1,534 gpm
G.G.S. No.: 322

Color: 2
Temperature (°F): 73
Date of collection: May 15, 1957
pH: 8.0
Specific conductance (micromhos 25°C): 362

Constituents	Parts per million	Equivalents per million
Silica (SiO_2)	26	
Iron (Fe)	.06	
Calcium (Ca)	24	1.20
Magnesium (Mg)	9.2	.76
Sodium (Na)	45	1.96
Potassium (K)	2.0	.05
Bicarbonate (HCO_3)	221	3.52
Carbonate (CO_3)	0	.00
Sulfate (SO_4)	9.5	.20
Chloride (Cl)	6.8	.19
Fluoride (F)	.4	.02
Nitrate (NO_3)	.3	.00
Dissolved solids	238	
Hardness as $CaCO_3$		
Total	. . 98	
Noncarbonate	. . 0	

Casing record					Aquifer
Size (inches)	From (feet)	To (feet)	Depth of well (feet)	Screen setting (feet)	
26	0	45			
20	0	250			
10	230	676	800	270-275	Tallahatta formation
				290-300	Do.
				312-322	Do.
				335-345	Do.
				373-378	Do.
				400-420	Do.
				430-460	Do.
				480-490	Do.
				676-800 a/	Clayton formation

a/ Open hole in limestone

Location: Americus, Sumter County
Owner: Municipal
Well No.: Gray Well
Date drilled: 1927
Yield: --
G.G.S. No.: --

Color: 3
Temperature (°F): 69
Date of collection: April 1, 1958
pH: 7.4
Specific conductance (micromhos 25°C): 240

Constituents	Parts per million	Equivalents per million
Silica (SiO_2)	25	
Iron (Fe)	.37	
Calcium (Ca)	42	2.10
Magnesium (Mg)	3.2	.26
Sodium (Na)	2.7	.12
Potassium (K)	2.6	.07
Bicarbonate (HCO_3)	133	2.18
Carbonate (CO_3)	0	.00
Sulfate (SO_4)	17	.35
Chloride (Cl)	2.2	.06
Fluoride (F)	.2	.01
Nitrate (NO_3)	.0	.00
Dissolved solids	175	
Hardness as $CaCO_3$		
Total	118	
Noncarbonate	9	

Casing record					Aquifer
Size (inches)	From (feet)	To (feet)	Depth of well (feet)	Screen setting (feet)	
--	--	--	±200	--	Clayton formation

Location: Ashburn, Turner County
Owner: Municipal
Well No.: City Well 2
Date drilled: 1949
Yield: 460 gpm
G.G.S. No.: --

Color: 3
Temperature (°F): 70
Date of collection: April 25, 1958
pH: 7.9
Specific conductance (micromhos 25°C): 164

Constituents	Parts per million	Equivalents per million
Silica (SiO_2)	19	
Iron (Fe)	.03	
Calcium (Ca)	22	1.10
Magnesium (Mg)	6.1	.50
Sodium (Na)	2.6	.11
Potassium (K)	.8	.02
Bicarbonate (HCO_3)	102	1.67
Carbonate (CO_3)	0	.00
Sulfate (SO_4)	1.5	.03
Chloride (Cl)	2.0	.06
Fluoride (F)	.5	.03
Nitrate (NO_3)	.1	.00
Dissolved solids	103	
Hardness as $CaCO_3$		
Total	80	
Noncarbonate	0	

Casing record					Aquifer
Size (inches)	From (feet)	To (feet)	Depth of well (feet)	Screen setting (feet)	
12	0	250	648	a/	

a/ Open hole in limestone

Location: Bainbridge, Decatur County
Owner: Municipal
Well No.: City Well 4
Date drilled: May, 1951
Yield: 1,550 gpm
G.G.S. No.: 228

Color: 2
Temperature (°F): 66 (from tap)
Date of collection: February 26, 1958
pH: 7.7
Specific conductance (micromhos 25°C): 201

Constituents	Parts per million	Equivalents per million
Silica (SiO_2)	7.8	
Iron (Fe)	.01	
Calcium (Ca)	36	1.80
Magnesium (Mg)	3.6	.30
Sodium (Na)	1.5	.07
Potassium (K)	.1	.00
Bicarbonate (HCO_3)	122	2.00
Carbonate (CO_3)	0	.00
Sulfate (SO_4)	.5	.01
Chloride (Cl)	2.8	.08
Fluoride (F)	.1	.01
Nitrate (NO_3)	1.2	.02
Dissolved solids	124	
Hardness as $CaCO_3$		
Total	105	
Noncarbonate	5	

Casing record					Aquifer
Size (inches)	From (feet)	To (feet)	Depth of well (feet)	Screen setting (feet)	
20	0	147	485	147-485 a/	Ocala limestone

a/ Open hole in limestone

Location: Blakely, Early County
Owner: Municipal
Well No.: City Well 2
Date drilled: --
Yield: --

G.G.S. No.: 321

Color: 1
Temperature (°F): 77
Date of collection: May 13, 1958

pH: 8.4
Specific conductance (micromhos 25°C): 342

Constituents	Parts per million	Equivalents per million
Silica (SiO_2)	15	
Iron (Fe)	.01	
Calcium (Ca)	3.2	.16
Magnesium (Mg)	1.5	.12
Sodium (Na)	78	3.39
Potassium (K)	1.8	.05
Bicarbonate (HCO_3)	184	3.02
Carbonate (CO_3)	3	.10
Sulfate (SO_4)	16	.33
Chloride (Cl)	7.0	.20
Fluoride (F)	.6	.03
Nitrate (NO_3)	.7	.01
Dissolved solids	214	
Hardness as $CaCO_3$		
Total	14	
Noncarbonate	0	

Casing record					Aquifer
Size (inches)	From (feet)	To (feet)	Depth of well (feet)	Screen setting (feet)	
12	0	300		---	
10	300	960	900	---	Upper Cretaceous series

Location: Bronwood, Terrell County
Owner: Municipal
Well No.: City Well 2
Date drilled: November, 1954
Yield: 260 gpm
G.G.S. No.: 406

Color: 3
Temperature (°F): 71
Date of collection: April 8, 1958
pH: 7.7
Specific conductance (micromhos 25°C): 222

Constituents	Parts per million	Equivalents per million
Silica (SiO_2)	25	
Iron (Fe)	.11	
Calcium (Ca)	32	1.60
Magnesium (Mg)	3.4	.28
Sodium (Na)	9.3	.40
Potassium (K)	2.0	.05
Bicarbonate (HCO_3)	116	1.90
Carbonate (CO_3)	0	.00
Sulfate (SO_4)	5.5	.11
Chloride (Cl)	2.2	.06
Fluoride (F)	.2	.01
Nitrate (NO_3)	.0	.00
Dissolved solids	143	
Hardness as $CaCO_3$		
Total	94	
Noncarbonate	0	

Casing record					Aquifer
Size (inches)	From (feet)	To (feet)	Depth of well (feet)	Screen setting (feet)	
8	0	395	453		Clayton formation
				395-453 a/	

a/ Open hole in limestone

Location: Cairo, Grady County
Owner: Municipal
Well No.: City Wells 3 and 4
Date drilled: Well 3, Aug., 1946, Well 4, April, 1950
Yield: ---
G.G.S. No.: Well 3, 141 Well 4, 205

Color: 1
Temperature (°F): 74
Date of collection: May 12, 1958
pH: 7.7
Specific conductance (micromhos 25°C): 829

Constituents	Parts per million	Equivalents per million
Silica (SiO_2)	18	
Iron (Fe)	.01	
Calcium (Ca)	75	3.74
Magnesium (Mg)	36	2.96
Sodium (Na)	45	1.96
Potassium (K)	3.7	.09
Bicarbonate (HCO_3)	152	2.49
Carbonate (CO_3)	0	.00
Sulfate (SO_4)	255	5.31
Chloride (Cl)	42	1.18
Fluoride (F)	.5	.03
Nitrate (NO_3)	.0	.00
Dissolved solids	605	
Hardness as $CaCO_3$		
Total	335	
Noncarbonate	210	

Casing record					Aquifer
Size (inches)	From (feet)	To (feet)	Depth of well (feet)	Screen setting (feet)	
12	0	280	495	280-495 a/	) Miocene series
12	0	300	586	300-586 a/	) Oligocene series
					Ocala ls.

Location: Camilla, Mitchell County
Owner: Municipal
Well No.: City Well 4
Date drilled: November, 1957
Yield: 2,000 gpm
G.G.S. No.: 564

Color: 1
Temperature (°F): 69
Date of collection: May 8, 1958
pH: 7.8
Specific conductance (micromhos 25°C): 249

Constituents	Parts per million	Equivalents per million
Silica (SiO_2)	9.4	
Iron (Fe)	.01	
Calcium (Ca)	48	2.40
Magnesium (Mg)	.0	.00
Sodium (Na)	2.6	.11
Potassium (K)	.4	.01
Bicarbonate (HCO_3)	150	2.46
Carbonate (CO_3)	0	.00
Sulfate (SO_4)	.8	.02
Chloride (Cl)	4.0	.11
Fluoride (F)	.0	.00
Nitrate (NO_3)	2.3	.04
Dissolved solids	140	
Hardness as $CaCO_3$		
Total	120	
Noncarbonate	0	

Casing record					Aquifer
Size (inches)	From (feet)	To (feet)	Depth of well (feet)	Screen setting (feet)	
12	0	150	355	150-355 a/	Ocala limestone

a/ Open hole in limestone

Location: Colquitt, Miller County
Owner: Municipal
Well No.: City Well 2
Date drilled: 1947-48
Yield: 350 gpm
G.G.S. No.: ---

Color: 0
Temperature (°F): 70
Date of collection: May 13, 1958
pH: 7.7
Specific conductance (micromhos 25°C): 219

Constituents	Parts per million	Equivalents per million
Silica (SiO_2)	7.1	
Iron (Fe)	.01	
Calcium (Ca)	42	2.10
Magnesium (Mg)	.2	.02
Sodium (Na)	2.0	.09
Potassium (K)	.1	.00
Bicarbonate (HCO_3)	130	2.13
Carbonate (CO_3)	0	.00
Sulfate (SO_4)	.5	.01
Chloride (Cl)	3.0	.08
Fluoride (F)	.1	.01
Nitrate (NO_3)	2.5	.04
Dissolved solids	125	
Hardness as $CaCO_3$		
Total	106	
Noncarbonate	0	

Casing record					Aquifer
Size (inches)	From (feet)	To (feet)	Depth of well (feet)	Screen setting (feet)	
8	---	---	234	-234 a/	Ocala limestone

a/ Open hole in limestone

Location: Cordele, Crisp County
Owner: Municipal
Well No.: City Well 4
Date drilled: 1954
Yield: 1,230 gpm
G.G.S. No.: 390

Color: 1
Temperature (°F): 71
Date of collection: May 14, 1958
pH: 7.6
Specific conductance (micromhos 25°C): 261

Constituents	Parts per million	Equivalents per million
Silica (SiO_2)	19	
Iron (Fe)	.00	
Calcium (Ca)	49	2.45
Magnesium (Mg)	1.8	.15
Sodium (Na)	1.9	.08
Potassium (K)	.8	.02
Bicarbonate (HCO_3)	149	2.44
Carbonate (CO_3)	0	.00
Sulfate (SO_4)	7.5	.16
Chloride (Cl)	3.0	.08
Fluoride (F)	.2	.01
Nitrate (NO_3)	.3	.00
Dissolved solids	160	
Hardness as $CaCO_3$		
Total	. . 130	
Noncarbonate	. . 8	

Casing record					Aquifer
Size (inches)	From (feet)	To (feet)	Depth of well (feet)	Screen setting (feet)	
26	0	145			
20	0	245			
12	200	600		270-280	Claiborne group
				350-360	Do.
				375-385	Do.
				410-420	Do.
				430-460	Do.
				490-510	Do.
				580-590	Wilcox group

Location: Cuthbert, Randolph County
Owner: Municipal
Well No.: City Well 3
Date drilled: January, 1958
Yield: 400 gpm
G.G.S. No.: 552

Color: 5
Temperature (°F): 68
Date of collection: April 8, 1958
pH: 7.8
Specific conductance (micromhos 25°C): 254

Constituents	Parts per million	Equivalents per million
Silica (SiO_2)	17	
Iron (Fe)	.29	
Calcium (Ca)	39	1.95
Magnesium (Mg)	8.4	.69
Sodium (Na)	1.4	.06
Potassium (K)	1.1	.03
Bicarbonate (HCO_3)	147	2.41
Carbonate (CO_3)	.0	.00
Sulfate (SO_4)	12	.25
Chloride (Cl)	2.5	.07
Fluoride (F)	.1	.01
Nitrate (NO_3)	.0	.00
Dissolved solids	153	
Hardness as $CaCO_3$		
Total	132	
Noncarbonate	12	

Casing record					Aquifer
Size (inches)	From (feet)	To (feet)	Depth of well (feet)	Screen setting (feet)	
8	0	250	350	a/	Clayton formation

a/ Open hole in limestone

Location: Dawson, Terrell County
Owner: Municipal
Well No.: City Well 3
Date drilled: December, 1950
Yield: 800 gpm
G.G.S. No.: 213

Color: 3
Temperature (°F): 71
Date of collection: April 8, 1958
pH: 7.6
Specific conductance (micromhos 25°C): 249

Constituents	Parts per million	Equivalents per million
Silica (SiO_2)	26	
Iron (Fe)	.08	
Calcium (Ca)	40	2.00
Magnesium (Mg)	3.9	.32
Sodium (Na)	6.5	.28
Potassium (K)	2.0	.05
Bicarbonate (HCO_3)	143	2.34
Carbonate (CO_3)	0	.00
Sulfate (SO_4)	13	.27
Chloride (Cl)	2.0	.06
Fluoride (F)	.1	.01
Nitrate (NO_3)	.0	.00
Dissolved solids	164	
Hardness as $CaCO_3$		
Total	116	
Noncarbonate	0	

Casing record					Aquifer
Size (inches)	From (feet)	To (feet)	Depth of well (feet)	Screen setting (feet)	
20	0	345	496	345-496 a/	Clayton formation

a/ Open hole in limestone

Location: Donaldsonville, Seminole County
Owner: Municipal
Well No.: City Well 2
Date drilled: ---
Yield: 225 gpm
G.G.S. No.: ---

Color: 3
Temperature (°F): 69
Date of collection: February 26, 1958
pH: 7.5
Specific conductance (micromhos 25°C): 250

Constituents	Parts per million	Equivalents per million
Silica (SiO_2)	6.1	
Iron (Fe)	.01	
Calcium (Ca)	50	2.50
Magnesium (Mg)	.2	.02
Sodium (Na)	2.3	.10
Potassium (K)	.1	.00
Bicarbonate (HCO_3)	153	2.51
Carbonate (CO_3)	0	.00
Sulfate (SO_4)	.2	.00
Chloride (Cl)	3.5	.10
Fluoride (F)	.0	.00
Nitrate (NO_3)	1.4	.02
Dissolved solids	140	
Hardness as $CaCO_3$		
Total	126	
Noncarbonate	0	

Casing record					Aquifer
Size (inches)	From (feet)	To (feet)	Depth of well (feet)	Screen setting (feet)	
8	0	180	210	180-210	Ocala limestone

a/ Open hole in limestone

Location: Edison, Calhoun County
Owner: Municipal
Well No.: City Well 2
Date drilled: July, 1953
Yield: 250 (Est.) gpm
G.G.S. No.: 353

Color: 1
Temperature (°F): 71
Date of collection: May 9, 1958
pH: 7.7
Specific conductance (micromhos 25°C): 251

Constituents	Parts per million	Equivalents per million
Silica (SiO_2)	23	
Iron (Fe)	.15	
Calcium (Ca)	35	1.75
Magnesium (Mg)	5.0	.41
Sodium (Na)	12	.52
Potassium (K)	1.9	.05
Bicarbonate (HCO_3)	149	2.44
Carbonate (CO_3)	0	.00
Sulfate (SO_4)	9.5	.20
Chloride (Cl)	.0	.00
Fluoride (F)	.1	.01
Nitrate (NO_3)	.2	.00
Dissolved solids	161	
Hardness as $CaCO_3$		
Total	108	
Noncarbonate	0	

Casing record					Aquifer
Size (inches)	From (feet)	To (feet)	Depth of well (feet)	Screen setting (feet)	
8	0	395	515	395-515 a/	Clayton formation

a/ Open hole in limestone

Location: Fort Gaines, Clay County
Owner: Municipal
Well No.: City Well 3
Date drilled: March 1958
Yield: 300 gpm pump; 100 gpm flow

G.G.S. No.: 556

Color: 4
Temperature (°F): 68
Date of collection: April 8, 1958

pH: 8.3
Specific conductance (micromhos 25°C): 403

Constituents	Parts per million	Equivalents per million
Silica (SiO_2)	16	
Iron (Fe)	.15	
Calcium (Ca)	5.6	.28
Magnesium (Mg)	1.5	.12
Sodium (Na)	90	3.92
Potassium (K)	1.7	.04
Bicarbonate (HCO_3)	226	3.70
Carbonate (CO_3)	0	.00
Sulfate (SO_4)	12	.25
Chloride (Cl)	15	.42
Fluoride (F)	1.0	.05
Nitrate (NO_3)	.0	.00
Dissolved solids	251	
Hardness as $CaCO_3$		
Total	20	
Noncarbonate	0	

Casing record					Aquifer
Size (inches)	From (feet)	To (feet)	Depth of well (feet)	Screen setting (feet)	
8	0	370	370	310-320	Upper Cretaceous series
				350-360	Do.

Location: Georgetown, Quitman County
Owner: Municipal
Well No.: City Well 1
Date drilled: October, 1956
Yield: 100 gpm
G.G.S. No.: 502

Color: 5
Temperature (°F): --
Date of collection: April 8, 1958
pH: 8.5
Specific conductance (micromhos 25°C): 497

Constituents	Parts per million	Equivalents per million
Silica (SiO_2)	15	
Iron (Fe)	.06	
Calcium (Ca)	1.6	.08
Magnesium (Mg)	.0	.00
Sodium (Na)	123	5.35
Potassium (K)	2.4	.06
Bicarbonate (HCO_3)	319	5.23
Carbonate (CO_3)	6	.20
Sulfate (SO_4)	.0	.00
Chloride (Cl)	7.0	.20
Fluoride (F)	.7	.04
Nitrate (NO_3)	.0	.00
Dissolved solids	326	
Hardness as $CaCO_3$		
Total	4	
Noncarbonate	0	

Casing record					Aquifer
Size (inches)	From (feet)	To (feet)	Depth of well (feet)	Screen setting (feet)	
6	0	300	1,365	1,325-1,360	Eutaw formation
4	300	1,365			

Location: Leesburg, Lee County
Owner: Municipal
Well No.: City Well
Date drilled: May, 1938
Yield: --
G.G.S. No.: --

Color: 3
Temperature (°F): --
Date of collection: April 1, 1958
pH: 7.5
Specific conductance (micromhos 25°C): 240

Constituents	Parts per million	Equivalents per million
Silica (SiO_2)	15	
Iron (Fe)	.01	
Calcium (Ca)	44	2.20
Magnesium (Mg)	2.2	.18
Sodium (Na)	2.6	.11
Potassium (K)	.4	.01
Bicarbonate (HCO_3)	144	2.36
Carbonate (CO_3)	0	.00
Sulfate (SO_4)	1.5	.03
Chloride (Cl)	3.0	.08
Fluoride (F)	.2	.01
Nitrate (NO_3)	2.1	.03
Dissolved solids	144	
Hardness as $CaCO_3$		
Total	119	
Noncarbonate	1	

Casing record					Aquifer
Size (inches)	From (feet)	To (feet)	Depth of well (feet)	Screen setting (feet)	
8	0	320	320	---	Claiborne group

Location: Leslie, Sumter County
Owner: Municipal
Well No.: City Well 1
Date drilled: 1927
Yield: ---
G.G.S. No.: ---

Color: 4
Temperature (°F): 68
Date of collection: April 1, 1958
pH: 7.6
Specific conductance (micromhos 25°C): 214

Constituents	Parts per million	Equivalents per million
Silica (SiO_2)	21	
Iron (Fe)	.06	
Calcium (Ca)	43	2.15
Magnesium (Mg)	1.6	.13
Sodium (Na)	1.0	.04
Potassium (K)	.2	.01
Bicarbonate (HCO_3)	134	2.20
Carbonate (CO_3)	0	.00
Sulfate (SO_4)	3.2	.07
Chloride (Cl)	2.0	.06
Fluoride (F)	.2	.01
Nitrate (NO_3)	.1	.00
Dissolved solids	137	
Hardness as $CaCO_3$		
Total	114	
Noncarbonate	4	

Casing record					Aquifer
Size (inches)	From (feet)	To (feet)	Depth of well (feet)	Screen setting (feet)	
8	0	210			Claiborne group

Location: Merck and Co[redacted], Dougherty County
Owner: Private, (Merck and Co[redacted])
Well No.: Owner's Well 1
Date drilled: December, 1951
Yield: 1,000 gpm
G.G.S. No.: 253

Color: 2
Temperature (°F): 69
Date of collection: May 2, 1957
pH: 7.7
Specific conductance (micromhos 25°C): 239

Constituents	Parts per million	Equivalents per million
Silica (SiO_2)	11	
Iron (Fe)	.08	
Calcium (Ca)	47	2.35
Magnesium (Mg)	1.1	.09
Sodium (Na)	2.2	.10
Potassium (K)	.2	.01
Bicarbonate (HCO_3)	150	2.46
Carbonate (CO_3)	0	.00
Sulfate (SO_4)	.2	.00
Chloride (Cl)	2.0	.06
Fluoride (F)	.0	.00
Nitrate (NO_3)	1.3	.02
Dissolved solids	143	
Hardness as $CaCO_3$		
Total	122	
Noncarbonate	0	

Casing record					Aquifer
Size (inches)	From (feet)	To (feet)	Depth of well (feet)	Screen setting (feet)	
10	0	80	247	80-247 a/	Ocala limestone, Lisbon formation

a/ Open hole in limestone

Location: Moultrie, Colquitt County
Owner: Municipal
Well No.: City Well 3
Date drilled: December, 1949
Yield: --
G.G.S. No.: ---

Color: 4
Temperature (°F): 75
Date of collection: April 9, 1958
pH: 7.8
Specific conductance (micromhos 25°C): 966

Constituents	Parts per million	Equivalents per million
Silica (SiO_2)	24	
Iron (Fe)	.10	
Calcium (Ca)	102	5.09
Magnesium (Mg)	47	3.87
Sodium (Na)	38	1.65
Potassium (K)	5.7	.15
Bicarbonate (HCO_3)	140	2.29
Carbonate (CO_3)	0	.00
Sulfate (SO_4)	405	8.43
Chloride (Cl)	12	.34
Fluoride (F)	1.2	.06
Nitrate (NO_3)	.0	.00
Dissolved solids	761	
Hardness as $CaCO_3$		
Total	448	
Noncarbonate	334	

Casing record					Aquifer
Size (inches)	From (feet)	To (feet)	Depth of well (feet)	Screen setting (feet)	
16	0	425	752	425-752 a/	Oligocene series
					Ocala limestone

a/ Open hole in limestone

Location: Newton, Baker County
Owner: Municipal
Well No.: City Well 2
Date drilled: --
Yield: --
G.G.S. No.: --

Color: 0
Temperature (°F): 70
Date of collection: May 13, 1958
pH: 7.8
Specific conductance (micromhos 25°C): 218

Constituents	Parts per million	Equivalents per million
Silica (SiO_2)	15	
Iron (Fe)	.01	
Calcium (Ca)	36	1.80
Magnesium (Mg)	3.4	.28
Sodium (Na)	6.0	.26
Potassium (K)	.7	.02
Bicarbonate (HCO_3)	131	2.15
Carbonate (CO_3)	0	.00
Sulfate (SO_4)	3.0	.06
Chloride (Cl)	2.0	.06
Fluoride (F)	.1	.01
Nitrate (NO_3)	1.5	.02
Dissolved solids	127	
Hardness as $CaCO_3$		
Total	104	
Noncarbonate	0	

Casing record					Aquifer
Size (inches)	From (feet)	To (feet)	Depth of well (feet)	Screen setting (feet)	
8	0	---	475	-475 a/	Ocala limestone

a/ Open hole in limestone

Location: Plains, Sumter County
Owner: Municipal
Well No.: City Well 2
Date drilled: June, 1952
Yield: --
G.G.S. No.: --

Color: 3
Temperature (°F): 68
Date of collection: April 1, 1958
pH: 7.3
Specific conductance (micromhos 25°C): 150

Constituents	Parts per million	Equivalents per million
Silica (SiO_2)	49	
Iron (Fe)	.11	
Calcium (Ca)	22	1.10
Magnesium (Mg)	3.6	.30
Sodium (Na)	2.4	.10
Potassium (K)	3.1	.08
Bicarbonate (HCO_3)	76	1.25
Carbonate (CO_3)	0	.00
Sulfate (SO_4)	12	.25
Chloride (Cl)	2.2	.06
Fluoride (F)	.1	.01
Nitrate (NO_3)	.5	.01
Dissolved solids	131	
Hardness as $CaCO_3$		
Total	70	
Noncarbonate	8	

Casing record					Aquifer
Size (inches)	From (feet)	To (feet)	Depth of well (feet)	Screen setting (feet)	
18	0	86			
8	65	247		170-180	Wilcox group
				197-202	Do.
			514	247-514 a/	Clayton formation

a/ Open hole in limestone

Location: Quitman, Brooks County
Owner: Municipal
Well No.: City Well 3
Date drilled: 1954
Yield: 700 gpm
G.G.S. No.: --

Color: 0
Temperature (°F): 70
Date of collection: May 12, 1958
pH: 7.5
Specific conductance (micromhos 25°C): 268

Constituents	Parts per million	Equivalents per million
Silica (SiO_2)	17	
Iron (Fe)	.00	
Calcium (Ca)	40	2.00
Magnesium (Mg)	8.3	.68
Sodium (Na)	2.5	.11
Potassium (K)	.6	.02
Bicarbonate (HCO_3)	162	2.66
Carbonate (CO_3)	0	.00
Sulfate (SO_4)	1.2	.02
Chloride (Cl)	3.5	.10
Fluoride (F)	.2	.01
Nitrate (NO_3)	.5	.01
Dissolved solids	154	
Hardness as $CaCO_3$		
Total	134	
Noncarbonate	1	

Casing record					Aquifer
Size (inches)	From (feet)	To (feet)	Depth of well (feet)	Screen setting (feet)	
12	0	120	304	120-304 a/	Miocene series
					Oligocene series
					Ocala limestone

a/ Open hole in limestone

Location: Smithville, Lee County
Owner: Municipal
Well No.: City Well
Date drilled: December, 1950
Yield: --
G.G.S. No.: --

Color: 3
Temperature (°F): 68.5
Date of collection: April 1, 1958
pH: 6.6
Specific conductance (micromhos 25°C): 113

Constituents	Parts per million	Equivalents per million
Silica (SiO_2)	15	
Iron (Fe)	.02	
Calcium (Ca)	16	.80
Magnesium (Mg)	.5	.04
Sodium (Na)	5.7	.25
Potassium (K)	.4	.01
Bicarbonate (HCO_3)	48	.79
Carbonate (CO_3)	0	.00
Sulfate (SO_4)	.0	.00
Chloride (Cl)	8.2	.23
Fluoride (F)	.0	.00
Nitrate (NO_3)	5.3	.09
Dissolved solids	81	
Hardness as $CaCO_3$		
Total	42	
Noncarbonate	2	

Casing record					Aquifer
Size (inches)	From (feet)	To (feet)	Depth of well (feet)	Screen setting (feet)	
14	0	40			
8	0	140			
4	140	180	185	105-140	Ocala Limestone
				170-180	Claiborne group

Location: Sylvester, Worth County
Owner: Municipal
Well No.: City Well 1
Date drilled: Prior to 1926
Yield: 540 gpm

G.G.S. No.: --

Color: 3
Temperature (°F): 71
Date of collection: April 25, 1958

pH: 7.8
Specific conductance (micromhos 25°C): 294

Constituents	Parts per million	Equivalents per million
Silica (SiO_2)	26	
Iron (Fe)	.07	
Calcium (Ca)	45	2.25
Magnesium (Mg)	7.4	.61
Sodium (Na)	3.5	.15
Potassium (K)	1.1	.03
Bicarbonate (HCO_3)	190	3.11
Carbonate (CO_3)	0	.00
Sulfate (SO_4)	1.8	.04
Chloride (Cl)	3.2	.09
Fluoride (F)	.2	.01
Nitrate (NO_3)	.2	.00
Dissolved solids	180	
Hardness as $CaCO_3$		
Total	143	
Noncarbonate	0	

Casing record					Aquifer
Size (inches)	From (feet)	To (feet)	Depth of well (feet)	Screen setting (feet)	
12	--	--	400	a/	Oligocene series
					Ocala limestone

a/ Open hole in limestone

Location: Thomasville, Thomas County
Owner: Municipal
Well No.: City Well 5
Date drilled: February, 1949
Yield: 1,200 gpm
G.G.S. No.: --

Color: 2
Temperature (°F): 76
Date of collection: May 8, 1958
pH: 7.8
Specific conductance (micromhos 25°C): 418

Constituents	Parts per million	Equivalents per million
Silica (SiO_2)	22	
Iron (Fe)	.00	
Calcium (Ca)	47	2.35
Magnesium (Mg)	20	1.64
Sodium (Na)	7.8	.34
Potassium (K)	1.0	.03
Bicarbonate (HCO_3)	158	2.59
Carbonate (CO_3)	0	.00
Sulfate (SO_4)	82	1.71
Chloride (Cl)	9.0	.25
Fluoride (F)	.4	.02
Nitrate (NO_3)	.0	.00
Dissolved solids	288	
Hardness as $CaCO_3$		
Total	200	
Noncarbonate	70	

Casing record					Aquifer
Size (inches)	From (feet)	To (feet)	Depth of well (feet)	Screen setting (feet)	
16	0	95	400	95-400 a/	Oligocene series
					Ocala limestone

a/ Open hole in limestone

Location: Tifton, Tift County
Owner: Municipal
Well No.: City Well 2
Date drilled: 1940
Yield: --

G.G.S. No.: 292

Color: 2
Temperature (°F): 72
Date of collection: April 28, 1958

pH: 7.9
Specific conductance (micromhos 25°C): 271

Constituents	Parts per million	Equivalents per million
Silica (SiO_2)	18	
Iron (Fe)	.14	
Calcium (Ca)	40	2.00
Magnesium (Mg)	8.3	.68
Sodium (Na)	2.9	.13
Potassium (K)	.9	.02
Bicarbonate (HCO_3)	178	2.92
Carbonate (CO_3)	0	.00
Sulfate (SO_4)	.8	.02
Chloride (Cl)	2.8	.08
Fluoride (F)	.2	.01
Nitrate (NO_3)	.1	.00
Dissolved solids	161	
Hardness as $CaCO_3$		
Total	134	
Noncarbonate	0	

Casing record					Aquifer
Size (inches)	From (feet)	To (feet)	Depth of well (feet)	Screen setting (feet)	
12	0	--	501	-501 a/	Miocene series Oligocene series

a/ Open hole in limestone

Location: Valdosta, Lowndes County
Owner: Municipal
Well No.: City Well 4
Date drilled: August, 1957
Yield: --

G.G.S. No.: 511

Color: 34
Temperature (°F): --
Date of collection: August 27, 1957

pH: 7.3
Specific conductance (micromhos 25°C): 149

Constituents	Parts per million	Equivalents per million
Silica (SiO_2)	12	
Iron (Fe)	.07	
Calcium (Ca)	23	1.15
Magnesium (Mg)	2.8	.23
Sodium (Na)	4.7	.20
Potassium (K)	.4	.01
Bicarbonate (HCO_3)	81	1.33
Carbonate (CO_3)	0	.00
Sulfate (SO_4)	.8	.02
Chloride (Cl)	7.8	.22
Fluoride (F)	.3	.02
Nitrate (NO_3)	.0	.00
Dissolved solids	105	
Hardness as $CaCO_3$		
Total	69	
Noncarbonate	2	

Casing record					Aquifer
Size (inches)	From (feet)	To (feet)	Depth of well (feet)	Screen setting (feet)	
8	0	190	400	190-400 a/	Miocene series
					Oligocene series

a/ Open hole in limestone

Location: Vienna, Dooly County
Owner: Municipal
Well No.: City Well 2
Date drilled: March, 1947
Yield: 800 gpm
G.G.S. No.: 143

Color: 2
pH: 7.5
Temperature (°F): 69
Specific conductance (micromhos 25°C): 254
Date of collection: May 14, 1958

Constituents	Parts per million	Equivalents per million
Silica (SiO_2)	15	
Iron (Fe)	.09	
Calcium (Ca)	50	2.50
Magnesium (Mg)	.2	.02
Sodium (Na)	1.8	.08
Potassium (K)	.2	.01
Bicarbonate (HCO_3)	153	2.51
Carbonate (CO_3)	0	.00
Sulfate (SO_4)	7.0	.15
Chloride (Cl)	2.0	.06
Fluoride (F)	.1	.01
Nitrate (NO_3)	.2	.00
Dissolved solids	151	
Hardness as $CaCO_3$		
Total	126	
Noncarbonate	0	

Casing record					Aquifer
Size (inches)	From (feet)	To (feet)	Depth of well (feet)	Screen setting (feet)	
20	0	200			
10	181	581	581	250-260	Claiborne group
				292-312	Do.
				322-342	Do.
				352-362	Do.
				380-390	Do.
				408-413	Do.
				566-571	Wilcox group

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