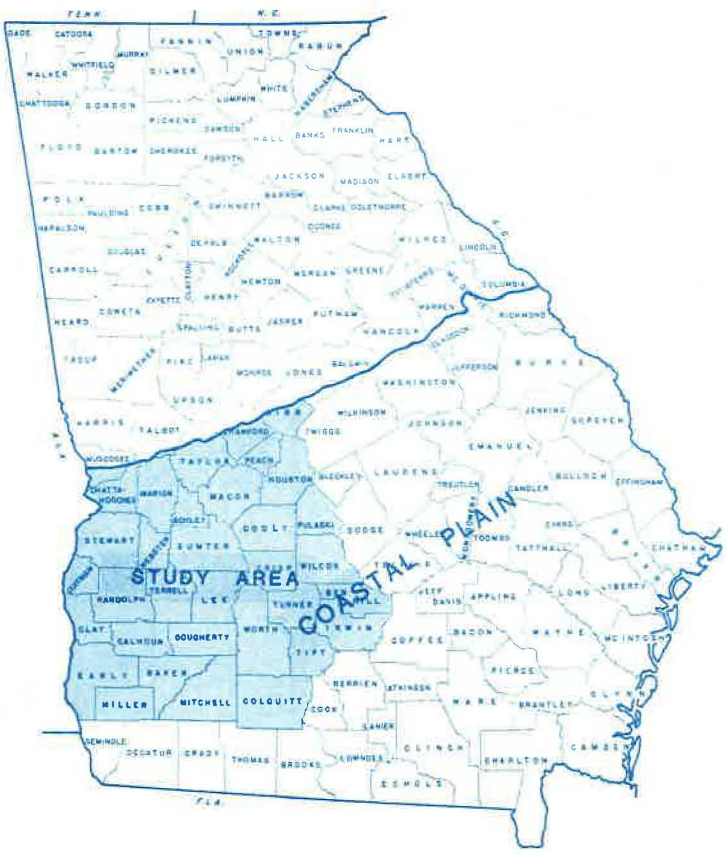
HYDROLOGIC ATLAS 13

HYDROGEOLOGY OF THE CLAYTON AQUIFER OF SOUTHWEST GEORGIA

John S. Clarke, Robert E. Faye and Rebekah Brooks



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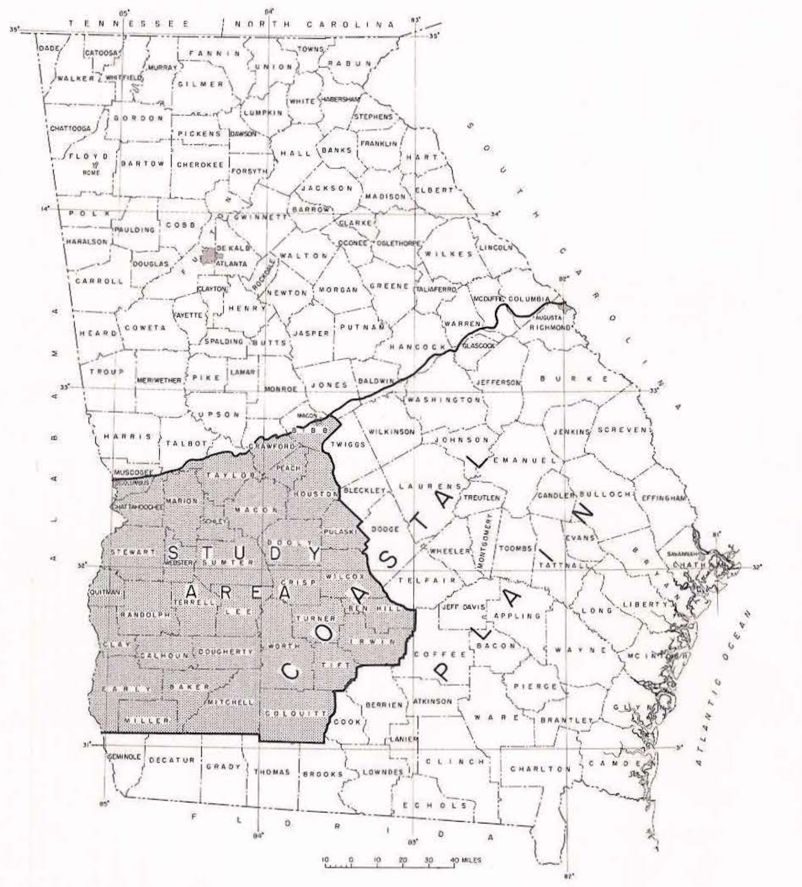

Figure 1.—Location of study area.

INTRODUCTION

Population growth and changes in farming practices in southwest Georgia since 1950 have resulted in a significant increase in agricultural, industrial, and municipal ground-water use. The total number of ground-water supplied irrigation systems in southwest Georgia increased from 57 in 1955 to about 3,000 in 1979. Total ground-water use from all aquifers increased about 240 percent in Albany from 1950 to 1980, and about 190 percent in Dawson from 1958 to 1980. Pumping in these and adjacent areas caused water levels in the Clayton aquifer to decline as much as 100 ft since 1954. By 1981, water levels had declined about 150 ft at Dawson and 175 ft at Albany since the predevelopment period.

The purpose of this study was to describe the hydrogeology of the Clayton aquifer and evaluate the effects of water use on the ground-water system. The study area lies within the southwestern part of the Coastal Plain physiographic province of Georgia and is outlined in figure 1. This atlas is part of a series intended to present results of the Upper Cretaceous-lower Tertiary aquifer study being conducted as part of the Georgia Accelerated Ground-Water Program.

The predevelopment, 1954, and March 1981 potentiometric surfaces of the Clayton aquifer were constructed from data listed by Stephenson and Veatch (1915), Wait (1963), and Ripy and others (1981); and from data files of the U.S. Geological Survey, the Georgia Geologic Survey, and the Georgia Environmental Protection Division. Hydrogeologic sections and structure-contour and thickness maps of the Clayton aquifer were constructed based on geophysical, lithologic, and paleontologic data from wells in the study area. The Arrowhead test well in Pulaski County, drilled in 1981 as part of this study, provided key information for evaluation of other wells.

Table 1.—Generalized correlation of stratigraphic, lithologic, and aquifer units of Mesozoic and Cenozoic age in southwest Georgia

ERA	SYSTEM	SERIES	GULF COAST STAGE	GROUP, FORMATION, AND MEMBER	LITHOLOGY	AQUIFER OR CONFINING ZONE, THIS REPORT	THICKNESS (FEET)
CENOZOIC	TERTIARY	Oligocene	Chickasawhayan				
			Vicksburgian				
		Eocene	Jacksonian	Ocala Limestone	White to light-pink, fossiliferous limestone.[1]	Principal artesian aquifer	0-200
			Claibornian	Claiborne Group: Lisbon Formation	Fine sand and marl, dense, earthy, fossiliferous; contains thin beds of sandstone and hard, sandy, fossiliferous, glauconitic limestone.	Lisbon confining zone	0-70
				Claiborne Group: Tallahatta Formation	Sand, fine to coarse; gravelly at the base; grades upward into poorly sorted fine to coarse sand interbedded with highly fossiliferous limestone layers.	Claiborne aquifer[3]	0-270
			Sabinian	Wilcox Group: Tallahatta Formation (?)[2]	Hatchetigbee Formation--In updip areas the formation consists of crossbedded fine to medium sand and interlaminated sequences of very fine sand, silt, and clay. In downdip areas, the formation consists of massively bedded, very fine to fine, well-sorted quartz sand that contains little or no glauconite.[2]		
				Wilcox Group: Bashi Formation / Hatchetigbee Formation	Bashi Formation--Very fine to fine sand, often clayey, silty, and calcareous; massively bedded; contains abundant glauconite and calcareous fossils. In downdip areas, the formation becomes clayey silt and very fine sand. The Bashi Formation is a downdip facies equivalent of the Hatchetigbee Formation.[2]	Wilcox confining zone--In some areas, sand and limestone layers in the Hatchetigbee Formation, Tuscahoma Formation, Nanafalia Formation, and upper Clayton Formation provide ample supplies for domestic use.	0-260
		Paleocene		Wilcox Group: Tuscahoma Formation	Basal unit consists of glauconitic, medium to coarse sand containing quartz and phosphate pebbles, clay clasts, and shells. Upper unit consists of laminated silts and clays that are commonly carbonaceous and nonfossiliferous.[2]		
				Wilcox Group: Nanafalia Formation: Baker Hill Formation	Baker Hill Formation--Kaolinitic and bauxitic massively bedded clay, carbonaceous clay, and crossbedded micaceous quartz sand. The Baker Hill Formation is an updip facies equivalent of the Nanafalia Formation.[2]		
				Wilcox Group: Nanafalia Formation	Nanafalia Formation--Upper part consists of very-fine to coarse, glauconitic, micaceous, fossiliferous sand and clayey sand. Lower part consists of fine to coarse, micaceous quartz sand and carbonaceous clay.[4]		
			Midwayan	Midway Group: Porters Creek Clay	Dark-gray to black clay, waxy appearing, silty, fissle, fossiliferous, somewhat indurated, interbedded with fine sand. Unit absent over most of the western part of study area.[4]		
				Midway Group: Clayton Formation	Clastic area[5]: Medium to coarse, massive or cross-bedded sand containing layers of clay, calcareous sand or sandy limestone, and local shell lenses. Carbonate area[5]: Upper unit--very-fine to medium, calcareous, silty sand containing thin beds of limestone and clay. Middle unit--massive, recrystallized, highly fossiliferous limestone containing varying percentages of sand. Lower unit--calcareous, fine to coarse sand and sandy marl that is locally arkosic, glauconitic, and fossiliferous. Unit may be derived in part from erosion and redeposition of the underlying Providence Sand. Transition area[5]: Well-sorted calcareous sand, silt, and clay containing thin layers of clayey fossiliferous limestone.	Clayton aquifer--Over most of the clastic area, forms a single aquifer unit with upper member of the Providence Sand and provides ample supplies of water for domestic use. In the carbonate area, the aquifer consists primarily of limestone and provides ample water for municipal, agricultural, and industrial supply. In the transition area, the aquifer consists of calcareous sand interbedded with thin limestone and clay layers and provides ample supplies of water for domestic use.	0-265
						Clayton-Providence confining zone--over most of the clastic area, the confining zone is absent and the Clayton Formation and upper member of the Providence Sand form a single aquifer unit.	0-130
MESOZOIC	CRETACEOUS	Upper Cretaceous (Gulfian)	Navarroan	Providence Sand (upper unnamed sand member)	Fine to coarse silty sand, grades from a thickly bedded sand updip to a massive marine sand containing calcareous intervals downdip.[4] In Albany, Dougherty County, upper part is a dense, clayey, fine sand; middle part is a slightly dolomitic coquina grading upward to a siltstone; lower part is sand containing varying amounts of silt.[1] Unit grades to a silty clay and very clayey sand at the Arrowhead test well in the northwestern part of the study area.	Providence aquifer--Forms single aquifer unit with the Clayton Formation over most of the clastic area. Downdip and eastward, the Providence may form a single aquifer unit with the Ripley Formation and upper Cusseta Sand.	0-390
				Providence Sand (Perote member)	Silt or very-fine sand, dark gray, highly micaceous, carbonaceous. Unit merges with upper member east of Schley County where it grades into coarse sand.	Providence-Ripley confining zone--Where absent, the Providence Sand, Ripley Formation, and upper Cusseta Sand form a single aquifer unit.	0-300
				Ripley Formation	Sand, fine, clayey, micaceous, fossiliferous. Unit grades to clayey coarse sand in the eastern part of the study area.		
			Tayloran	Cusseta Sand	Sand, coarse, containing increasing amounts of thinly bedded carbonaceous clay toward the upper contact. Size and amount of sand decreases downdip where micaceous silt and clay dominate.[4]	Cusseta aquifer--Forms a single aquifer unit with the Providence Sand and Ripley Formation downdip and eastward.	0-150
				Blufftown Formation	Lower part consists of crossbedded, glauconitic, calcareous fine sand to micaceous clay and marl. Upper part consists of carbonaceous clay and silt, crossbedded sand, and highly fossiliferous clay to glauconitic fine sand.[4]	Blufftown aquifer.	0-700
			Austinian Eaglefordian Woodbinian	Eutaw and Tuscaloosa Formations (undivided)	Alternating layers of sand, sandy clay, and clay.		200-1200

1 Hicks and others, 1981.
2 Gibson, 1982.
3 Ripy and others, 1981.
4 Reinhardt and Gibson, 1980.
5 Location of areas shown in figure 2.

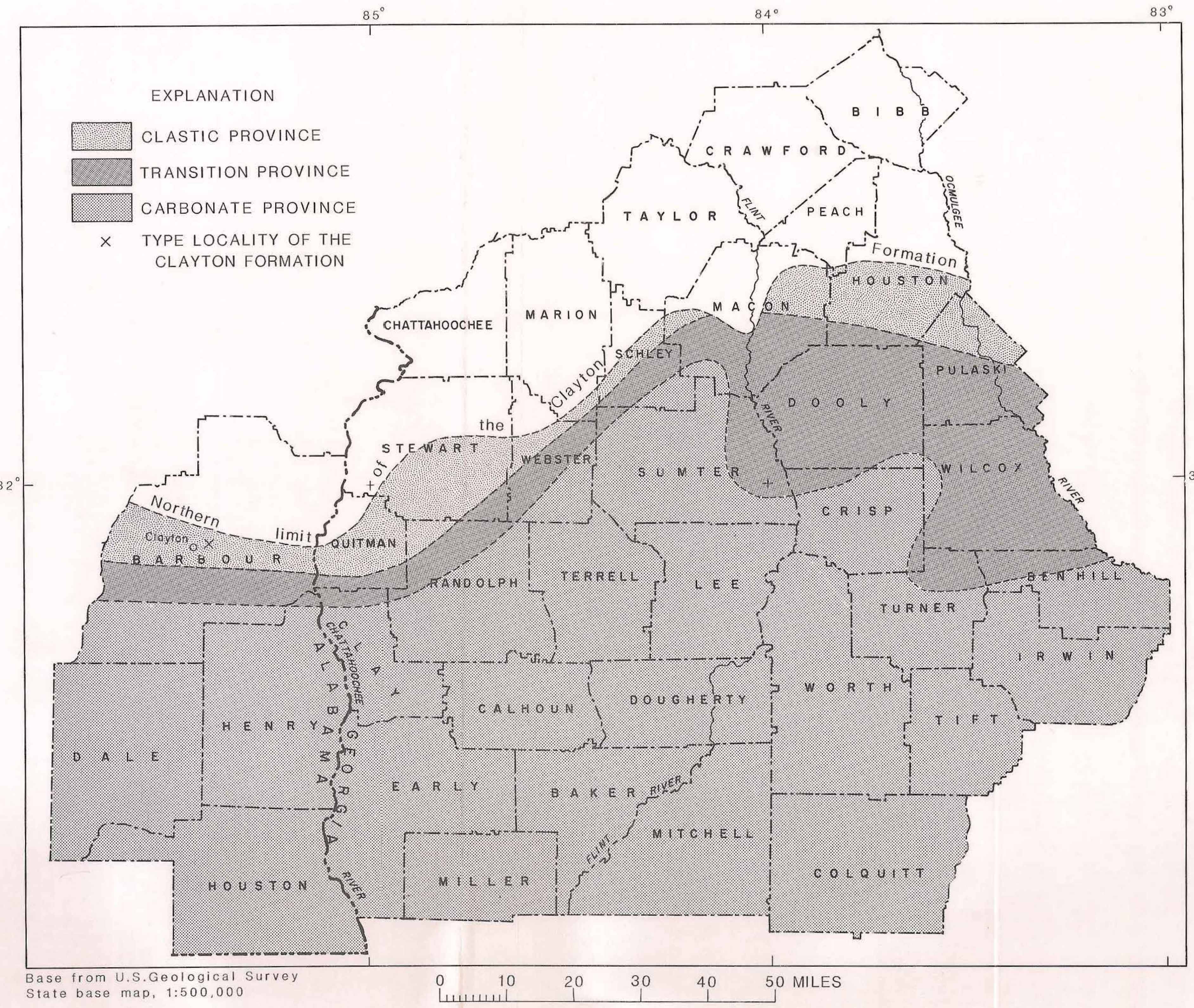

Figure 2.—Type locality and lithologic provinces of the Clayton Formation.

PREVIOUS STUDIES

Previous investigations in the study area include comprehensive studies of the geology and ground-water resources of Dougherty County (Wait, 1963); Lee and Sumter Counties (Owen, 1963); the Macon area, including Houston, Macon, and Schley Counties (LeGrand, 1962); and the Albany area (Hicks and others, 1981). Stewart (1973) discussed the effects of dewatering the Clayton Formation during construction of the Walter F. George Lock and Dam. The hydrogeology of the Providence aquifer in southwest Georgia was described by Clarke and others (1983).

The hydrogeology of the Clayton and Claiborne aquifers in a 15-county area in southwestern Georgia was described in an interim report by Ripy and others (1981) and in a final report by McFadden and Perriello (1983). The present report describes the hydrogeology of the Clayton aquifer over an expanded 34-county area and relates sediments of the Clayton Formation in southwestern Georgia to sediments of equivalent age in eastern Alabama and east-central Georgia. The report also describes hydrologic relations between the Clayton aquifer and the underlying Providence aquifer.

Geologic studies in the area include descriptions of Upper Cretaceous and lower Tertiary units of the Chattahoochee River valley by Toulmin and LaMoreaux (1963), Marsalis and Friddell (1975), and Reinhardt and Gibson (1980). Herrick (1961) presented 354 lithologic logs of wells throughout the Coastal Plain of Georgia. Other hydrologic and geologic reports on the study area are listed in Selected References.

WELL-NUMBERING SYSTEM

Wells in this report are numbered according to a system based on the Georgia index map of U.S. Geological Survey 7.5-minute topographic quadrangle maps. Each quadrangle in the State has been given a number and letter designation according to its location based on a generally Cartesian pattern with its origin at the southwest corner of the State. Numbers increase eastward and letters increase alphabetically northward. Quadrangles in the northern part of the State are designated by double letters. Wells inventoried in each quadrangle are numbered consecutively beginning with one. Thus the third well scheduled in the Doverel quadrangle in Randolph County is designated 9P3. Additional information regarding wells used in this report may be obtained by referring to the well identification in any correspondence to the U.S. Geological Survey, 6481-B Peachtree Industrial Boulevard, Doraville, GA 30360.

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GEOLOGY

GENERAL SETTING

The study area is characterized by alternating units of sand, limestone, clay, and shale of Late Cretaceous to Holocene age, having a maximum thickness of at least 5,000 ft. The general stratigraphy and lithology of the sedimentary units are described in table 1.

The boundary between the Coastal Plain and the Piedmont physiographic provinces and the approximate inner margin of Coastal Plain sediments is marked by the Fall Line (fig. 1). The sedimentary units are exposed in northeast-trending belts that parallel the Fall Line and dip to the southeast, progressively thickening in that direction. The sedimentary sequence unconformably overlies metamorphic, igneous, and sedimentary rocks of probable Precambrian to Paleozoic age, and red beds and diabase of early Mesozoic age (Chowns and Williams, 1983).

GEOLOGIC UNITS

LATE CRETACEOUS

Providence Sand

The Providence Sand is the youngest formation of Late Cretaceous age in the study area. At the type locality at Providence Canyon, Stewart County, the Providence is about 85 ft thick and is divided into two members: the lower Perote Member and an upper unnamed sand member.

The Perote Member consists of dark-gray, highly micaceous, carbonaceous silt or very-fine sand. The upper unnamed sand member consists primarily of medium to coarse silty sand that is thick and well bedded in the outcrop area. South of the outcrop area, the upper member is a massively bedded marine sand that contains local calcareous material. East of Schley County, the Perote Member grades into coarse sand and is indistinguishable from the upper sand member. At the Arrowhead test well (well 18T1, figs. 3, 7), in the northeastern part of the study area, the members grade into silty clay and very clayey sand.

PALEOCENE-EARLY EOCENE

Midway Group

Clayton formation and Clayton formation equivalents.--The Clayton formation as used in this report includes all beds that unconformably overlie the Providence Sand of Late Cretaceous age and that are unconformably overlain by formations of the Wilcox Group of Paleocene-early Eocene age (table 1). For the purpose of simplicity, the Clayton formation has been expanded to include strata of equivalent age and stratigraphic position that are not present at the type locality.

Areal changes in the composition of the Clayton formation were mapped from descriptions of drill cuttings and cores and by examining geophysical logs. Three separate areas (fig. 2) were identified on the basis of lithology: (1) a clastic province in the northern part of the study area in which the principal sediments are sand and clay; (2) a carbonate province in the southern two thirds of the study area where the principal sediments are limestone and calcareous sand; and (3) a transition province that occurs between the clastic and carbonate provinces and contains sedimentary elements common to both areas and a high percentage of fine-grained sediment. The lithologic provinces probably represent areas where the depositional environment altered the lithologic character of the sediments.

In the clastic province, the Clayton formation consists of about 10 to 120 ft of medium to coarse, massive, crossbedded, locally calcareous sand containing layers of clay, sandy limestone, and discontinuous shell-rich lenses. This lithology was described at the type locality of the Clayton Formation at Clayton, Ala., and represents nearshore subtidal deposition (Reinhardt and Gibson, 1980, p. 403). A similar lithology is shown in Section B-B' at the Hatcher test well (5N2, fig. 4) in southern Quitman County. At the Arrowhead test well in Pulaski County (well 18T1, fig. 3) in the northeastern part of the study area, fine to medium, noncalcareous, clayey sand that is the same age as the Clayton and deposited largely in a deltaic environment (David C. Prowell, U.S. Geological Survey, written commun., 1983) is herein included in the Clayton formation in the clastic province.

In the carbonate province, the Clayton formation includes:

(1) A lower unit consisting of about 10 to 30 ft of calcareous, fine to coarse sand and sandy marl that is locally arkosic, glauconitic, and fossiliferous, and may be derived, in part, from erosion and redeposition of the underlying Providence Sand.
(2) A middle unit consisting of about 10 to 265 ft of massive, recrystallized, highly fossiliferous limestone containing varying percentages of sand.
(3) An upper unit consisting of about 10 to 90 ft of very-fine to medium, calcareous, silty sand containing thin layers of limestone and clay.

The carbonate province is the most widespread in the study area and was recognized in wells 5L7, 6M1, 9M7, 10N18, 11N2, 12P4, 6K9, 10Q4, 21L21, 13H8, and 15N1 (table 2, figs. 3-7). In this province, the Clayton formation is mainly limestone, indicative of deposition in an offshore marine environment. However, at wells 7J1 and 7G3 (fig. 4) in the southern part of the carbonate province, more than 50 percent of the Clayton formation consists of fine to coarse sand and interbedded clay that locally is silty and fossiliferous. At well 13L10 (fig. 5) in Dougherty County, the Clayton formation consists of fossiliferous, calcareous siltstone and clayey limestone, which are lithologies similar to those of the transition province. The high percentage of sand at wells 7J1 and 7G3, and the transition-type lithologies at well 13L10 suggest a local clastic influx, possibly due to offshore turbidity currents.

In the transition province, the Clayton formation consists of about 10 to 60 ft of calcareous well-sorted fine sand, silt, and clay containing layers of clayey, fossiliferous limestone as much as 20 ft thick. These strata represent the change between predominantly clastic deposition in northern areas to predominantly carbonate deposition in southern areas (fig. 2). The mixture of fine clastic sediment and carbonate suggests that these sediments were deposited in a shallow-shelf marine environment. Lithologies characteristic of the transition province were recognized in wells 14Q7 and 15R7 (fig. 3) in the northeastern part of the study area.

Porters Creek Clay.--The Porters Creek Clay consists of dark-gray to black, waxy, silty, fissle, fossiliferous, somewhat indurated clay interbedded with fine sand. This unit is absent over most of the western part of the study area and reaches a maximum thickness of 60 ft at the Arrowhead test well (well 18T1, fig. 3) in the northeastern part of the study area.

Wilcox Group

The Wilcox Group in southwestern Georgia consists of the Nanafalia Formation, Baker Hill Formation, Tuscahoma Formation, Bashi Formation, Hatchetigbee Formation, and lower part of the Tallahatta Formation (table 1). The Wilcox Group ranges in thickness from about 10 to 200 ft and is characterized by alternating layers of clay and very-fine to coarse sand that locally is glauconitic, silty, micaceous, clayey, calcareous, and fossiliferous. Strata of the lower part of the Wilcox Group are characterized by a relatively high clay content, good sorting, and a fine-grained character.

Cartography by Willis G. Hester

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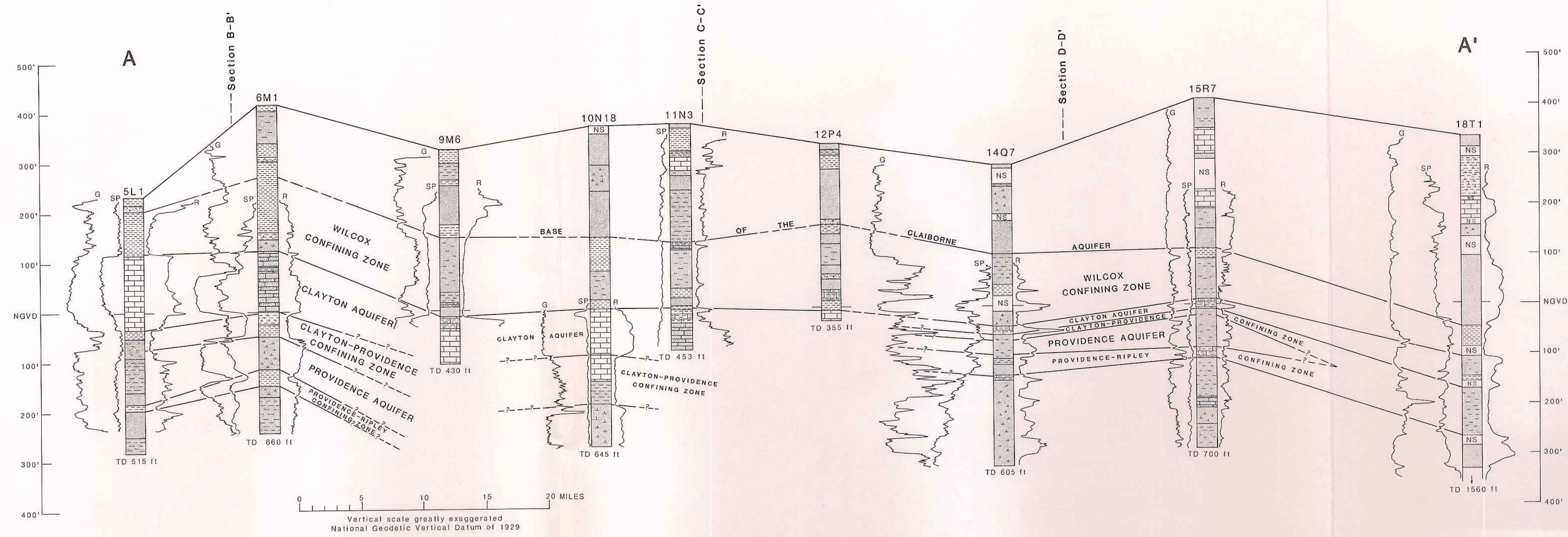

Figure 3.—Hydrogeologic section A-A'.

EXPLANATION

SAND	CALCAREOUS CLAY
SAND AND GRAVEL	LIMESTONE
CLAYEY SAND	SANDY LIMESTONE
CALCAREOUS SAND	CLAYEY LIMESTONE
CLAY	COQUINA
SANDY CLAY	NS NO SAMPLES

GEOPHYSICAL LOGS

G NATURAL GAMMA
SP SPONTANEOUS POTENTIAL
R RESISTIVITY

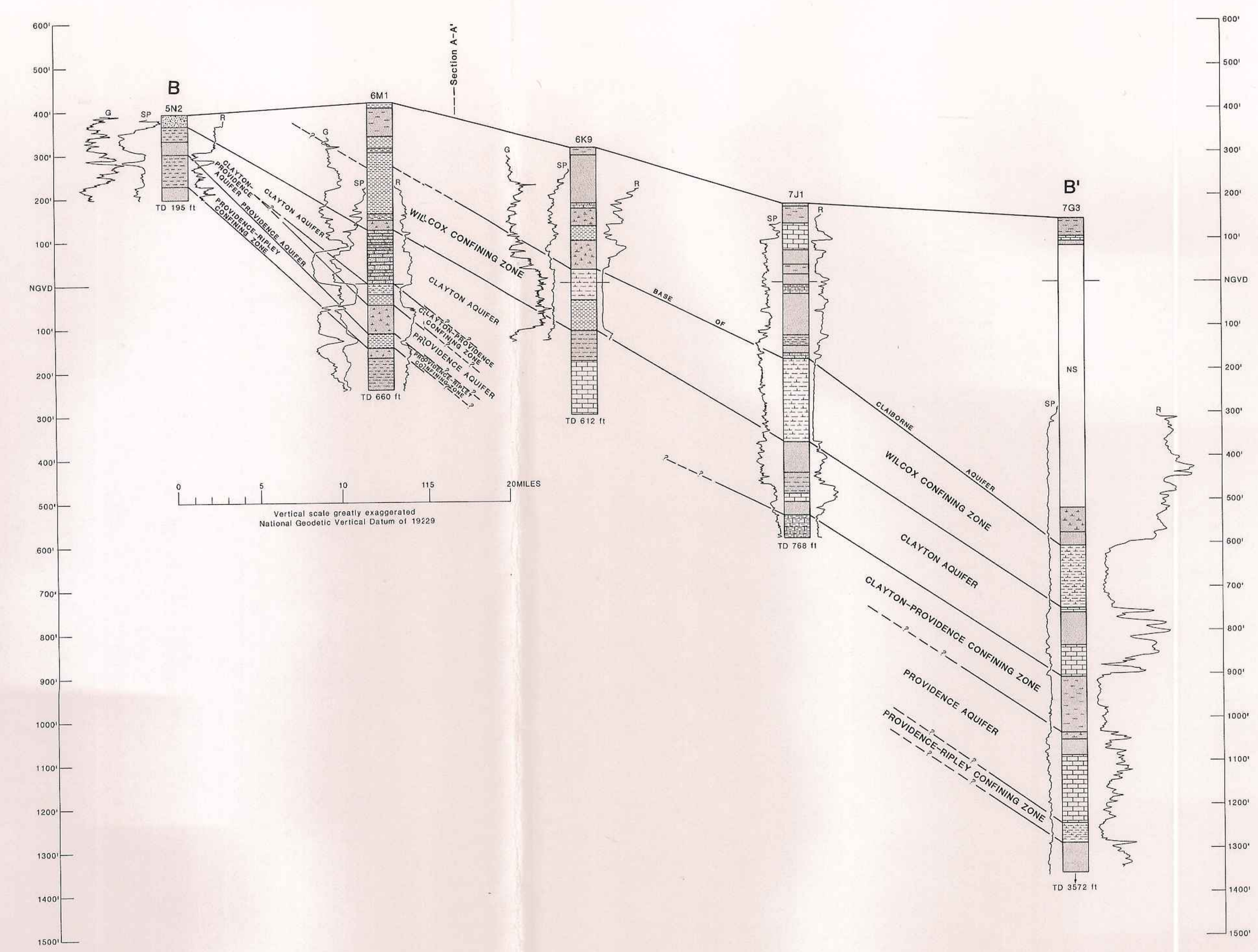

Figure 4.—Hydrogeologic section B-B'.

AQUIFER DEFINITION

In the study area, several aquifers are used for water supply. They are, in descending order: (1) the principal artesian aquifer (Warren, 1944); (2) the Claiborne aquifer (Ripy and others, 1981); (3) the Clayton aquifer (covered in this report); (4) the Providence aquifer (Clarke and others, 1983); (5) the Cusseta aquifer; (6) the Blufftown aquifer; and (7) the Tuscaloosa aquifer. The general lithology, thickness, and correlation of the aquifer units are listed in table 1.

In the clastic province (fig. 2), the Clayton aquifer consists mainly of medium to coarse sand. In this area, the Clayton aquifer yields quantities of water sufficient for domestic use.

In the carbonate province (fig. 2), the Clayton aquifer is limited mainly to the middle limestone unit of the Clayton formation (figs. 3-6). An exception occurs at wells 6K9, 7J1, and 7G3 (figs. 4, 9) in the western part of the province, and at well 12L21 (fig. 5) near Albany, Dougherty County, where the aquifer locally includes 10-90 ft of permeable sand of the upper part of the Clayton formation and the lowermost beds of the Wilcox Group. At well 15N1 (figs. 6, 7) in southern Crisp County, the aquifer includes 15 ft of sand from the lower part of the Clayton formation. The water-bearing properties of the Clayton aquifer are greatest in the carbonate area. (See section on Aquifer Properties.)

In the transition province (fig. 2), the upper part of the aquifer consists of 10 to 20 ft of clayey limestone (wells 14Q7, 15R7, fig. 6). The remainder of the aquifer consists of silty, fine to medium, calcareous sand containing thin limestone and clay layers. Because of the high clay and silt content in this area, the water-bearing characteristics of the Clayton aquifer are significantly reduced.

In the carbonate and transition provinces, the Clayton aquifer is confined below by the lower part of the Clayton formation and the uppermost part of the Providence Sand, which combine to form the Clayton-Providence confining zone (table 1). In most of the clastic province (fig. 2), the Clayton-Providence confining zone is absent and the Clayton aquifer directly overlies fine to coarse sand of the Providence aquifer (table 1) and forms the Clayton-Providence aquifer (well 5N2, fig. 4). An exception occurs between wells 15R7 and 18T1 (fig. 3) in the eastern part of the clastic province, where sediments that make up the Providence aquifer grade into silty clay and very clayey sand and form an underlying confining zone.

Throughout most of the study area, the Clayton aquifer is confined above by silt and clay beds of the Wilcox Group and the upper part of the Clayton formation which together form the Wilcox confining zone (table 1). In the eastern part of the study area, the Wilcox confining zone includes the Porters Creek Clay (table 1) which is absent in the western part of the study area. The Wilcox confining zone is distinguished on well logs as a zone of high natural gamma radiation and of low electrical resistivity (figs. 3-6). Sandy layers within the Wilcox confining zone may yield quantities of water sufficient for domestic use.

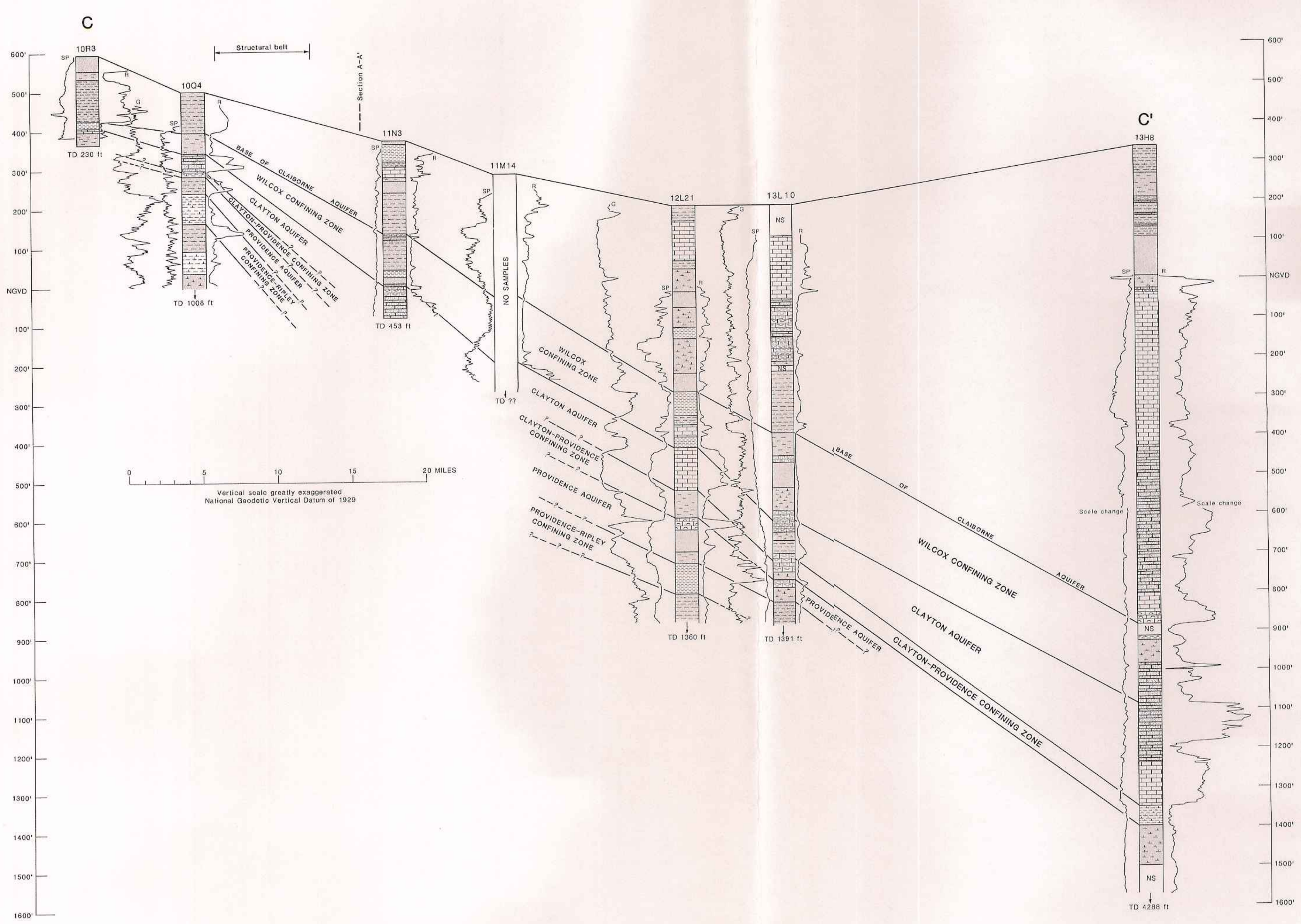

Figure 5.—Hydrogeologic section C-C'.

Table 2.—Record of wells used on hydrogeologic sections

County	Well No.	Georgia Geologic Survey No.	Latitude-longitude	Name or owner	Date drilled	Altitude of land surface (ft)	Comments
Clay	5L7	--	313628-085314	Fort Gaines, 4 (1979 well)	2/79	232	General lithology from driller's log.
Crisp	14P14	3518a	315731-0835423	Veterans Memorial St. Park, GGS TW-1	2/82	252	Do.
Do.	15N1	108	314950-0834608	Cecil Pate, 1	2/46	364	Lithologic log by S. M. Herrick.[2]
Dooly	14R6	3393	321209-0835422	Byromville, 2	5/79	358	General lithology from driller's log.
Do.	15R7	3159	321111-0834628	William Horne, GGS TW-1	5/82	412	Lithologic log by M. Y. Curtin.[1]
Dougherty	12L21	3406	313534-084103	USGS TW-10	12/78	198	Lithologic log from Hicks and others (1981).
Do.	13L10	3187	313105-084064	USGS TW-1	4/77	195	Lithologic log by P. E. Huddleston.[1]
Early	6K9	3443	312827-0845515	Kolomoki State Park, GGS TW-1	11/79	310	Lithologic log by A. Gernazian[1] and B. J. Ripy.[1]
Do.	7J1	437	311742-0834135	W. J. Howell (Farmers Gin & Warehouse, 1)	6/55	180	Lithologic log from Herrick (1961). Reversals on Sp log.
Lee	11M14	--	314220-0841637	E. F. Carlton (Nichols TW)	10/78	283	--
Mitchell	13H8	109	310828-0840403	J. H. Pullen	8/44	338	Lithologic log from Herrick (1961).
Pulaski	18T1	3511	322245-0832901	Arrowhead TW-1	4/81	334	Lithologic log by D. C. Prowell.[2]
Quitman	5N2	--	314854-0850324	USGS Hatcher, TW 1	--	390	Lithologic log by A. D. Donovan.[2]
Randolph	6M1	--	314020-0845338	Coleman	2/83	416	General lithology from driller's log.
Do.	9M7	3449	313953-0843615	C. T. Martin, GGS TW-2	4/80	322	Lithologic log by B. J. Ripy.[1]
Seminole	7G3	187	310317-0844840	W. E. Harlow, 1	2/49	147	Lithologic log from Herrick (1961).
Sumter	10Q4	--	320241-0842214	Univ. of Ga. Experiment Sta.	12/79	500	General lithology from driller's log.
Do.	14Q7	3366	320403-0835910	Danville Ferry, GGS TW-9	11/78	283	Lithologic log by P. E. Huddleston.[1]
Do.	12P4	225	325842-0841253	L. G. Childers	1/51	328	Preliminary lithologic log by Vaux Owen.[2]
Terrell	10N18	--	314636-0842641	Dawson, 5 Lemon St. well	7/78	368	Lithologic log from nearby GGS well 213 (Herrick, 1961).
Do.	11N2	406	314948-0842150	Bronwood, 1	11/54	370	Lithologic log from Herrick (1961).
Webster	10R3	488	320703-0842648	Jeb Sewell (Winkler Farms)	3/56	593	Do.
Worth	16J30	3154	311903-0834413	S'thrn. Invstrs., Cecil Key, 1	3/76	320	Poor-quality drill cuttings available.

1 Georgia Geologic Survey.
2 U.S. Geological Survey.

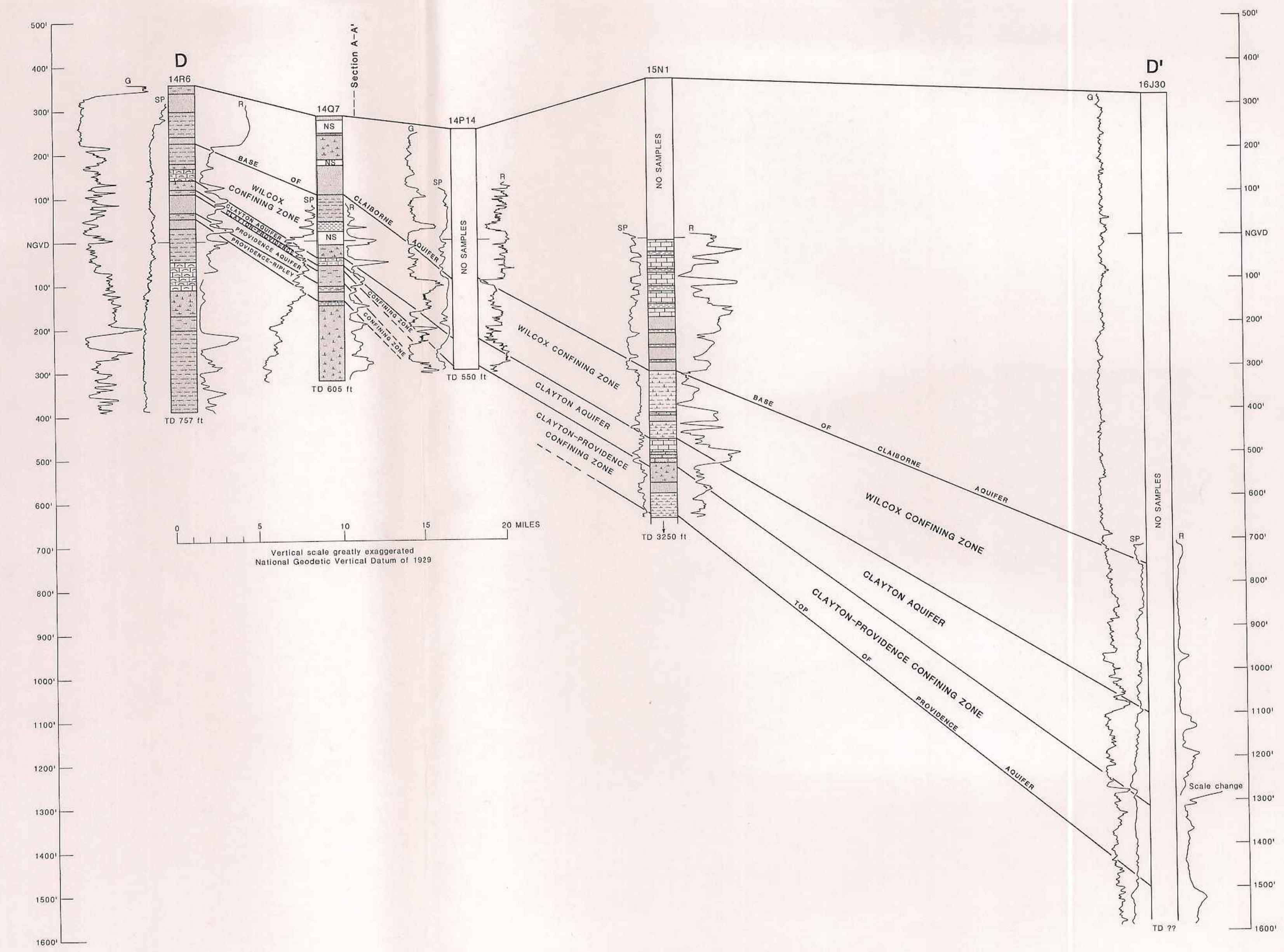

Figure 6.—Hydrogeologic section D-D'.

Cartography by Willis G. Hester

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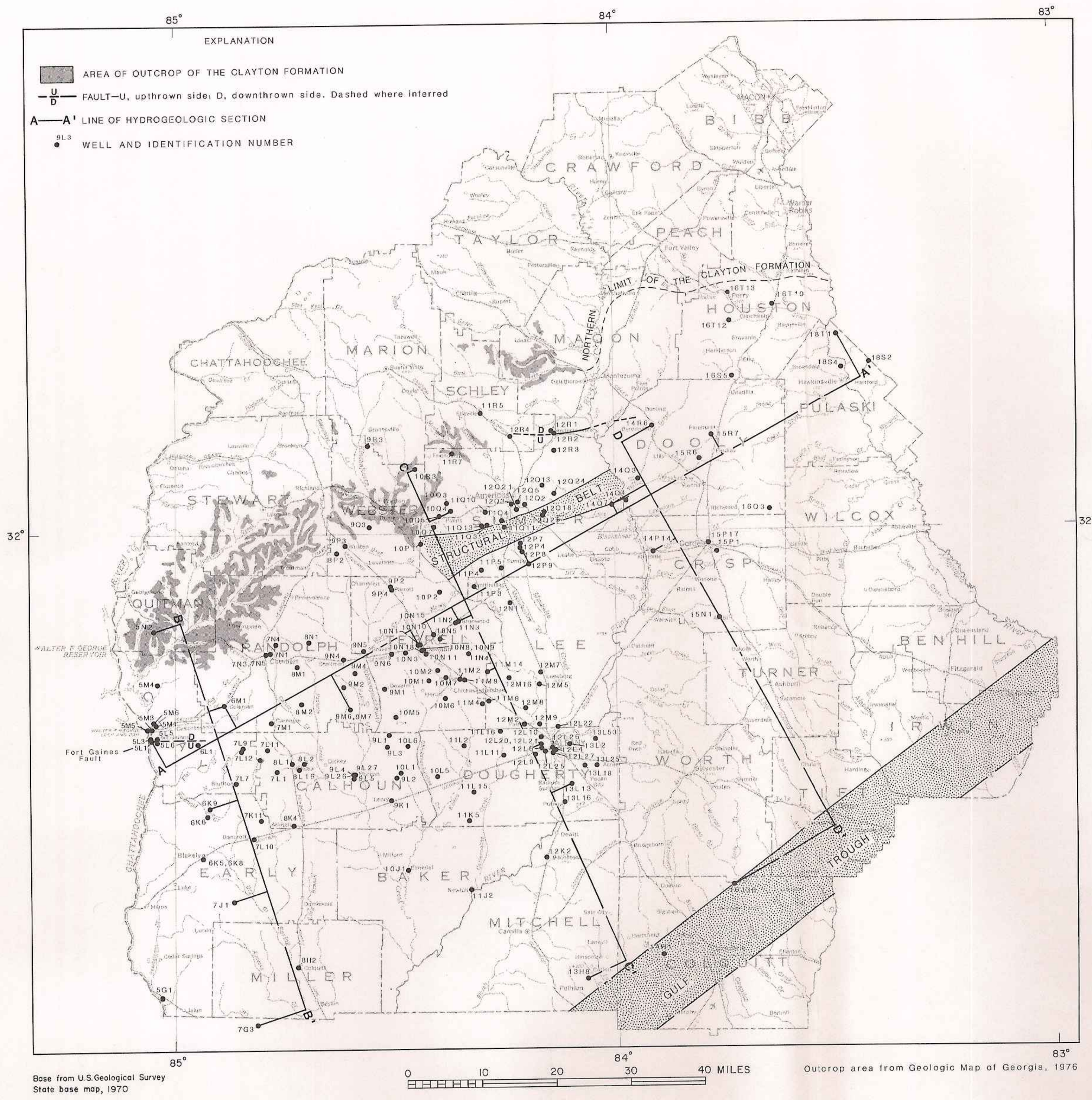

Figure 7.—Structural features, outcrop area, and locations of wells and hydrogeologic sections.

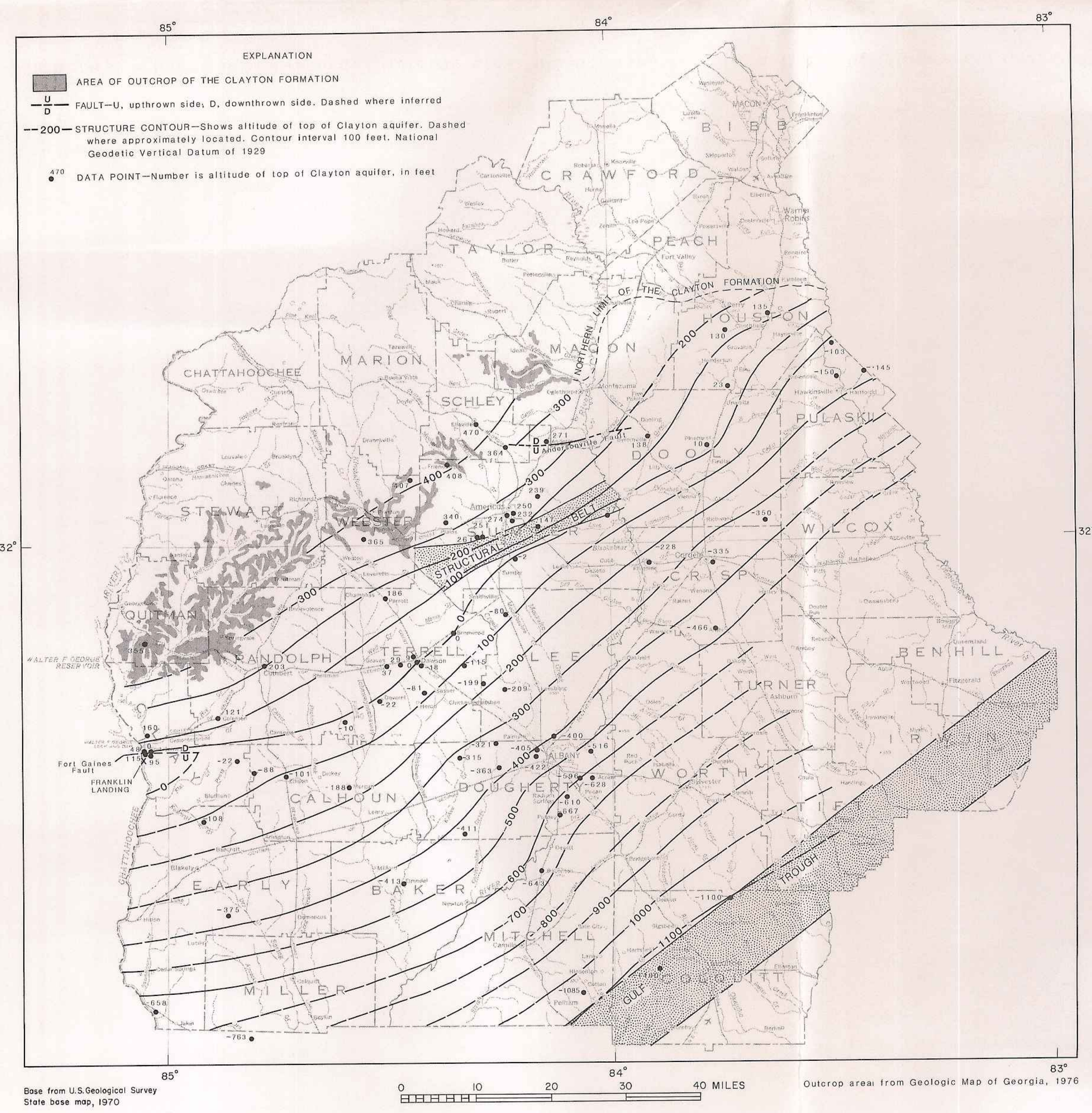

Figure 8.—Structural features, outcrop area, and altitude of the top of the Clayton aquifer.

STRUCTURE OF THE CLAYTON FORMATION

In the study area, the top of the Clayton formation trends northeastward and dips to the southeast at about 20 ft/mi. Irregularities in the top of the Clayton formation in some areas may be due to solution of the limestone. Major structural features (fig. 8) that affect the Clayton formation in the study area include: (1) the Structural Belt of Owen (1963) in Sumter County; (2) the Andersonville Fault (Zapp, 1943) in Schley, Sumter, Macon, and Dooly Counties; (3) an inferred fault near Fort Gaines in Clay County; and (4) the Gulf Trough (Herrick and Vorhis, 1963) in Mitchell, Colquitt, Tift, Irwin, and Ben Hill Counties.

Within the northeast-trending Structural Belt, Owen (1963, p. 38) reported that the regional dip of Upper Cretaceous sediments, the lower Paleocene Clayton formation, and the upper Paleocene Tuscahoma Formation is about twice as great as elsewhere and concluded that the steepened dip may be due to a monoclinal flexure, a fault, or a series of faults. The contours in figure 8 of the top of the aquifer also reflect structure in the Clayton and indicate that at the midpoint of the belt, the dip of the top of the limestone unit of the Clayton formation steepens from about 18 ft/mi north of the belt to about 66 ft/mi within the belt. The increase is less pronounced at the ends of the belt, where the dip diminishes from about 66 ft/mi to about 33 ft/mi.

The Andersonville Fault (fig. 8) is an east-west-trending fault that is upthrown on the south side. Zapp (1965) shows the fault as nearly vertical and reports a maximum vertical displacement of 100 ft at the top of the Clayton formation.

At Fort Gaines, Clay County (fig. 8), the altitude of the top of the middle limestone unit of the Clayton formation shows a difference of 95 ft between the Clay County School (formerly Speight School) well (altitude of 0 ft) and Fort Gaines city well 2 (altitude of 95 ft). Because the wells are less than 2,000 ft apart, Herrick (1961, p. 115) postulated a fault between them, with the Clay County School well on the downthrown side. Although solution of limestone may account for some of this difference, the authors agree with Herrick's postulation of a fault. It is likely the same fault caused a 67-ft offset between city wells 4 (altitude of 115 ft) and 3 (altitude of 48 ft), which are less than 1,500 ft apart. This fault, herein named the Fort Gaines Fault (fig. 8), has the same general east-west orientation as the Andersonville Fault, and, like the Andersonville Fault, is upthrown on the south side.

The northeast-trending Gulf Trough (fig. 8) crosses the southeastern part of the study area in Mitchell, Colquitt, Tift, Irwin, and Ben Hill Counties. Several different opinions as to the nature and origin of the Gulf Trough have been expressed by previous investigators. Patterson and Herrick (1971, p. 11-12) presented a summary of these differing views:

(1) that the feature represents a buried submarine valley or strait,
(2) that it is a graben,
(3) that it is a syncline, or
(4) that it is a buried solution valley.

The authors prefer the second hypothesis. Further study will be required to definitively assess the nature and origin of the Gulf Trough. The Gulf Trough has an adverse effect on the ground-water-flow system, as evidenced by low well yields, low transmissivity, high dissolved-solids concentrations, and steepened potentiometric gradients in the principal artesian aquifer (Zimmerman, 1977).

AQUIFER GEOMETRY

AQUIFER TOP

The altitude of the top of the Clayton aquifer was estimated from geophysical and lithologic logs of 76 wells in the study area (fig. 8). Depths to the top of the aquifer may be estimated by subtracting the altitude of the top of the aquifer (fig. 8) from the altitude of land surface (available on U.S. Geological Survey 7.5-minute topographic quadrangle maps).

AQUIFER THICKNESS

The thickness of the Clayton aquifer was estimated from geophysical and lithologic logs of 51 wells (fig. 9) and by comparing maps of the altitude of the top of the Clayton aquifer with the altitude of the top of the Clayton-Providence confining zone, which forms the base of the Clayton aquifer (table 1).

The Clayton aquifer ranges in thickness from less than 50 ft in most of the clastic and transition provinces (fig. 2) to more than 265 ft in the southern part of the carbonate province. In the clastic province in Pulaski County, the aquifer reaches a maximum thickness of 120 ft.

In the carbonate province, the thickness of the Clayton aquifer may be reduced locally by sinkholes in the top of the limestone that are filled with fine-grained sediments. For example, a sinkhole at Franklin Landing, Ala. (fig. 9), is filled with fine sand and clay of the overlying Nanafalia Formation (Reinhardt and Gibson, 1980, p. 450), thus reducing the effective thickness of the aquifer by about 12 ft.

AQUIFER PROPERTIES

The specific capacity of a well is defined as the rate of yield per unit of drawdown, generally expressed in gallons per minute per foot [(gal/min)/ft]. Values for the Clayton aquifer range from 1.7 (gal/min)/ft at well 13L2 in Dougherty County to 40 (gal/min)/ft at well 7N1 in Randolph County (Appendix A).

The transmissivity of an aquifer is defined as the rate at which water will flow through a unit width of aquifer under a unit hydraulic gradient (Lohman, 1972, p. 6). It is, thus, a measure of the aquifer's ability to transmit water, generally expressed in feet squared per day (ft^2/d). Transmissivity may be estimated from time-drawdown, time-recovery, and specific-capacity data. Estimates of transmissivity from specific-capacity data, due to well losses, are generally lower than values calculated from time-drawdown data at the same well. With the exception of values at wells 9M2, 9M4, 5M5, and 12M9, transmissivities in this report were computed by applying Jacob's modified nonequilibrium formula to specific-capacity data (Ferris and others, 1962, p. 99). Transmissivities for wells 9M2, 9M4, 5M5, and 12M9 were computed from time-drawdown or time-recovery data.

The Clayton aquifer shows variations in transmissivity largely due to changes in lithology (fig. 10). Transmissivities are generally greatest in the carbonate province and lowest in the transition province (fig. 2).

In the carbonate province, transmissivities range from 1,400 ft^2/d at well 9P2 in northern Terrell County to more than 5,000 ft^2/d in two large areas--one in Randolph and Clay Counties; the other in Terrell and Lee Counties (fig. 10). In these two areas, aquifer sediments are relatively free of clay and silt and reported yields range from 350 to 2,150 gal/min. East of Albany, Dougherty County, the percentage of clay and silt in the aquifer increases and transmissivities are less than 1,000 ft^2/d (well 13L2). Although aquifer-test data in the transition province (fig. 2) are lacking, the high percentage of clay and silt suggests that transmissivities are less than 1,000 ft^2/d.

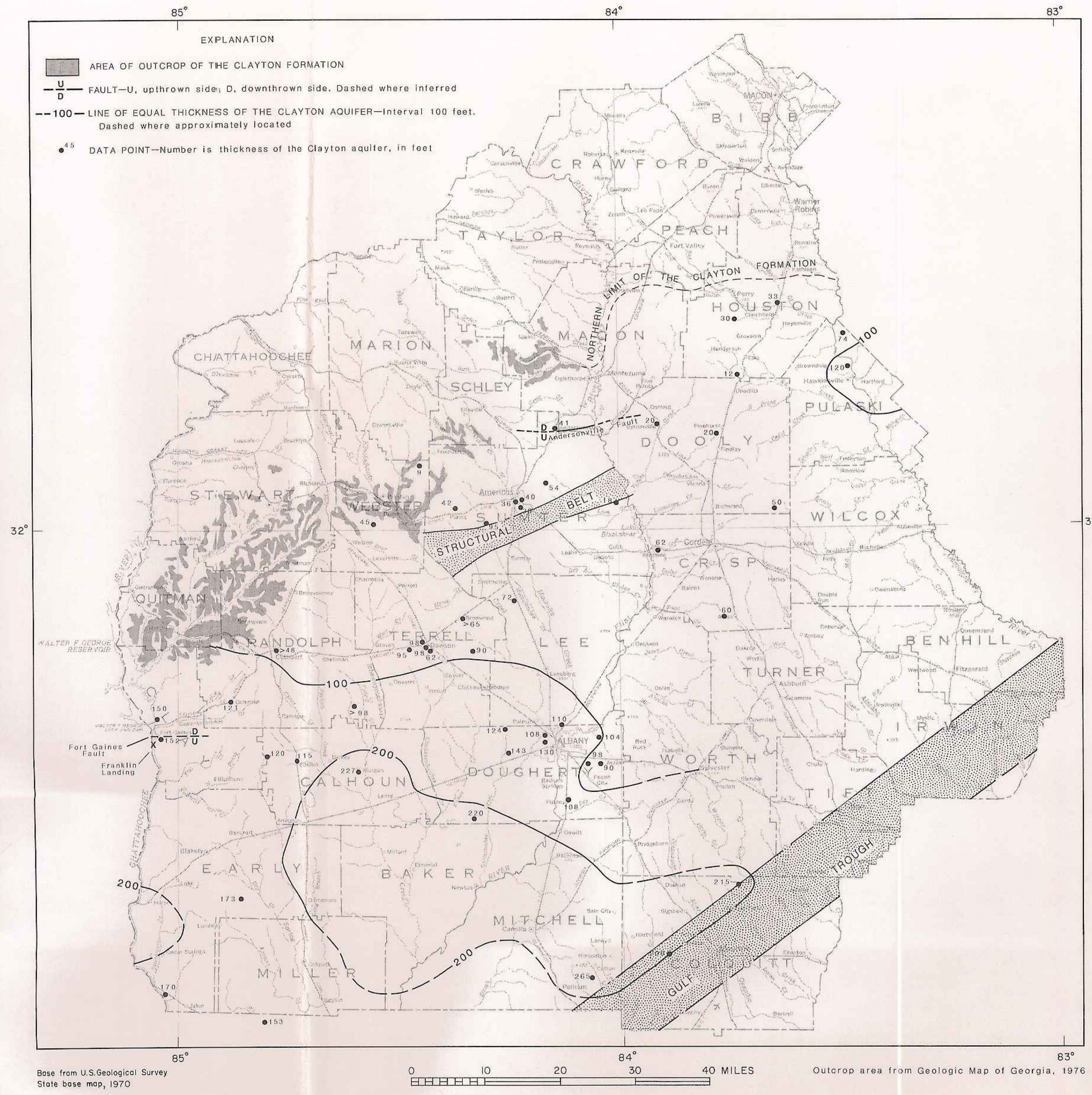

Figure 9.—Structural features, outcrop area, and thickness of the Clayton aquifer.

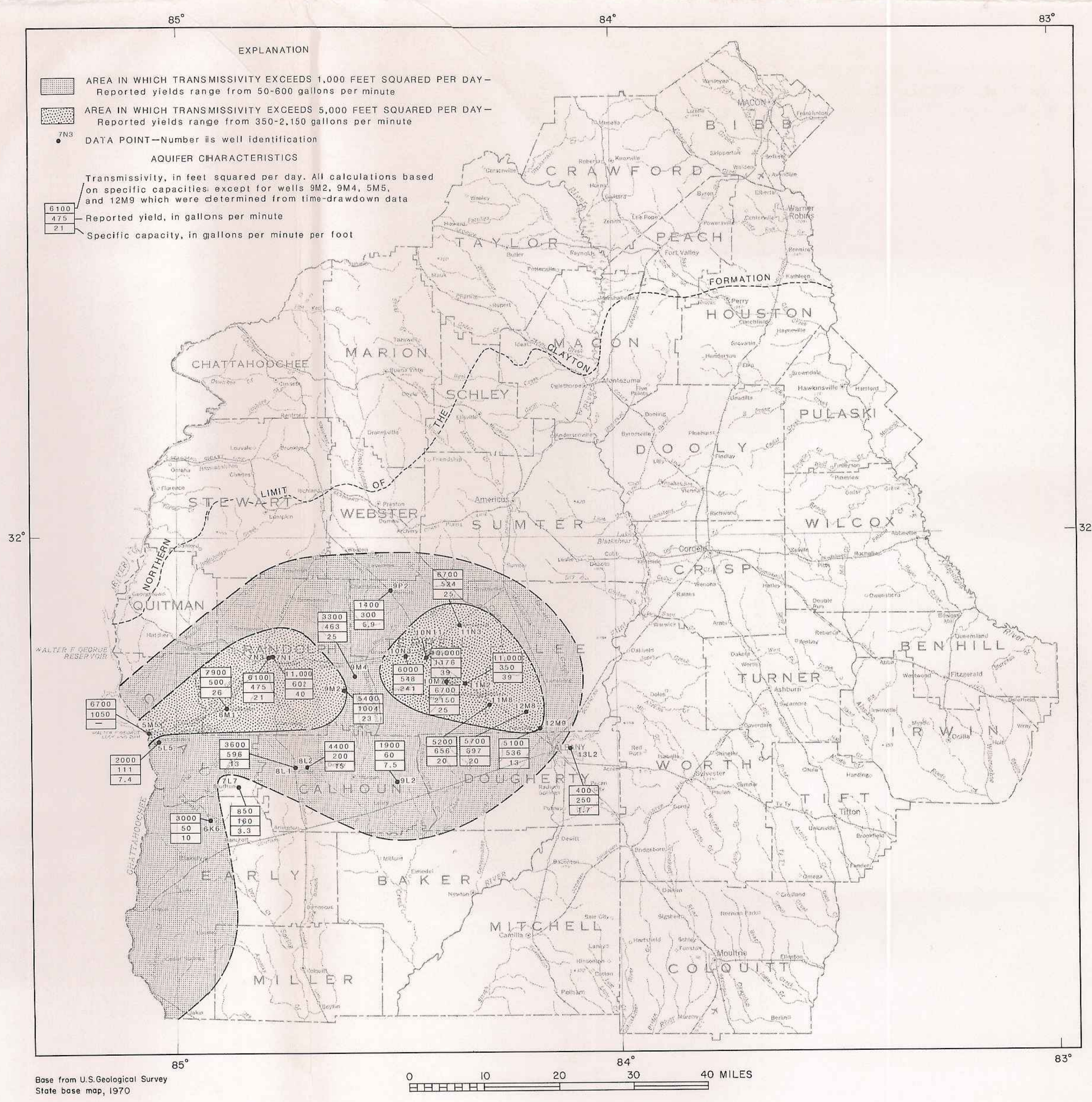

Figure 10.—Aquifer transmissivity, reported yield, and specific capacity of wells tapping the Clayton aquifer.

Cartography by Willis G. Hester

HYDROGEOLOGY OF THE CLAYTON AQUIFER OF SOUTHWEST GEORGIA.

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WATER-LEVEL FLUCTUATIONS

Water-level fluctuations in the Clayton aquifer are related to seasonal changes in precipitation, evapotranspiration, and rates of pumping. Observed annual fluctuations in mean daily water levels during 1980 ranged from 11.2 ft at well 5L1 in Clay County to 40.2 ft at well 12L20 in Dougherty County.

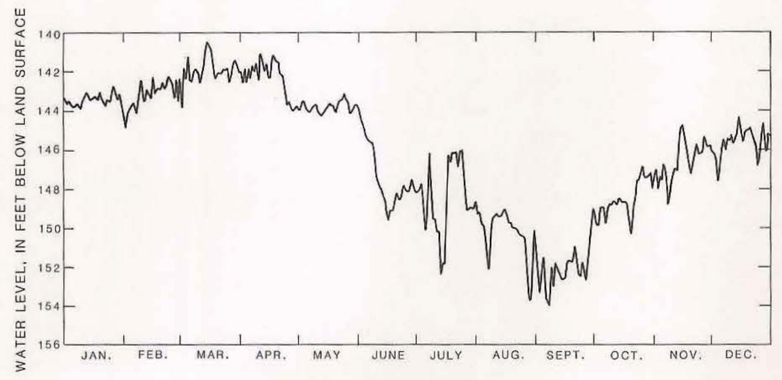

Figure 11.—Mean daily water levels in the Clayton aquifer at well 7N1 at Cuthbert, Randolph County, 1980.

CUTHBERT AREA

Water levels in the Clayton aquifer in the Cuthbert area are affected primarily by seasonal changes in local and regional pumping and precipitation (fig. 11). During 1981, water levels in observation well 7N1 near the outcrop area in Cuthbert fluctuated 13.3 ft between the highest recorded water level in March and the lowest level in September. Sharp, small-scale fluctuations throughout the year reflect changes in local pumping.

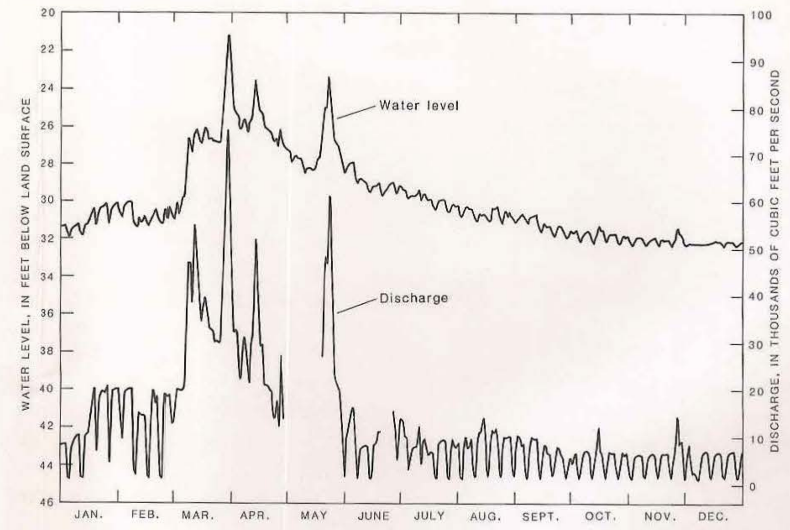

Figure 12.—Mean daily water levels in the Clayton aquifer at well 5L1 at Fort Gaines, Clay County, and average daily stream discharge at gaging station 02343801 near Hilton, Early County, 1980.

FORT GAINES AREA

In the vicinity of Fort Gaines, water levels in the Clayton aquifer are affected by changing reservoir stages and Chattahoochee River stages caused by operation of the Walter F. George Lock and Dam. South of the Walter F. George Reservoir, the water level in well 5L1 at Fort Gaines rose 10.7 ft from January 6 to March 31, 1980, corresponding to a rise in river stage produced by increased discharge from the lock and dam (fig. 12). A comparison of 1980 mean daily water levels at well 5L1 and the average daily stream discharge at gaging station 02343801 near Hilton, Early County (See location, fig. 17.), indicates that when there was an increase in river discharge (stage) downstream from the dam, ground water that normally discharged into the river backed up into the aquifer causing the water level in the well to rise.

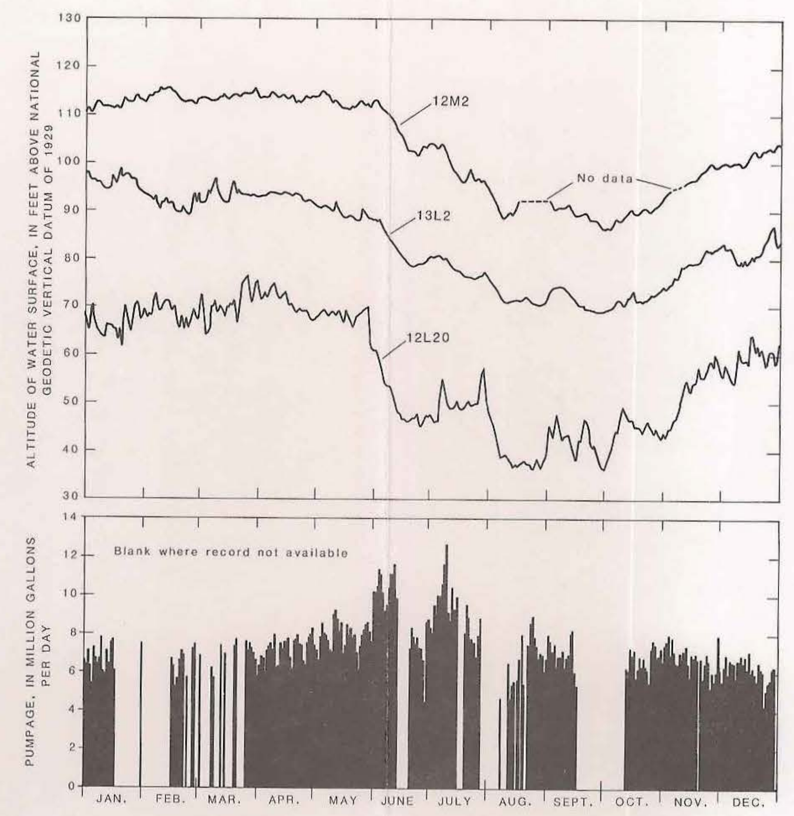

Figure 13.—Estimated mean daily pumpage from the Clayton aquifer by the city of Albany, and mean daily water levels in the Clayton aquifer at wells 12M2, 13L2, and 12L20 near Albany, Dougherty County, 1980.

ALBANY AREA

In the Albany area, water levels in the Clayton aquifer are primarily affected by changes in local pumping. During 1980, mean daily water levels in the Clayton aquifer at wells 12L20, 13L2, and 12M2 near the center of pumping at Albany showed annual fluctuations of 40.2, 29.6, and 29.3 ft, respectively (fig. 13). A comparison of mean daily water levels in these wells with the estimated average daily pumpage from the Clayton aquifer by the city of Albany indicates that the fluctuations correspond to seasonal variations in pumping at Albany.

Mean daily water levels in well 11L2, in western Dougherty County, fluctuated 39.1 ft during 1980 (fig. 14). This fluctuation was primarily in response to seasonal irrigation pumping. Records indicate that from 1974 to 1977, mean monthly water levels in this well fluctuated an average of about 2.3 ft annually (fig. 23), mainly because of seasonal changes in regional pumping. The annual water-level fluctuations were 12.5 ft in 1977 and 29 ft in 1981. The increased fluctuations in those years correspond to seasonal increases in irrigation pumping.

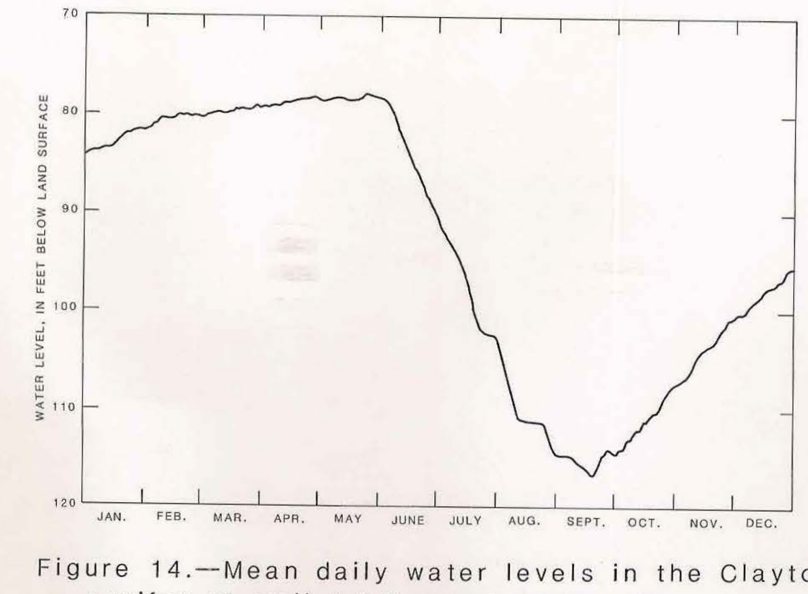

Figure 14.—Mean daily water levels in the Clayton aquifer at well 11L2, western Dougherty County, 1980.

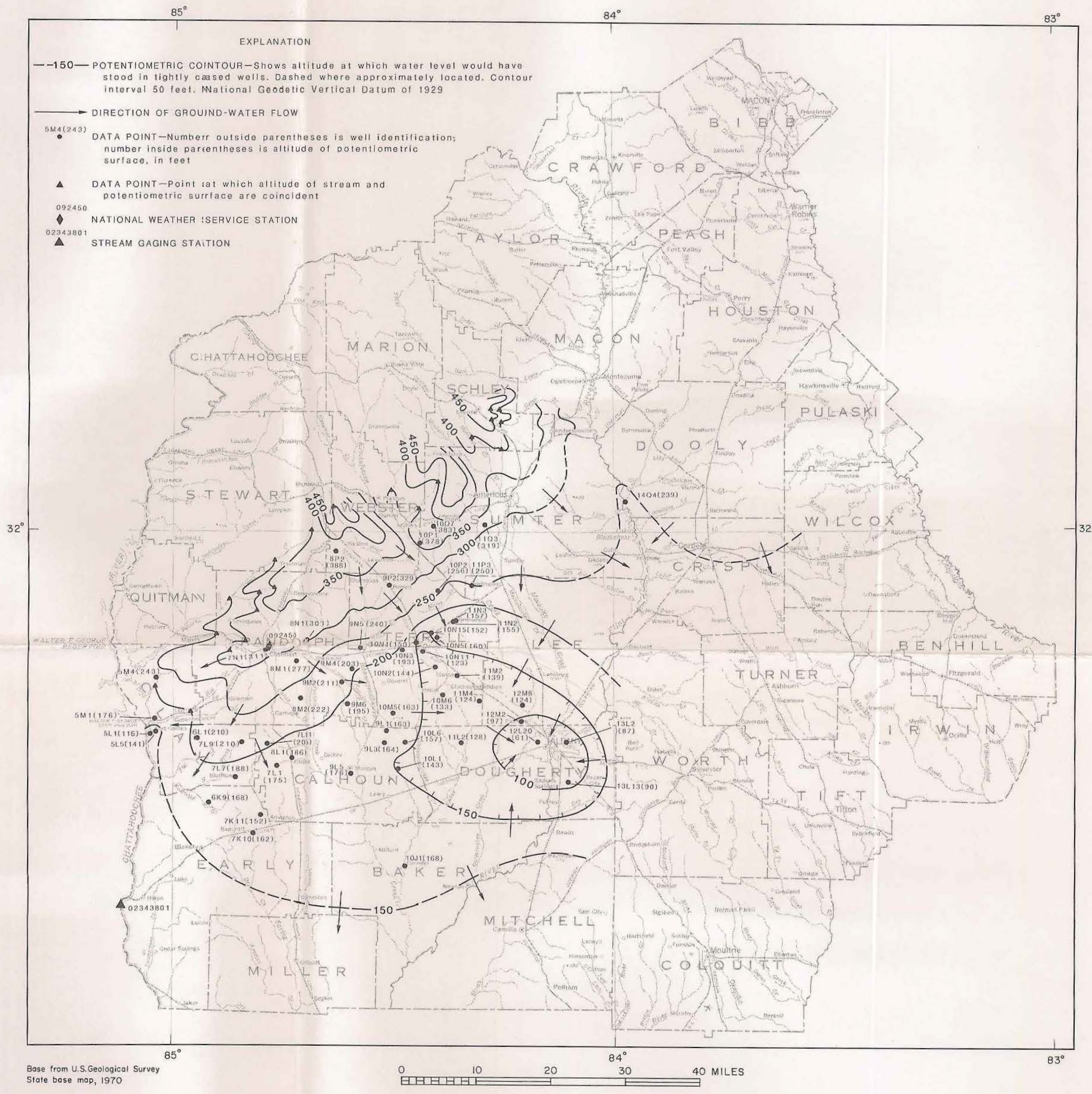

Figure 17.—Potentiometric surface of the Clayton aquifer, March 1981.

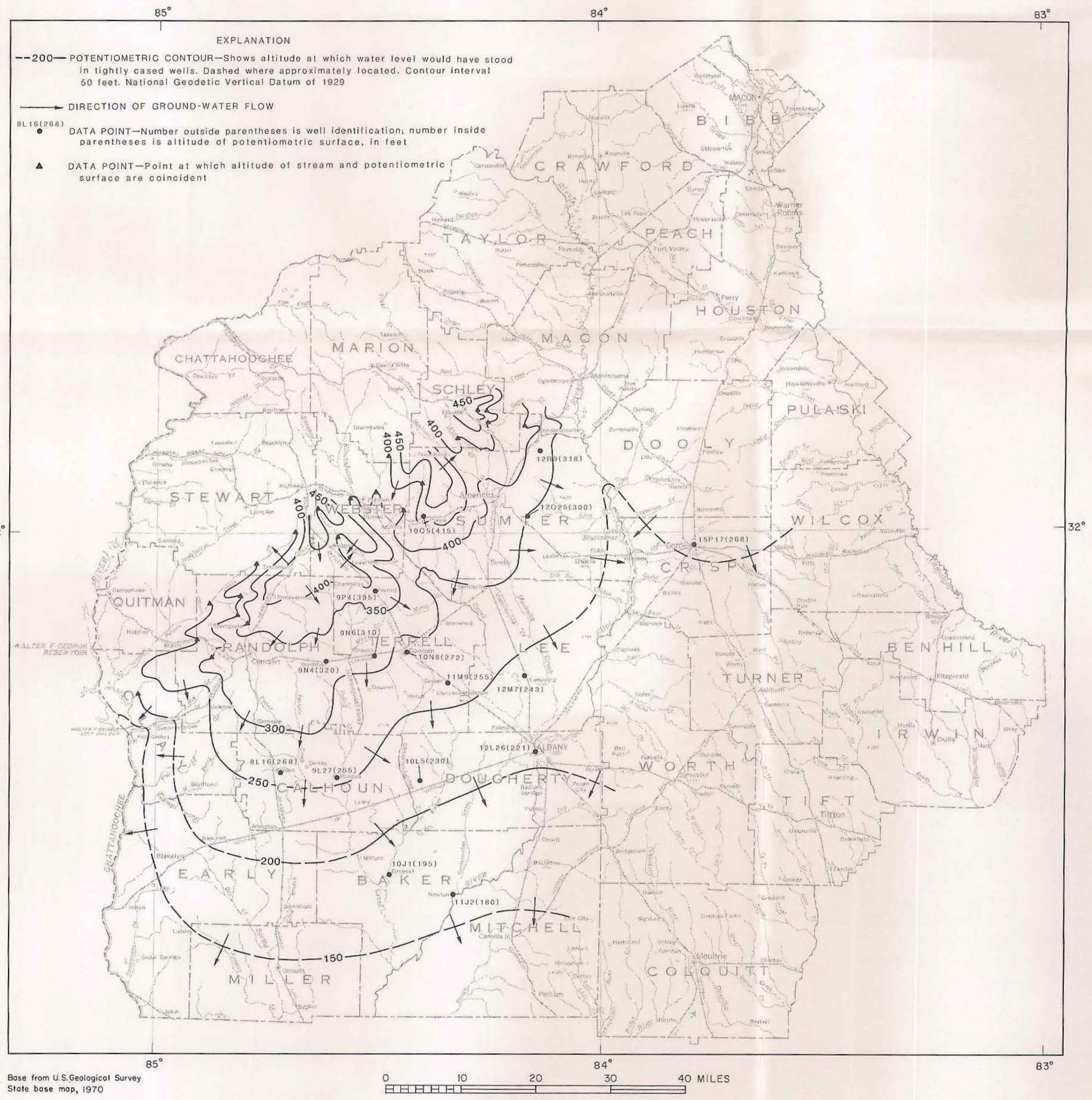

Figure 15.—Inferred predevelopment potentiometric surface of the Clayton aquifer.

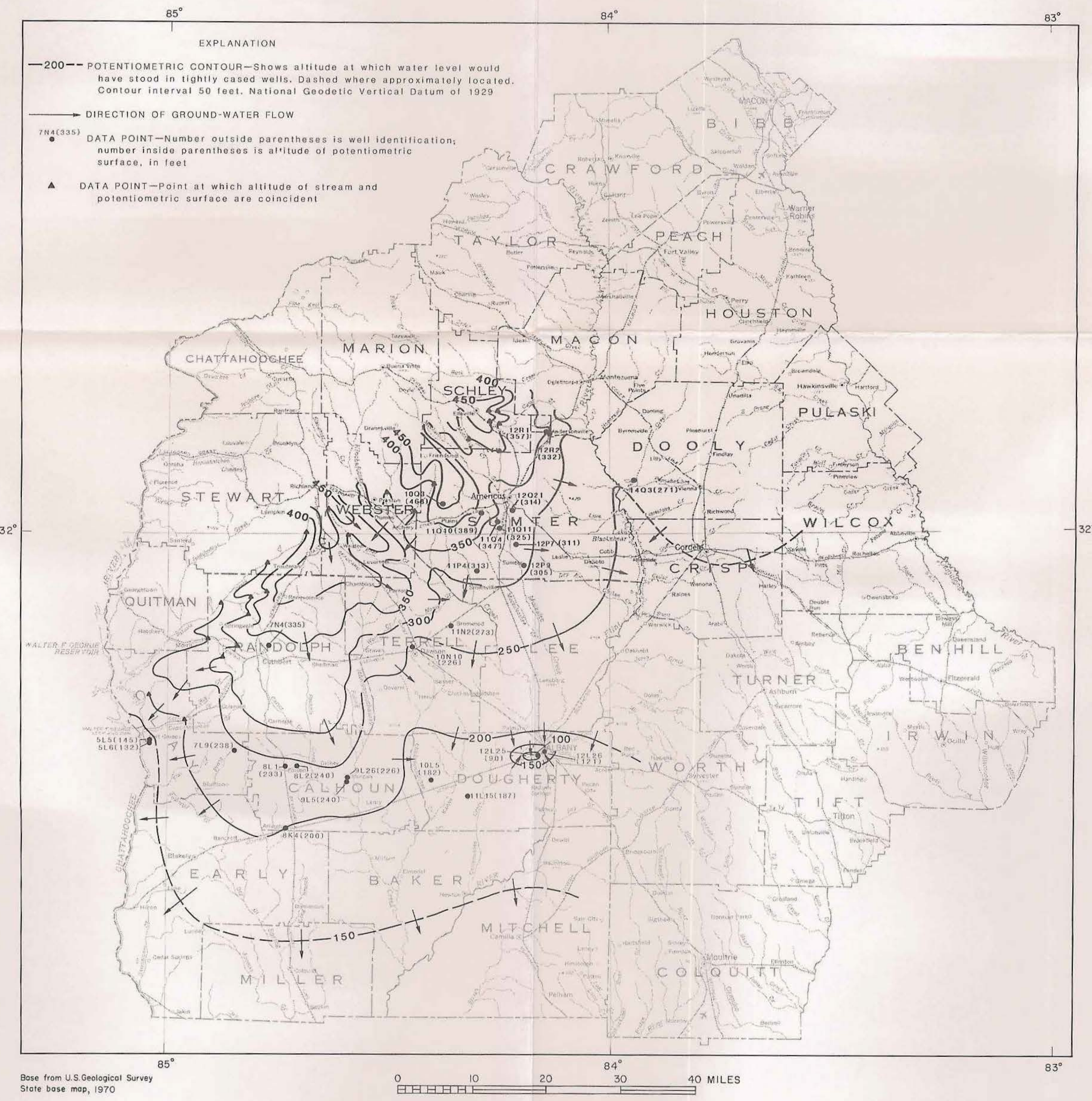

Figure 16.—Estimated potentiometric surface of the Clayton aquifer, 1954.

POTENTIOMETRIC SURFACE

The potentiometric surface of an aquifer is an imaginary surface representing the altitude to which water would rise in tightly cased wells that penetrate the aquifer (Lohman, 1972, p. 8). Potentiometric levels are highest in areas of recharge and lowest in areas of discharge; thus, ground water moves from areas of recharge toward areas of discharge. In some areas, pumping can lower the potentiometric surface and form a cone of depression.

The potentiometric surface of the Clayton aquifer (figs. 15-17) was based on control-well data and, within and near the outcrop area, on the observed sensitivity of potentiometric altitudes to rivers and streams. The small triangles at streams on figures 15 to 17 represent areas where the altitude of the stream surface is considered to be nearly coincident with the altitude of the potentiometric surface. Although there are no data to indicate the extent of water-level fluctuations in the outcrop area, annual water-level fluctuations probably range from about 5 to 20 ft depending on the location and amount of precipitation. For example, the water level in well 7N1 (fig. 26), about 3 mi south of the outcrop area at Cuthbert, Randolph County, showed average annual water-level fluctuations ranging from less than 5 ft to about 20 ft during 1965-81. In addition, the volume of water pumped from the Clayton aquifer in the outcrop area is small because withdrawals are mainly for domestic use. Consequently, water-level fluctuations in the outcrop area from pumping and natural fluctuations are probably too small to alter the configuration of the potentiometric surface at the contour interval used in figures 15-17.

PREDEVELOPMENT SURFACE

The predevelopment potentiometric surface of an aquifer represents the natural condition of the aquifer before man-induced stresses, such as pumping, were applied. The inferred predevelopment potentiometric surface of the Clayton aquifer, based on data collected between 1891 and 1924, is shown in figure 15.

Predevelopment flow directions within the Clayton aquifer generally were from the outcrop area southward and toward major rivers and streams. Two major discharge areas—the Chattahoochee River to the west, and the Flint River to the east--were drains in the ground-water flow system. This naturally occurring discharge is indicated by potentiometric contours that bend upstream in an inverted "V" pattern, showing that the hydraulic gradient is toward the stream. Potentiometric contours also indicate that two major ground-water divides were present--one to the southwest between the Chattahoochee and Flint Rivers, and a second to the southeast between the Flint and Ocmulgee Rivers--that generally correspond to interstream drainage divides. In the outcrop area, these interstream areas were sites of major aquifer recharge.

ESTIMATED 1954 SURFACE

The estimated 1954 potentiometric surface of the Clayton aquifer is shown in figure 16. Potentiometric data used to construct this surface were collected during 1950-55. Unpublished data from the files of the U.S. Geological Survey indicate that, with the exception of the Albany, Dawson, and Fort Gaines areas, water levels in the Clayton aquifer underwent little or no change during this period. The potentiometric surface shown in figure 16 is considered to be most representative of 1954, because data for the areas of greatest stress were collected during 1953-55. Where data were available for multiple time periods, the data for the year closest to 1954 were used.

In Dougherty, Terrell, Clay, Sumter, and Calhoun Counties, ground-water withdrawals caused water-level declines and altered the configuration of the predevelopment potentiometric surface. By 1954, a cone of depression had developed in Albany, Dougherty County, and the principal direction of ground-water flow was toward the center of pumping. Water-level data from old city well 3 at Americus, Sumter County, indicate that a cone of depression existed there as early as 1942. Because data for this well are lacking for the period 1953-55, the cone of depression is not shown in figure 16.

MARCH 1981 SURFACE

The March 1981 potentiometric surface of the Clayton aquifer is shown in figure 17. Ground-water withdrawals since 1954 caused water levels to decline, thereby changing the configuration of the potentiometric surface. As a result, the major ground-water divide between the Chattahoochee and Flint Rivers became less pronounced and the cone of depression at Albany expanded.

By March 1981, agricultural pumping northwest of Dougherty County caused the cone of depression at Albany to expand northwestward. The principal direction of ground-water flow in parts of Dougherty, Terrell, Lee, Randolph, and Calhoun Counties was toward the area of greatest withdrawal, which was in the Albany area (Hicks and others, 1981, p. 25).

In the Fort Gaines area, the water level in the Clayton aquifer was affected by construction of the Walter F. George Lock and Dam and the subsequent filling of the reservoir. During 1957-61, pumping of 3 to 12.6 Mgal/d to dewater the construction site lowered the water level as much as 80 ft. Upon cessation of pumping, the water level made a full recovery (Stewart, 1973). Filling the reservoir in 1963 caused the water level in the aquifer to rise, both upstream and downstream from the dam. This rise in water level shifted the 150-ft water-level contour at Fort Gaines on the 1954 surface (fig. 16) southward to the position shown on the 1981 surface (fig. 17).

HYDROGEOLOGY OF THE CLAYTON AQUIFER OF SOUTHWEST GEORGIA.

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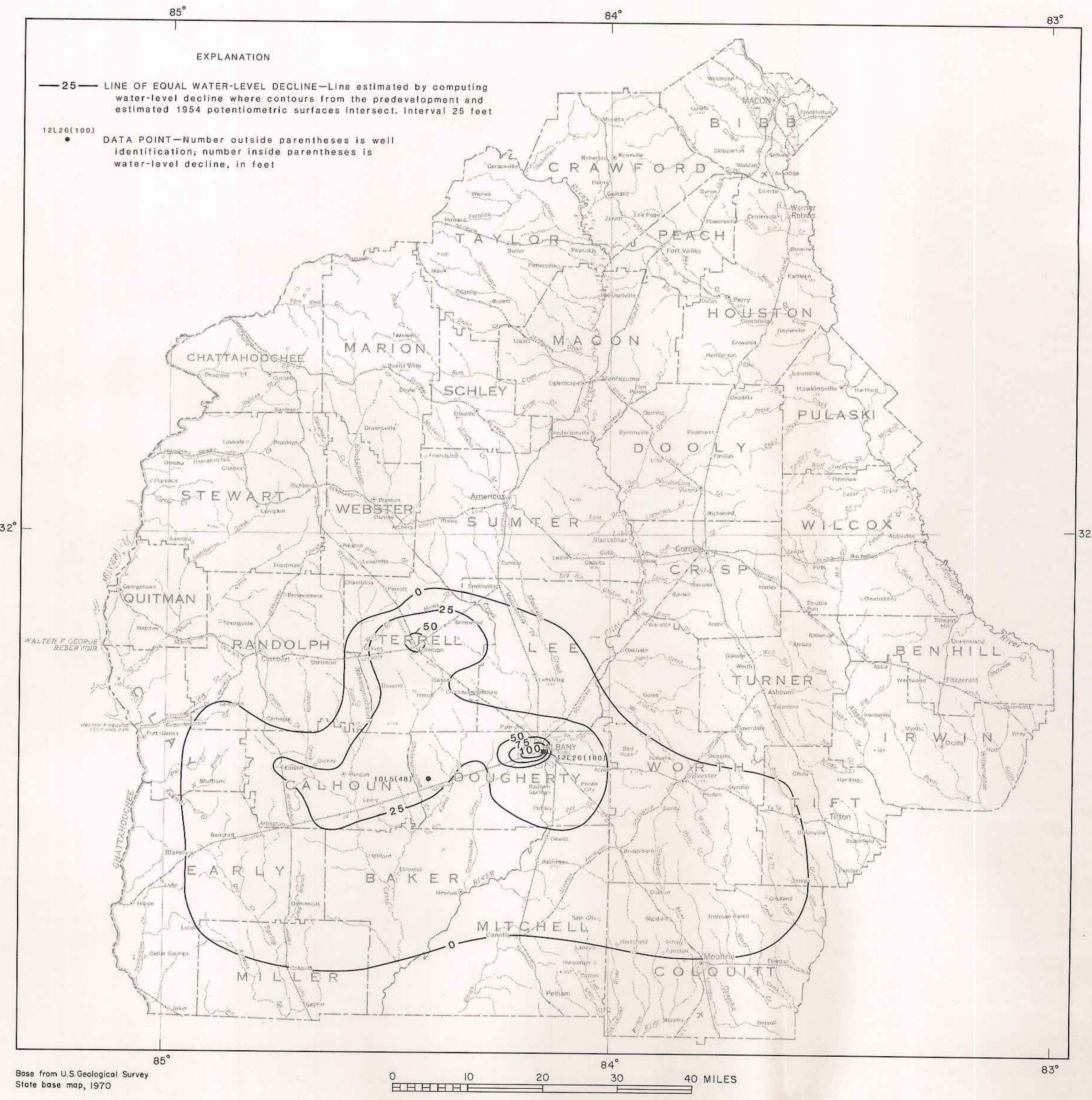

Figure 18.—Water-level declines in the Clayton aquifer, predevelopment to 1954.

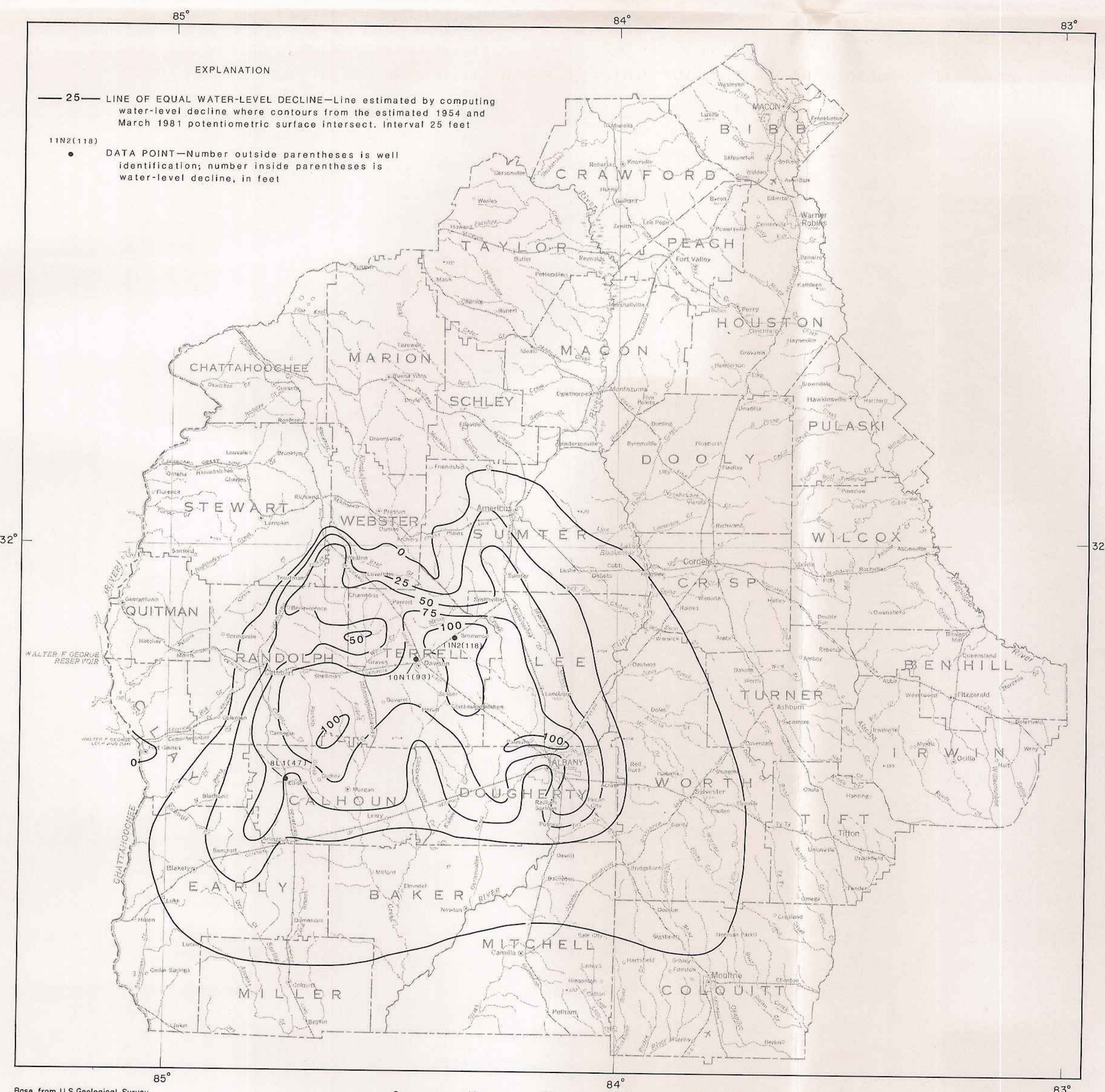

Figure 19.—Water-level declines in the Clayton aquifer, 1954-81.

LONG-TERM WATER-LEVEL DECLINES

During the early 1900's, with the exception of the Albany area, water levels in the Clayton aquifer remained generally steady as aquifer recharge and discharge maintained a natural equilibrium. Increased pumping in some areas, however, reduced compressive aquifer storage (Lohman, 1972, p. 8) and resulted in a corresponding decline in water level. By 1954, the water level had declined more than 25 ft below the predevelopment surface in parts of Dougherty, Calhoun, Terrell, and Lee Counties; 50 ft below at Dawson, Terrell County; and 100 ft below at Albany, Dougherty County (fig. 18). The water level declined 75 ft from 1954 to 1981 in parts of Dougherty, Calhoun, Terrell, Randolph, and Lee Counties, and more than 100 ft in areas of localized large-scale pumping (fig. 19). The decline from the predevelopment period to 1981 was about 150 ft at Dawson and 175 ft at Albany.

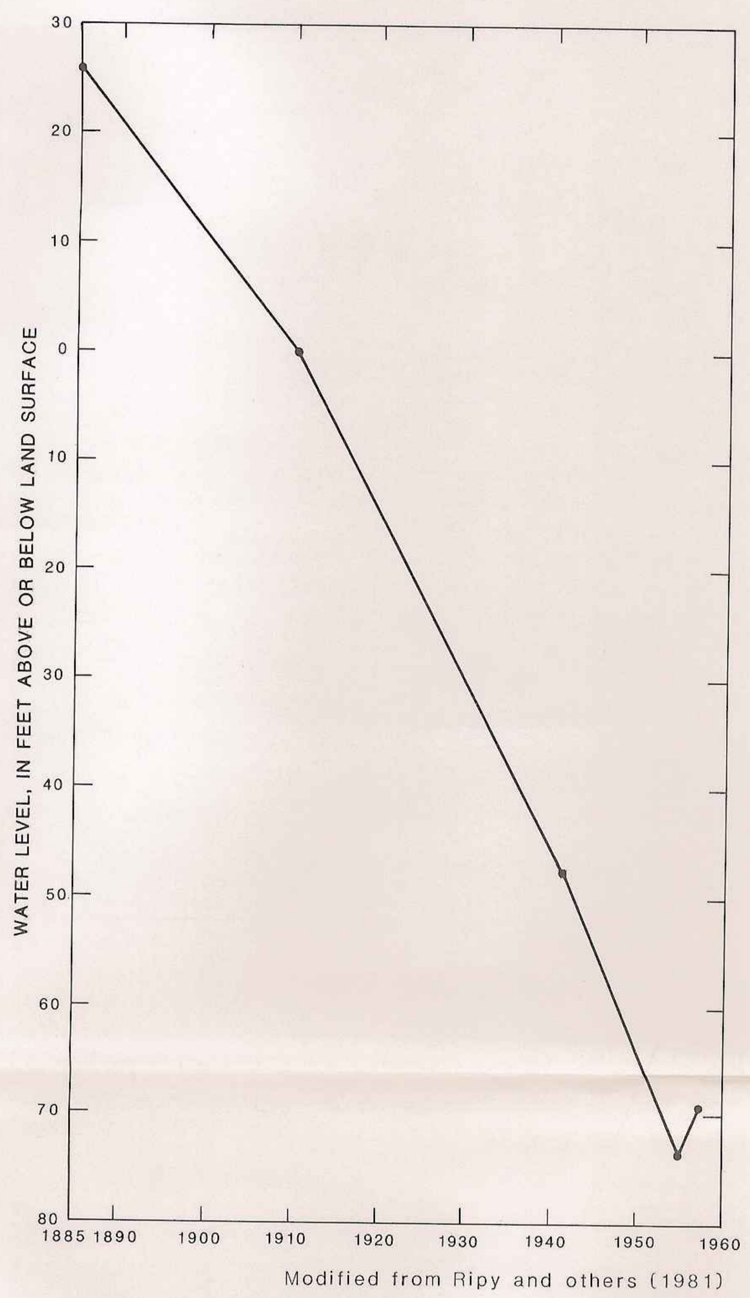

Figure 20.—Intermittent measurements of water levels in the Clayton aquifer at well 12L26 at Albany, Dougherty County, 1901-57.

ALBANY AREA

Ground-water withdrawals from 1885 to 1955 resulted in the development of a cone of depression at Albany. A well owned by the Atlantic Ice Co. (12L26), tapping the Clayton aquifer at Albany, flowed in 1885, but by 1910 pumping caused the water level to decline 26 ft and the well ceased flowing (fig. 20). The water level continued to decline, and by 1955 the total decline in the well was 100 ft.

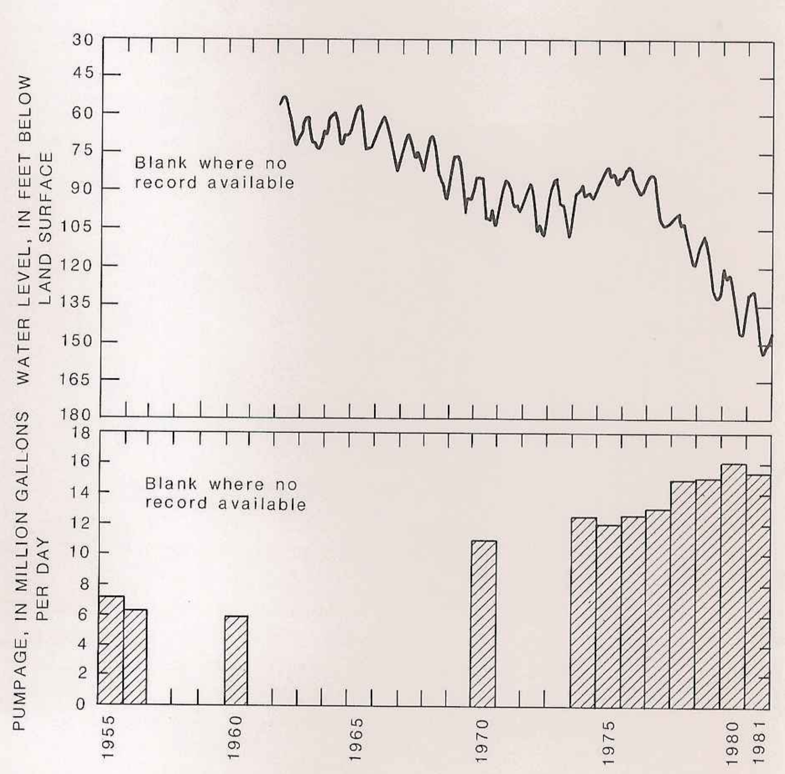

Figure 21.—Mean monthly water levels in the Clayton aquifer at well 13L2 at Albany, 1962-81, and average daily ground-water withdrawals by the city of Albany, Dougherty County, 1955-81.

During 1954-81, the cone of depression at Albany continued to expand and water levels in the Clayton aquifer north of Albany declined 100 ft (fig. 19). The decline corresponded to a general increase in ground-water withdrawal by the city of Albany during 1955-81 (fig. 21). Mean monthly water levels in well 13L2, located near the center of pumping at Albany, declined 69.2 ft from March 1962 to March 1981, with most of the decline occurring between 1977-81 (fig. 21). The accelerated rate of decline during 1977-81 corresponded to an increase in seasonal irrigation pumping.

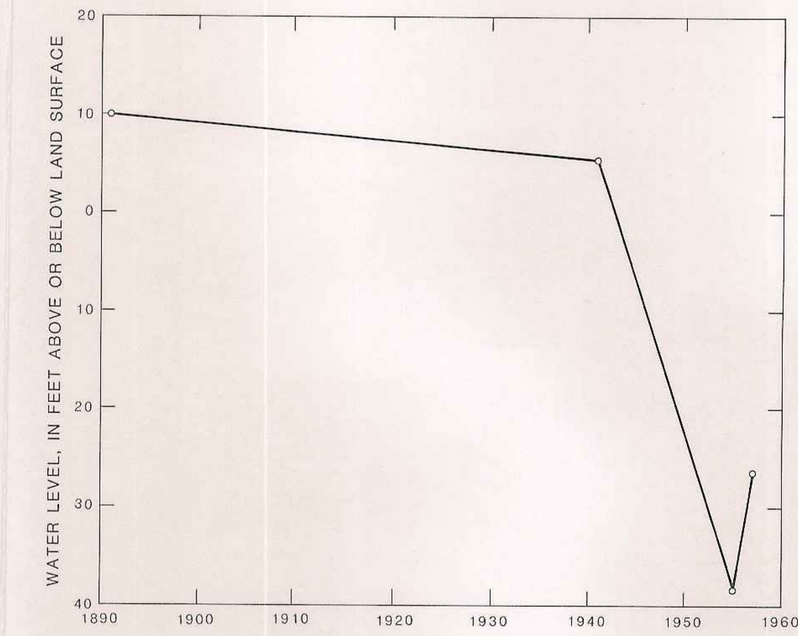

Figure 22.—Intermittent measurements of water levels in the Clayton aquifer at well 10L5, western Dougherty County, 1891-1957.

From 1891 to about 1943 in western Dougherty County, the potentiometric head in the Clayton aquifer was sufficient to produce a flow at well 10L5 (fig. 22). From 1891 to 1941, the water level in the well showed little decline. Between 1941-55, the water level declined at an accelerated rate, probably in response to increased pumping at Albany. The total decline in the well during 1891-1955 was 48 ft.

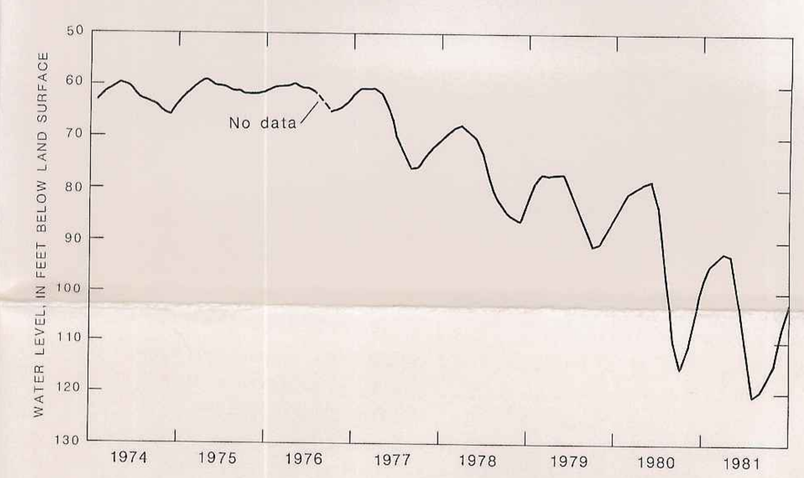

Figure 23.—Mean monthly water levels in the Clayton aquifer at well 11L2, western Dougherty County, 1974-81.

Between April 1974 and March 1981, mean monthly water levels in well 11L2 in western Dougherty County declined 32.6 ft (fig. 23). Prior to 1977, water levels in this well showed little seasonal fluctuation and only a slight decline. From March 1976 to March 1981, the seasonal fluctuations increased substantially and the decline in mean monthly water levels was 31.6 ft. The increased rate of decline and larger seasonal fluctuations were the result of increased irrigation pumping.

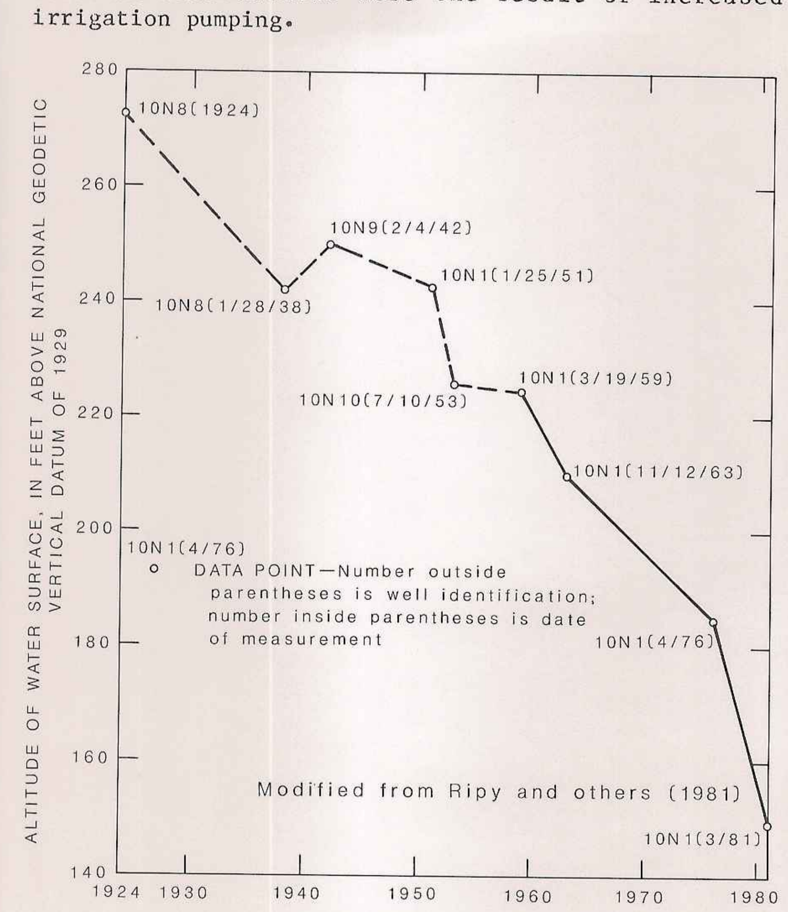

Figure 24.—Intermittent measurements of the altitude of the water surface in the Clayton aquifer at wells 10N1, 10N8, 10N9, and 10N10 at Dawson, Terrell County, 1924-81.

DAWSON AREA

Water levels in the Clayton aquifer at Dawson in Terrell County are affected primarily by changes in local and regional pumping. A plot of the altitude of the water surface in adjacent wells tapping the Clayton aquifer at Dawson during the period 1924-81 is shown in figure 24. Increased regional pumping caused water levels in the Clayton aquifer at Dawson to decline 122 ft over the period 1924-81. The rate of decline increased after 1976, corresponding to an increase in seasonal irrigation pumping and the growth of the cone of depression at Albany. By March 1981, the 150-foot contour depicting the Albany cone of depression had expanded north of the city of Dawson (fig. 17).

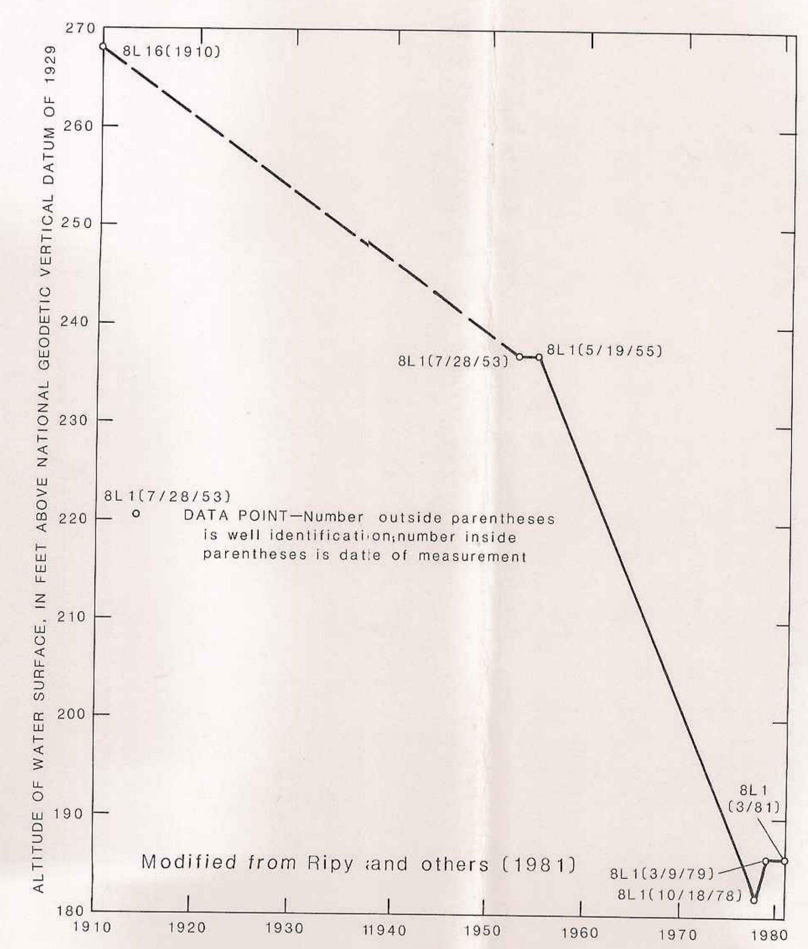

Figure 25.—Intermittent measurements of the altitude of the water surface in the Clayton aquifer at wells 8L1 and 8L16 at Edison, Calhoun County, 1910-81.

EDISON AREA

Water levels in the Clayton aquifer at Edison in Calhoun County are affected primarily by changes in regional pumping. A plot of the altitude of the water surface in adjacent wells tapping the Clayton aquifer at Edison during the period 1910-81 is shown in figure 25. Water levels in the Clayton aquifer at Edison declined 31 ft between 1910-53 and 51 ft between 1953-81, largely because of increases in regional pumping.

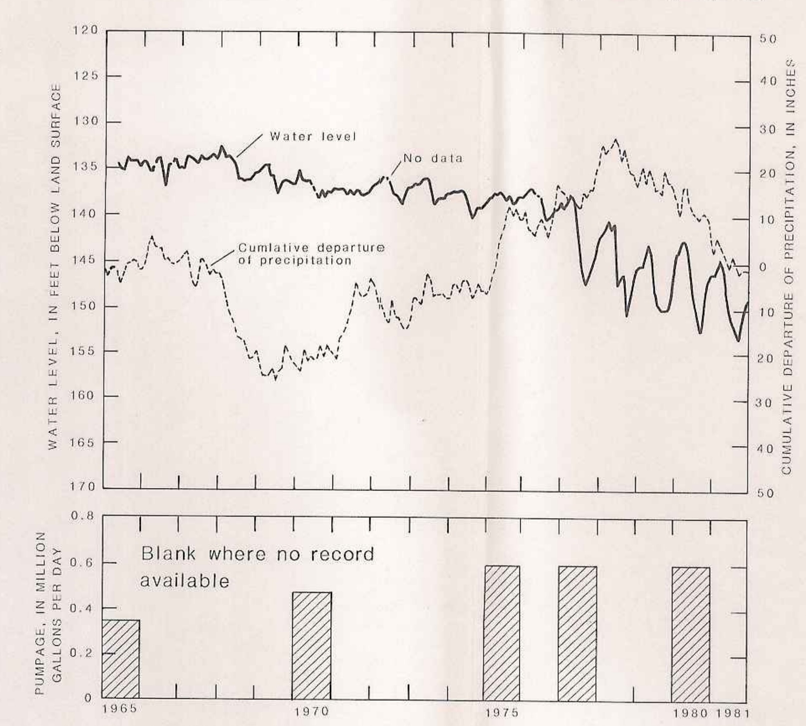

Figure 26.—Mean monthly water levels in the Clayton aquifer at well 7N1, the cumulative departure of precipitation at National Weather Service station 092450, and average daily ground-water withdrawals by the city of Cuthbert, Randolph County, 1965-81.

CUTHBERT AREA

Water levels in the Clayton aquifer near the outcrop area at Cuthbert in Randolph County are affected primarily by changes in the rates of pumping and precipitation. Increased regional pumping caused water levels in the Clayton aquifer at Cuthbert to decline about 20 ft during 1954-81 (fig. 19). A hydrograph of water levels in the Clayton aquifer at well 7N1 at Cuthbert shows that mean monthly water levels declined 3.2 ft from March 1968 to March 1976 and 6.5 ft from March 1977 to March 1981 (fig. 26). Declines during 1965-75 corresponded to a general increase in ground-water withdrawals in the Cuthbert area.

At National Weather Service station 092450 at Cuthbert (See location, fig. 17.), significant departures from normal precipitation occurred during 1968-69, 1971-78, and 1978-81 (fig. 26). A period of lower-than-normal precipitation occurred from 1968 to mid-1969, during which water levels in the Clayton aquifer showed a slight decline. The period from mid-1969 to mid-1978 was one of greater-than-normal precipitation, yet water levels in the aquifer continued to decline. This probably indicates that regional pumping has a greater influence on water levels in the aquifer than precipitation. Water levels in the Clayton aquifer declined at an accelerated rate from 1977 to 1981, corresponding to a significant increase in seasonal irrigation pumping and to lower-than-normal precipitation from 1978 to 1981.

RECHARGE

The Clayton aquifer is recharged by precipitation along parts of an irregular and discontinuous 200-mi^2 outcrop belt that extends from the Chattahoochee River valley in Clay and Quitman Counties northeastward to the Flint River valley in Schley and Sumter Counties (fig. 8).

In the Chattahoochee River area, recharge to the aquifer has increased since the impoundment of the Walter F. George Reservoir in 1963 (Stewart, 1973). The recharge water enters the aquifer where it is exposed and has a lower head than water in the reservoir.

South of the outcrop belt, in the Albany area, Dougherty County, the Clayton aquifer probably receives recharge through leakage from the underlying Providence aquifer, as indicated by water-quality analyses. (See section on Water Quality.) Water from the Providence aquifer, under greater hydraulic pressure than water in the Clayton aquifer, moves upward through the Clayton-Providence confining zone into the Clayton aquifer. In the Albany, Dawson, and Leary areas, declining water levels in the Clayton aquifer have increased this naturally occurring head difference, thereby increasing the amount of water moving from the Providence into the Clayton.

Under predevelopment conditions, water from the Clayton aquifer had a greater hydraulic pressure than water in overlying units and moved upward into sandy units within the Wilcox confining zone. Water-level declines and resulting head changes in the Clayton aquifer in the Albany, Dawson, and Leary areas, however, have reversed the direction of movement, and the Clayton aquifer now probably is locally recharged by water from the Wilcox confining zone.

DISCHARGE

Discharge from the Clayton aquifer is to streams in the outcrop area. Immediately south of the outcrop area, water under greater head than that in overlying units moves upward into sandy layers within the Wilcox confining zone and discharges into streams. However, in the Albany, Dawson, and Leary areas, the head has been decreased by pumping and the upward flow has been reversed. In these areas, ground water may now be moving downward from the Wilcox confining zone into the Clayton aquifer.

A similar situation occurs at Americus, Sumter County, where the head in the underlying Providence aquifer has been decreased by pumping. Here, water from the Clayton aquifer, under higher head than water in the Providence aquifer, may move downward through the Clayton-Providence confining zone into the Providence aquifer.

FLOW THROUGH MULTIAQUIFER WELLS

Idle multiaquifer wells near Albany, Dougherty County; Dawson, Terrell County; and Leary, Calhoun County, are conduits through which water enters the Clayton aquifer. In 1979, flowmeter tests were made in eight idle city wells at Albany (Hicks and others, 1981, p. 20). Tests at one of the wells (12L6, Appendix A; fig. 7) indicated that water from the Providence aquifer was moving through the well into the Clayton aquifer at a rate of 12 gal/min, and from the Claiborne aquifer at a rate of 46 gal/min. During 1979, the Clayton aquifer received an estimated 1.1 Mgal/d of recharge water through 25 multiaquifer wells in Albany (Hicks and others, 1981, p. 20). A similar test conducted in an idle Dawson city well (10N18, table 2) in 1981 indicated that the Clayton aquifer was being recharged through the well by the underlying Providence aquifer at the rate of 178 gal/min (D. W. Hicks, U.S. Geological Survey, oral commun., 1982). The greater discharge rate at Dawson probably results from a higher head differential.

A multiaquifer well at Americus, Sumter County, probably acts as a conduit through which water from the Clayton aquifer is discharged into underlying Upper Cretaceous aquifers. City well 5 (12Q2, Appendix A; fig. 7) taps the Clayton aquifer and the underlying Providence, Cusseta, and Blufftown aquifers of Late Cretaceous age (table 1). Water-level declines in the Cretaceous aquifers (Clarke and others, 1983) have resulted in head differentials that facilitate the potential for downward flow in the well. It is therefore likely that water from the Clayton aquifer is discharged through the well into the underlying Cretaceous aquifers.

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1984
Cartography by Willis G. Hester

WATER USE

The Clayton aquifer supplied an estimated 19.8 Mgal/d during 1980 (table 3), of which about 58 percent was used by municipalities, 35 percent by agriculture, and 7 percent by industry. Major users of the Clayton include the cities of Albany and Dawson; industries in Dougherty, Terrell, and Early Counties; and agricultural users in Calhoun, Lee, Clay, Dougherty, Terrell, Sumter, Early, and Randolph Counties.

Table 3.--Estimated water use from the Clayton aquifer, 1980

[<, less than]

County	Ground-water use (Mgal/d)			
	Agricultural[1]	Industrial	Municipal	Total[2]
Calhoun	1.1	—	0.5	1.6
Clay	.6	—	<.1	.6
Dooly	.1	—	<.1	.1
Dougherty	.4	0.2	7.9	8.5
Early	.3	.3	.8	1.4
Lee	.3	<.1	.5	.8
Mitchell	<.1	—	—	<.1
Randolph	2.7	—	.6	3.3
Sumter	.3	—	—	.3
Terrell	1.1	1.0	1.1	3.2
Webster	<.1	—	<.1	<.1
Total	6.9	1.5	11.4	19.8

1/ Values are estimated growing-season withdrawals averaged over a 365-day period.
2/ Total excludes domestic use.

MUNICIPAL USE

DAWSON

The city of Dawson is supplied by a system of three wells tapping the Clayton aquifer that yielded an average of 1 Mgal/d in 1980. Ground-water use in Dawson increased 0.65 Mgal/d or about 190 percent over the period 1958-80 (fig. 27).

BLAKELY

A system of three wells tapping the Clayton aquifer supplied an average 0.8 Mgal/d to the city of Blakely in 1980. Ground-water use in Blakely increased 0.2 Mgal/d or about 30 percent over the period 1960-80 (fig. 27).

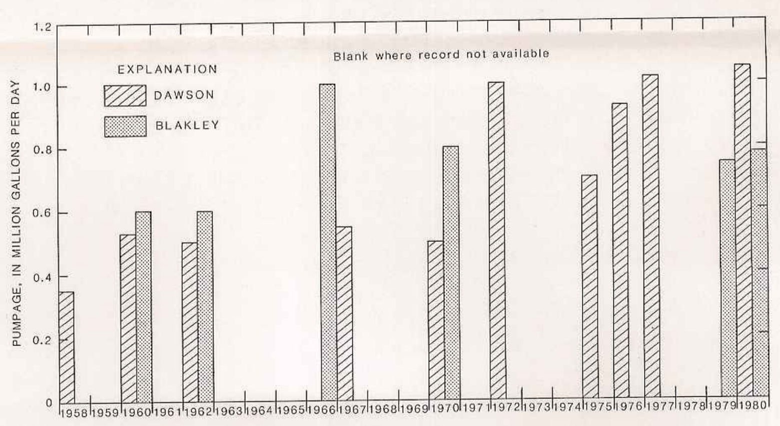

Figure 27.—Average daily ground-water withdrawals by Dawson and Blakely supply wells.

ALBANY

Since pumping began at Albany, water use has increased in response to population and industrial growth (fig. 21). Estimated water use at Albany increased from 0.025 Mgal/d in 1898 (McCallie, 1898, p. 181) to 4.8 Mgal/d in 1950. By 1980, the city of Albany was supplied by a system of 23 multiaquifer wells that produced 16 Mgal/d, an increase of about 235 percent from 1950. The Clayton aquifer yielded an estimated 7.2 Mgal/d, or about 45 percent of the 1980 supply.

CUTHBERT

The city of Cuthbert has a system of three wells tapping the Clayton aquifer that produced an average of 0.6 Mgal/d in 1980. Ground-water use increased 0.25 Mgal/d or 71 percent in Cuthbert over the period 1965-80 (fig. 26).

AGRICULTURAL USE

Ground-water withdrawals from the Clayton aquifer by agricultural users were computed by averaging the estimated growing season withdrawals over a 365-day period. The Clayton aquifer supplied an estimated 6.9 Mgal/d--about 35 percent of the total water pumped from the Clayton--to agricultural users during 1980 (table 3). Agricultural withdrawals exceeded 1 Mgal/d each in Randolph, Terrell, and Calhoun Counties. In addition, there are a large number of high-yielding irrigation wells of unknown construction in the study area, many of which probably tap the Clayton aquifer. Withdrawals from these wells were not estimated. Thus, total agricultural withdrawal from the Clayton during 1980 was probably greater than 6.9 Mgal/d. McFadden and Perriello (1983) included wells of unknown construction in their estimation of water use and reported that 15.5 Mgal/d was withdrawn from the Clayton aquifer by agricultural users in 1980.

In 1955 there were only 57 ground-water-supplied irrigation systems in southwest Georgia, but by 1979 the number had risen to about 3,000, an increase of more than 5,000 percent (Ripy and others, 1981, p. 4-5). The number of ground-water-supplied irrigation systems in southwest Georgia increased sharply from 1976 to 1981. According to Ripy and others (1981, p. 4-5), the number of irrigation wells increased 77 percent during 1977 in the area that includes Early, Clay, Quitman, Stewart, Randolph, Calhoun, Dougherty, Terrell, Webster, Lee, Sumter, Schley, Macon, Dooly, and Crisp Counties. Because the Clayton aquifer is an important source of water in these counties, it is likely that many of the wells tap the Clayton aquifer.

WELL CONSTRUCTION

Wells tapping the Clayton aquifer typically have open-hole or screenline construction, or a combination of both types (fig. 28; Appendix A). Where the aquifer consists of competent limestone, open-hole construction generally is used. Where the aquifer consists of sand and sandy limestone, screenlines generally are used (well 9P3, fig. 7; Appendix A). A combination of open-hole and screen-line construction may be used in areas where the Clayton consists of both consolidated limestone and loose sand or sandy limestone (well 12L9, fig. 7; Appendix A).

In some areas, the Clayton aquifer supplies insufficient quantities of water to meet municipal and industrial requirements and is used in combination with other aquifers. At Americus, Sumter County, multiaquifer wells tap combinations of the Clayton, Providence, Cusseta, and Blufftown aquifers. In municipal wells at Albany, the Clayton aquifer is used in combination with the Providence and Claiborne aquifers (well 12L9, fig. 7; Appendix A).

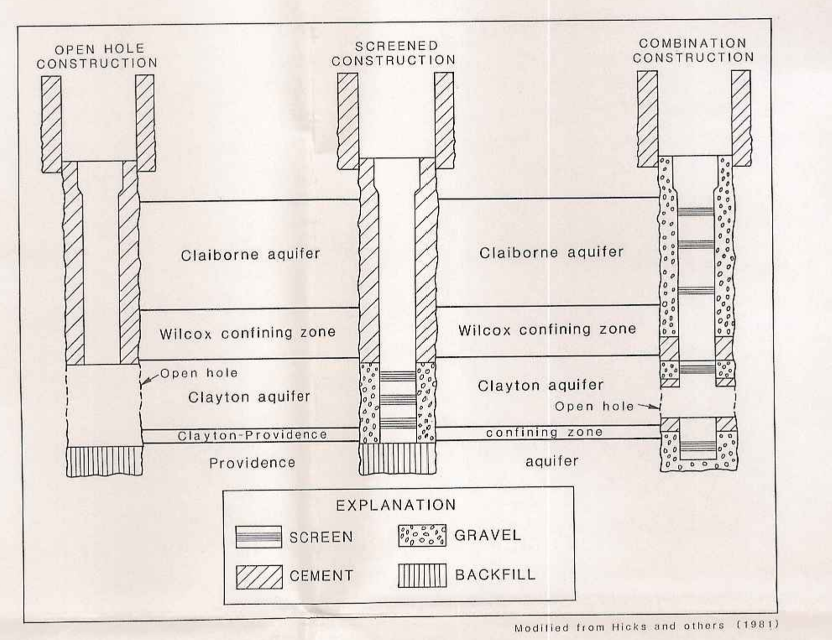

Figure 28.—Typical well construction.

WATER QUALITY

Water from the Clayton aquifer shows areal variations in constituent concentrations, but in that part of the study area where data are available, the concentrations generally do not exceed the Georgia Environmental Protection Division (1977) standards and recommended limits for drinking water (Appendix B).

The concentrations of dissolved solids and most other constituents appear to increase from the outcrop area southward (fig. 29; Appendix B). Concentrations of dissolved constituents in the southeastern part of the area, both within and south of the Gulf Trough (fig. 8), may exceed drinking water standards. Evidence of poor-quality water in the principal artesian and Claiborne aquifers (table 1) south of the Gulf Trough was reported by Wait (1960d).

The iron concentration in water from three wells (7N1, 7H1, 6M1) tapping the Clayton aquifer in Randolph County exceeds the 300 ug/L recommended limit set for drinking water (Appendix B). Iron concentrations in excess of 300 ug/L may result in the formation of a reddish-brown precipitate which will stain porcelain, white enamel, and clothing. Iron may be removed from water by aeration, coagulation, and filtration.

Throughout much of the study area where data are available, water from the Clayton aquifer has a calcium, magnesium hardness exceeding 100 mg/L and is classified as moderately hard to hard (fig. 29; Appendix B). Hardness exceeding 100 mg/L may result in reduced lathering of soap and the formation of scale on cooking utensils, and in boilers and hot water lines (Hem, 1970, p. 225). Hard water can be softened by ion exchange and through chemical treatment.

A diagram showing the chemical classification of ground water according to type is shown in figure 30. The plots represent the percentage concentrations of the various groups of ions in the water. The percentages were calculated from concentrations in milliequivalents per liter and were based on the sum of either the cations or the anions. Water from the Clayton and Providence aquifers has distinct chemical characteristics. Water from the Clayton is generally a moderately hard to hard, calcium carbonate type characteristic of limestone (well 7N1, at Cuthbert, Randolph County). On the other hand, water from the Providence aquifer is a soft, sodium bicarbonate type (well 12L21, at Albany, Dougherty County) typical of sand that contains much sodium feldspar. The sodium also may be derived from base exchange between calcium in the ground water and sodium in certain clay minerals (Wait, 1960b, p. 99). Wells tapping both aquifers yield a composite water representing a mixture controlled by the percentage of yield from each aquifer (well 9L4, at Morgan, Calhoun County).

In the Albany area, water from the Clayton aquifer has higher concentrations of sodium than elsewhere, and is a sodium bicarbonate type water (wells 12L20, 12M2), similar to water from the Providence aquifer (well 12L21). The similarity of water in the aquifers may indicate that: (1) water in the Clayton aquifer was derived, in part, from sodium-bearing sand in the lower part of the Clayton aquifer; (2) water from the Providence aquifer flowed into the Clayton aquifer through multiaquifer wells; or (3) water from the Providence aquifer leaked through the Clayton-Providence confining zone into the Clayton aquifer.

The first process, postulated by Wait (1960d, p. 12), probably has an effect on water quality in areas where the lower part of the Clayton aquifer consists of sodium-bearing sand. The second process occurs in the Albany, Dawson, and Leary areas, where multiaquifer wells tap both the Clayton and Providence aquifers. The third process may happen in areas where water from the Providence aquifer under higher head leaks upward into the Clayton aquifer. This probably occurs north and upgradient from multiaquifer wells at Albany where the Clayton aquifer does not include sodium-bearing sands (well 12M2; fig. 30).

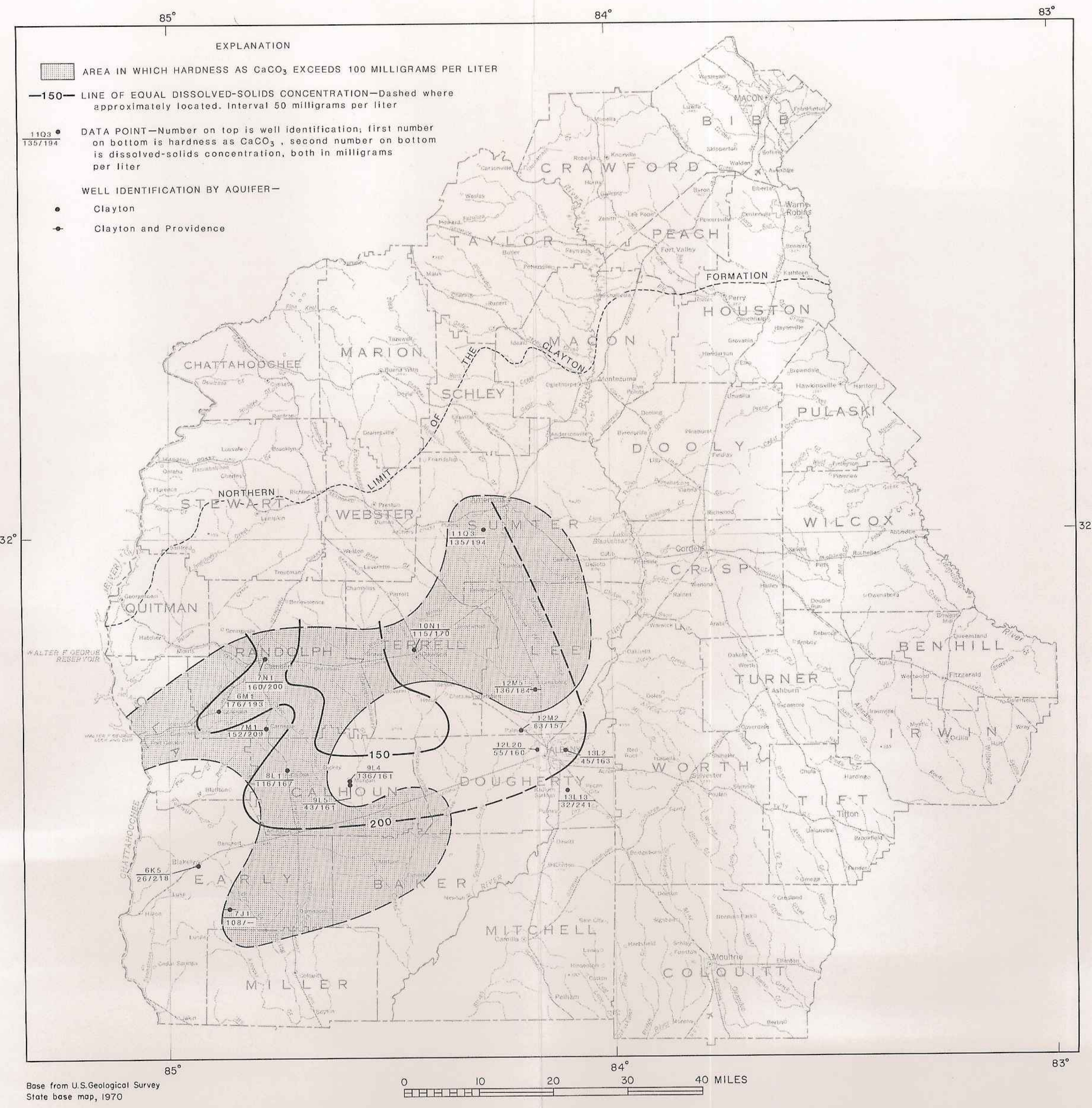

Figure 29.—Distribution of hardness as $CaCO_3$ and dissolved-solids concentrations in ground water from the Clayton aquifer, 1946-83.

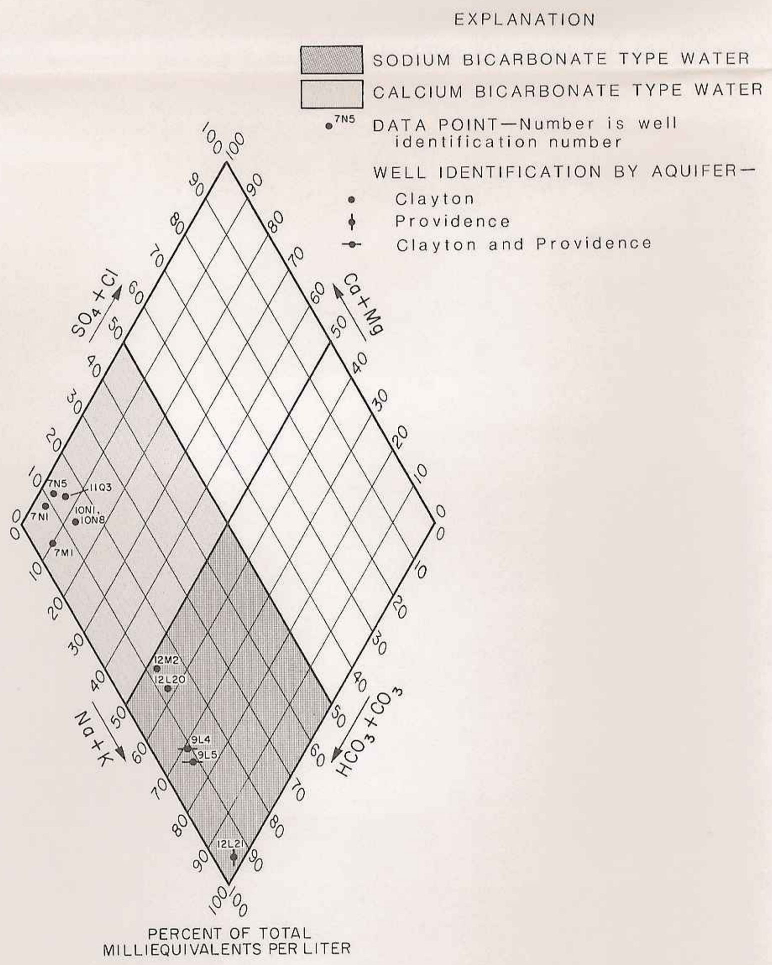

Figure 30.—Chemical classification according to type of ground water from the Clayton and Providence aquifers.

CONVERSION FACTORS

For use of readers who prefer to use metric units, conversion factors for terms used in this report are listed below:

Multiply	By	To obtain
	Length	
foot (ft)	0.3048	meter (m)
inch (in)	25.4	millimeter (mm)
mile (mi)	1.609	kilometer (km)
	Area	
square mile (mi^2)	2.590	square kilometer (km^2)
	Flow	
gallon per minute (gal/min)	0.06309	liter per second (L/s)
million gallon per day (Mgal/d)	0.04381	cubic meter per second (m^3/s)
	43.81	liter per second (L/s)
	Volume	
Part per million	1.0	milligram per liter (mg/L)
	1000.0	microgram per liter (ug/L)
	Transmissivity	
foot squared per day (ft^2/d)	0.0929	meter squared per day (m^2/d)
	Specific capacity	
gallon per minute per foot [(gal/min)/ft]	0.2070	liter per second per meter [(L/s)/m]
	Specific conductance	
micromho per centimeter at 25° Celsius (umoho/cm at 25°C)	1.000	microsiemens per centimeter at 25° Celsius (uS/cm at 25°C)
	Temperature	
degree Fahrenheit (°F)	$°C = \frac{5}{9}(°F-32)$	degree Celsius (°C)

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

SUMMARY

The Clayton aquifer of southwest Georgia consists of limestone and calcareous sand of Paleocene age and ranges in thickness from about 10 to 265 ft. The lithology of the aquifer is characterized by three provinces: (1) A clastic province in the northern part of the study area in which the principal sediments are sand and clay, (2) a carbonate province in the southern two thirds of the study area in which the principal sediments are limestone and calcareous sand, and (3) a transition province that occurs between the clastic and carbonate provinces and contains sedimentary elements common to both areas. The water-bearing characteristics of the aquifer are greatest in the carbonate province where transmissivities of 11,000 ft^2/d and yields of 2,150 gal/min have been reported.

During 1980, an estimated 20 Mgal/d was pumped from the Clayton aquifer. The greatest pumpage was in the Dawson and Albany areas where, by 1981, water levels in the Clayton aquifer had declined below predevelopment levels by as much as 150 and 175 ft, respectively. The rate of decline accelerated after 1976, corresponding to a significant increase in irrigation pumping throughout the study area.

The aquifer is recharged by precipitation in the northeast-trending outcrop belt; by leakage from the underlying Providence aquifer and overlying Wilcox confining zone downdip; and through idle multiaquifer wells in Albany, Dawson, and Leary. Declining water levels in the Clayton aquifer have increased the potential for leakage from the overlying and underlying units.

Constituent concentrations in water from the Clayton aquifer generally do not exceed drinking water standards. Exceptions are high concentrations of iron in Randolph County and possibly high dissolved-constituent concentrations in the vicinity of the Gulf Trough in the southeastern part of the study area.

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Cartography by Willis G. Hester

HYDROGEOLOGY OF THE CLAYTON AQUIFER OF SOUTHWEST GEORGIA.

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1984

Appendix A.— Record of selected wells

(Aquifers: Ec, Claiborne; Pw, Wilcox; Pc, Clayton; PcKp, Clayton-Providence; Kp, Providence; Kc, Cusseta; Kb, Blufftown. Use: I, industrial; P, public supply; A, agricultural; D, domestic; O, observation. Water level: Reported levels are given in feet, measured levels are given in feet and tenths. F, flowing)

County	Well No.	Georgia Geologic Survey No.	Latitude-longitude	Name or owner	Date drilled or modified	Depth of well (ft)	Depth of casing (ft)	Diameter of well (in.)	Altitude of land surface	Aquifer(s)	Water level: Above (+) or below (-) land surface (ft)	Water level: Date of measurement	Yield (gal/min)	Specific capacity (gal/min)/ft	Use	Remarks
Baker	10J1	—	312055- 0842854	McRainey Estate	Before 1907	661	365	—	165	Pw,Pc	+30 +3	1907 1981	70F	—	D	Open hole, 365-661 ft.
	11J2	—	311849- 0842006	Newton	1902	825	—	—	145	Pc	+35 +2	1902 02-27-64	15F 0.5F	—	P	
Calhoun	8L1	353	313331- 0844418	Edison, 2	1953?	515	395	—	289	Pc	-56 -103	04-15-53 03- -81	596	13	P	Open hole, 395-515 ft. Water-quality analysis, 5-19-55, 5-9-58, and 7-31-61. Transmissivity = 3,600 ft^2/d.
	8L2	—	313346- 0844230	Bill Israel	1954?	500	403	—	280	Pc	-40	06- -54	200	15	P	Open hole, 403-500 ft. Transmissivity = 4,400 ft^2/d.
	8K4	330	312621- 0844336	Arlington, 2	1953?	757	600	—	303	Pc,Kp	-103	02-06-53	305	6.5	P	Open hole, 600-757 ft.
	9L26	—	313250- 0843830	Morgan	1938	600	—	—	242	Pc	-16.05	07-28-53	—	—	P	Well caved below casing in 1953.
	9L5	—	313156- 0843602	Morgan, 2	1953?	636	485	—	240	Pc	F -64.4	1953 03- -81	—	—	P	Open hole, 485-636 ft. Water-quality analysis, 3-3-59.
	9K1	—	312912- 0840147	Leary, 2 (Old 3)	1953?	776	594	—	203	Pc,Kp	F	07-28-53	150F	—	P	Open hole, 594-776 ft. Water-quality analysis, 2-24-59 and 9-6-77.
	9L4	331	313220- 0843601	Morgan, 1	1952	657	485	—	242	Pc,Kp	-6 -55.7	12-19-52 03- -79	240	9.6	P	Open hole in limestone, 485-657 ft. Water-quality analysis, 2-2-54.
	9L2	997	313127- 0843011	Wildmead Plantation	1962	676	534	—	211	Pc	F -46.7	04-26-62 03- -81	15F	7.5	A	Open hole, 534-676 ft. Transmissivity = 1,900 ft^2/d.
	8L16	—	1/ 313330- 0844415	Edison	1910	563	—	6	300	Pc	-32	1910	215	—	P	
	9L27	—	1/ 313220- 0843601	Williams and Tinsley	1906	600	—	6	247	Pc	+8	1906	20F	—	I	
	7L1	—	313158- 0844625	Calvin Eubanks, 1	—	647	424	10	292	Pc,Kp	-108.6 -117.1	03-29-79 03- -81	900	—	A	Open hole, 424-647 ft.
	7L11	—	313458- 0844734	H. T. McClendon, 1	1969	480	—	4	365	Pc	-154.4 -160.1	03-29-79 03- -81	—	—	A	
	10L1	—	313227- 0842940	Adams-Curtiss and Bros., 2	1978	580	460	12	226	Pc	-82.7	03- -81	—	—	A	Open hole, 460-580 ft.
	10L6	—	313529- 0842825	Graham Angus Farms, 2	—	580	—	—	230	Pc	-68.0 -73.1	12- -79 03- -81	—	—	A	
	9L3	—	313517- 0843132	Adams-Curtiss and Bros., 1	—	540	440	10	260	Pc	-81.0 -95.8	03-01-79 03- -81	—	—	A	Open hole, 440-540 ft.
	9L1	—	313646- 0843109	Alvin Sudderth, 3	—	520	420	12	280	Pc	-110.7 -116.8	03-21-79 03- -81	—	—	A	Open hole, 420-520 ft.
Clay	5L6	435	313630- 0850223	Ft. Gaines, 2	1955	455	313	—	398	Pc	-266	04- -55	230	—	P	Open hole, 313-455 ft.
	5L5	402	313637- 0850206	Clay County School	1954?	500	340	6	395	Pc	-250 -253.6	08-02-54 03- -81	111	7.4	P	Formerly Speight School. Open hole, 340-405 ft. Transmissivity = 2,000 ft^2/d.
	5M3	—	313734- 0850245	E. R. Gay	1956?	130	—	—	160	Pc	+20 +17.8	1956 05-25-59	—	—	D	
	7L9	464	313510- 0845024	H. B. Hightower	1955?	555	436	8	408	Pc	-170 -168.2	11-11-55 04-21-59	100- 170	—	D	Open hole, 436-454 ft.
	5M1	—	313751- 0850210	Giles Brothers, 1 (observation well)	—	215	126	—	252	Pc	-78 -75.7	11-17-78 03- -81	—	—	O	Open hole, 126-215 ft.
	6L1	—	313539- 0845636	Bill Lindsey	—	560	450	—	390	Pc	-181 -180.5	12- -79 03- -81	1,300	—	A	Open hole, 450-560 ft.

County	Well No.	Georgia Geologic Survey No.	Latitude-longitude	Name or owner	Date drilled or modified	Depth of well (ft)	Depth of casing (ft)	Diameter of well (in.)	Altitude of land surface	Aquifer(s)	Water level: Above (+) or below (-) land surface (ft)	Water level: Date of measurement	Yield (gal/min)	Specific capacity (gal/min)/ft	Use	Remarks
Clay	7L12	—	313444- 0845047	Randall Richardson	—	555	435	—	390	Pc	-180	03- -81	—	—	A	Open hole, 435-555 ft.
	7L7	—	313115- 0845200	Bluffton, 1	—	555	480	—	322	Pc	-122 -133.7	03-05-70 03- -81	160	.30	P	Open hole, 480-555 ft. Transmissivity = 850 ft^2/d.
	5M4	—	314328- 0850127	E. E. Watson	—	100	85	—	275	Pc	-31 -31.6	07- -79 03- -81	—	—	D	Open hole, 85-100 ft.
	5L1	—	313637- 0844418	USACE, W. F. George, obsv.well	—	120	44	3	147	Pc	-32.3 -30.8	05-23-57 02-24-81	—	—	O	Open hole, 44-120 ft. Continuous water-level recorder installed, 5-23-57.
	5M5	—	313730- 0850349	USACE, W. F. George, well 564	1956	66	—	—	98	Pc	+10.4	02-09-56	1,050	—	O	Well destroyed when W. F. George Reservoir filled. Transmissivity = 6,700 ft^2/d.2/
Crisp	15P17	—	315813- 0834709	Cordele, 1	1905	735	600	—	300	Pc	-32	1905	—	—	P	Open hole, 600-735 ft. Well destroyed.
Dooly	14Q3	—	320605- 0835650	John Carroll	—	320	—	3	300	Pc	-13.8	01-31-51	—	—	D	Well destroyed prior to 1981.
	14Q4	—	320607- 0835834	J. E. Stewart	—	250	—	8	240	Pc,Pw	+3 -1	01-31-51 03-18-81	22.4	—	D	
	15R6	—	320338- 0834800	J. Grady Jones	—	500	—	—	365	Pc,Kp	-21.7 -32.5	02-01-51 04-02-81	—	—	D	
Dougherty	12L6	212	313455- 0841025	Albany, 11	1950	915	710	—	220	Ec,Pc,Kp	-107.6 -147.3	08-09-55 11-08-78	1,250	—	P	Screens 245-250, 265-270, 285-295, 325-335, 357-365, 385-390, 400-405, 430-435, 450-460, 490-495, 610-680, 690-700, 710-720, 730-740, 750-760, 780-790, 850-855, 865-875, 910-915 ft.
	12L25	—	313449- 0841006	Swift and Co.	—	594	—	—	195	Pw,Pc	+(?) -105.1 -143.4	1918 08-10-55 07-09-79	55F	—	I	Well sounded to 594 ft, 4-24-57. Well formerly owned by Virginia-Carolina Chemical Company.
	12L26	—	313511- 0840903	Atlantic Ice Co.	1901	710	660	—	195	Pc	+26 -72.1	1901 08-10-55	125F	—	I	Open hole, 660-710 ft. Well destroyed prior to 1979.
	11L15	—	313009- 0841849	St.Joe Paper Co., Red Cyprus well	1902?	595	580	—	180	Pc	+13.7 +6.8	11-28-41 08-24-55	17F	—	I	Open hole, 580-595 ft.
	10L5	—	313154- 0842441	J. P. Fort	1891	547	—	—	220	Pc	+10 -38.3	1891 08-18-55	—	—	D	Well destroyed prior to 1979.
	12L27	—	313445- 0840922	Albany, 1	1892	750	—	—	198	Pc	+10 -43.4	1892 1941	—	—	P	Well destroyed.
	12L20	—	313534- 0841300	USGS, TW 6	1978	690	619	4,3	198	Pc	-125.4 -137.0	01-18-78 03-10-81	—	—	O	Open hole, 619-690 ft. Water-quality analysis, 3-7-78. Continuous water-level recorder installed 1978.
	13L2	—	313554- 0840625	Turner City, test well	1951	760	713	12,8	213	Pc	-44.8 -125.7	05-13-57 03-10-81	250	1.70	O	Open hole, 713-760 ft. Continuous water-level recorder installed 1957. Water-quality analysis, 6-21-78. Transmissivity = 400 ft^2/d.
	13L13	—	313105- 0840642	USGS, TW 7	1978	882	716	6,4	184	Pc	-105.5	03-10-81	—	—	O	Open hole, 716-882 ft. Continuous water-level recorder installed 1978. Water-quality analysis, 5-31-78.
	11K5	3340	312654- 0842101	USGS, TW 12	1979	680	630	6,4	184	Pc	-23.0 -31.5	03-28-79 03- -81	—	—	O	Open hole, 630-680 ft. Continuous water-level recorder installed 1979.
	11L2	3173	313530- 0842032	Tallahassee Plan- tation, test well	1973	656	542	6	220	Pc	-86.3 -92.4	11-14-79 03-10-81	—	—	O	Open hole, 542-656 ft.
	12L4	151	313436- 0840818	Albany, 9	1948	795	330	—	193	Ec,Pc	-54	01-06-48	1,670	17	P	Screened, 300-345,357-362,370-410,425-465; open hole, 695-795 ft. Water-quality analysis,12-1-51 & 5-15-57.
	12L21	3406	313534- 0841030	USGS, TW 10	1978	840	810	14,5, 6	198	Kp	-116.9 -136.3	12-19-78 10- -80	—	—	O	Screened, 810-830 ft. Water-quality analysis, 11-21-78.
	12L9	367	313429- 0841123	Albany, 14	1954	885	275	20,10	212	Ec,Pc, Kp	-64	10- -54	1,320	7.9	P	Screened 275-295, 330-350, 385-395, 420-440, 480-490, 835-855 ft. Open hole 657-750 ft.
Early	6K9	3443	312827- 0845515	GGS, Kolomoki, TW 1	1979	612	492	—	310	Pc	-134.3 -141.7	12-14-79 03- -81	—	—	O	Open hole, 492-612 ft.
	7K11	3152	312657- 0844816	Singletary Farms, Fairfield well	—	675	509	—	230	Pc	-70 -78.1	06-06-74 03- -81	1,200	—	A	Open hole, 509-675 ft.
	7K10	1163	312445- 0844941	Singletary Farms, Bancroft well	—	770	624	—	232	Pc	-145 -69.6	1973 03- -81	—	—	A	
	6K8	—	312245- 0845558	Blakely, 2	1964	792	—	—	250	Pc	-95.7 -100.7	11-09-78 03- -81	—	—	P	

County	Well No.	Georgia Geologic Survey No.	Latitude-longitude	Name or owner	Date drilled or modified	Depth of well (ft)	Depth of casing (ft)	Diameter of well (in.)	Altitude of land surface	Aquifer(s)	Water level: Above (+) or below (-) land surface (ft)	Water level: Date of measurement	Yield (gal/min)	Specific capacity (gal/min)/ft	Use	Remarks
Early	6K6	—	312744- 0845536	Kolomoki State Park	1939	548	505	6	270	Pc	-85	11-30-39	50	10	P	Open hole, 505-548 ft. Transmissivity = 3,000 ft^2/d.
	7J1	437	311742- 0845135	W. J. Howell	1963	1,120	650	—	180	Pc,Kp	-22.8 -17.4	07-24-63 11-09-78	—	—	I	Open hole, 650-1120 ft. Former owner, S. A. Maddox. Water-quality analysis, 4-21-71. Also called Farmer's Gin and Warehouse.
	6K5	—	312246- 0845600	Blakely, 1	1931	809	650	8	240	Pc,Kp	-20	05-15-46	500	—	P	Open hole, 650-809 ft. Water-quality analysis, 10-1-40 and 5-16-46.
Lee	12M7	—	[1]314356- 0841210	Leesburg	1898	540	—	—	225	Pc	-12	1898	—	—	P	
	12M8	969	314000- 0841222	Fowltown Plantation, 1	1964?	700	560	—	245	Pc	-71 -120.7	1964 03- -81	—	20	A	Open hole, 560-680 ft. Transmissivity = 5,700 ft^2/d.
	11P3	—	315358- 0841819	Pete Long, 3	—	400	280	—	340	Pc	-90.5 -90	03-22-79 03- -81	—	—	A	Open hole, 280-400 ft.
	12M2	—	313812- 0841250	USGS, TW 9	1978	650	567	6	238	Pc	-119.2 -140.8	02-01-79 03-10-81	—	—	O	Open hole, 567-650 ft. Continuous water-level recorder installed 1978. Water-quality analysis, 9-28-78.
	12M9	3142	313801- 0841049	Creekwood Apts., 2	1973	668	560	12.25	202	Pc	-103 -103.4	10-25-73 07-11-79	536	13	P	Open hole, 560-668 ft. Transmissivity = 5,100 ft^2/d. Formerly LeHigh Acres, 2.
	11M8	1850	314030- 0841718	Lilliston Implement Co., 1	1967	644	520	12.25	265	Pc	-77	04-18-67	656	20	I	Open hole, 520-644 ft. Transmissivity = 5,200 ft^2/d.
	12M5	—	314236- 0841036	James Wingfield, 2	1952	717	555	—	230	Pc,Kp	-7.0 -25.0	1952 07-10-79	200	—	A	Open hole, 555-717 ft. Water-quality analysis, 1-4-59.
Miller	8H2	112	311018- 0844358	Colquitt, 2	—	1,035	785	8	169	Pc	-27.9	05-16-46	235	—	P	Open hole, 785-1,035 ft.
Randolph	7N4	—	314737- 0844520	Randolph County Prison Farm	1951?	329	270	6	481	Pc	-146	07-06-51	—	—	P	Open hole, 270-329 ft.
	9N4	—	314530- 0843657	Shellman	—	410	—	—	390	Pc	-70	1902	—	—	P	
	8N1	—	314743- 0844142	Earl Nisley	—	350	290	—	463	Pc	-159.7 -162.1	03-08-79 03- -81	700- 800	—	A	Open hole, 290-350 ft.
	7N1	—	314609- 0844743	USGS, Cuthbert observation well	1958?	372	250	—	455	Pc	-134.1 -144	01-05-65 03-10-81	—	—	O	Open hole, 250-272 ft. Continuous water-level recorder installed 1-65. Water-quality analysis, 6-22-78. Transmissivity = 11,000 ft^2/d.
	8M1	—	314352- 0844250	Bob Lovett	—	405	297	—	410	Pc	-126 -132.7	03- -75 03- -81	1,325	—	A	Open hole, 297-405 ft.
	8M2	—	313933- 0844241	James Grubbs and Sons, 1	—	470	350	—	370	Pc	-167.7 -148.3	12- -79 03- -81	—	—	A	Open hole, 350-470 ft.
	9M4	3069	314404- 0843537	Bruce Bynum	—	435	320	—	360	Pc	-140 -156.9	12- -70 03- -81	1,016	54	A	Open hole, 320-435 ft. Transmissivity = 3,300 ft^2/d.[2]
	9M2	—	314220- 0843716	T. E. Allen, III	—	475	338	12	370	Pc	-139 -158.7	07-09-74 03- -81	1,004	23	I	Open hole, 338-475 ft. Transmissivity = 5,900 ft^2/d.[2]
	9M6	—	313952- 0843610	C. T. Martin, TW 1	—	430	360	—	322	Pc	-127.1	03- -81	—	—	A	Open hole, 360-430 ft.
	9M7	3449	313953- 0843615	C. T. Martin, TW 2	1980	430	356	—	322	Pc	-120.3 -126.6	04-04-80 03- -81	—	—	O	Open hole, 356-430 ft.
	7N5	—	314609- 0844742	Cuthbert, 2 (Site 1)	—	480	—	—	460	Pc	—	—	600	—	P	Water-quality analysis, 4-21-71.
	7N3	1507	314627- 0844708	Cuthbert, 3 (Site 2)	—	309	248	—	460	Pc	-145	03-25-65	602	40	P	Open hole, 248-309 ft. Water-quality analysis, 4-8-58 and 7-31-61. Transmissivity = 6,100 ft^2/d.
	7M1	—	313826- 0844658	Max Sheppard	—	310	206	—	381	Pc	-78.8	05-03-66	20	—	D	Open hole, 206-310 ft. Water-quality analysis, 5-3-66.
	6M1	—	314020- 0855338	Coleman, 1	1982	442	343	8	416	Pc	-184	—	500	26	P	Open hole, 343-442 ft. Transmissivity = 7,900 ft^2/d. Water-quality analysis, 2-17-83.
Sumter	10Q5	—	320201- 0842330	Plains	—	244	—	3	500	Pc	-85	1909	10	1	P	Cavity at 243 ft.
	12R3	—	320942- 0840753	Hodges	—	244	200	3	450	Pc	-132	1915	—	—	D	Open hole, 200-244 ft.

County	Well No.	Georgia Geologic Survey No.	Latitude-longitude	Name or owner	Date drilled or modified	Depth of well (ft)	Depth of casing (ft)	Diameter of well (in.)	Altitude of land surface	Aquifer(s)	Water level: Above (+) or below (-) land surface (ft)	Water level: Date of measurement	Yield (gal/min)	Specific capacity (gal/min)/ft	Use	Remarks
Sumter	12Q2	692	320321-0841212	Americus, 5 (Ind. Pk. well)	1957	890	210	—	410	Pc,Kp, Kc,Kb	-99.6 -116.4	01-31-75 10-24-80	900	—	P	Screens 210-220, 255-260, 275-280, 310-315, 370-375, 385-390, 428-433, 455-460, 520-525, 630-635, 668-673, 740-745, 775-780, 807-812, 885-890 ft.
	12R2	345	321141-0840817	Andersonville, 2	1953	121	—	—	358	Pc	-26.0 -64.8	07-16-63 11-14-78	—	—	P	
	12R1	342	321148-0840839	Andersonville, 1	1953	216	—	—	412	Pc	-55.0 -73.8	07-16-53 10-24-80	—	—	P	
	10Q3	—	320456-0842242	Smith	1950	252	180	—	528	Pc	-60	10-18-50	—	—	D	Open hole, 252-180 ft.
	11Q10	278	320225-0841742	C. F. Stephens	—	271	—	—	486	Pc	-97	10-18-51	—	—	D	
	12Q21	281	320249-0841326	Home for the Aged	1952	207	180	—	392	Pc	-78	03-17-52	—	—	D	Open hole, 180-207 ft.
	11Q4	334	320131-0841521	J. R. Autry	1952	258	252	—	407	Pc	-60	01- -53	—	—	D	Open hole, 252-258 ft.
	11Q11	—	320039-0841516	Allison Adams	—	293	—	—	385	Pc	-60	01-19-53	—	—	D	
	12P7	—	315907-0841247	Reddick	—	300	300	—	351	Pc	-40	10-18-51	—	—	D	
	12P4	255	315842-0841253	L. G. Childers	12- -51	355	305	—	328	Pc	-46	10-18-51	—	—	D	Open hole, 305-355 ft.
	12P8	—	315803-0841242	Crisp	—	372	—	—	313	Pc	-14	1941	—	—	D	
	12P9	—	315623-0841149	Averitt	—	385	—	—	311	Pc	-6	10-18-51	—	—	D	
	11P4	—	315544-0841823	T. J. Suggs	1925	337	—	—	373	Pc	-60	03-16-51	—	—	D	
	10Q7	—	320059-0842440	Hugh Carter Worm Farm	—	230	—	—	480	Pc	-96 -96.7	11-09-78 03- -81	—	—	D	
	10P1	—	315846-0842620	G. Sutherland	—	190	—	—	445	Pc	-68 -66.5	12- -79 03- -81	—	—	D	
	11Q3	693	320105-0841733	Bowen	—	301	—	—	470	Pc	-140.5	11-08-78	—	—	D	Water-quality analysis, 1-9-59.
	12Q24	—	320443-0840836	Murphy	—	332	272	—	432	Pc	-92	—	—	—	D	Open hole, 272-332 ft.
	11P5	—	315607-0841535	Henry Williams	1951	357	—	—	329	Pw,Pc	-35	02-16-51	—	—	D	
	12Q25	—	1/ 320330-0841200	Perry and Brown	—	284	—	4	400	Pc	-100	1908	—	—	I	
Terrell	10N9	—	314641-0842635	Dawson	1903	447	—	8	368	Pc	-36 -117.5	1903 02-04-42	500	—	P	
	10M7	—	314321-0842315	Bob Lock, Irrigation well	—	520	421	14	290	Pc	-148.9	07-26-79	2,150	25	A	Open hole, 421-527 ft. Transmissivity = 6,700 ft^2/d.
	10N10	352	314659-0842653	Dawson Cotton Oil Co.	—	433	334	—	342	Pc	-116	07-10-53	448	28	I	Open hole, 334-433 ft.
	10N2	503	314615-0842854	Cocke Fish Hatchery	1956?	597	369	—	389	Pc	-127	08-29-56	363	—	A	Open hole, 369-597 ft.
	10N8	—	314636-0842637	Dawson	1924	475	360	—	368	Pc	-96 -126	1924 11-28-38	350 300	12	P	Open hole, 360-475 ft. Water-quality analysis 1938.
	9M1	677	314204-0843125	Miller, 2	1956	454	372	—	340	Pc	-99	11- -56	130	22	D	Open hole, 372-454 ft.
	9P2	3119	315348-0833045	Parrott, 2	—	401	290	—	483	Pc	-136 -154	03-15-73 03- -81	300	5.9	P	Open hole, 290-401 ft. Transmissivity = 1,400 ft^2/d.

Appendix A.— Record of selected wells — Continued

County	Well No.	Georgia Geologic Survey No.	Latitude-longitude	Name or owner	Date drilled or modified	Depth of well (ft)	Depth of casing (ft)	Diameter of well (in.)	Altitude of land surface	Aquifer(s)	Water level: Above (+) or below (-) land surface (ft)	Water level: Date of measurement	Yield (gal/min)	Specific capacity (gal/min)/ft	Use	Remarks
Terrell	10P2	—	315325-0842338	Don Foster	—	305	225	—	359	Pc	-70 -120.8	1973 03- -81	—	—	A	Open hole, 225-305 ft.
	11N3	—	314955-0842146	Bronwood, 2	—	465	390	—	360	Pc	-195 -203	08-20-74 08- -81	524	25	P	Open hole, 390-465 ft. Transmissivity = 6,700 ft^2/d.
	11N2	406	314948-0842150	Bronwood, 1	—	453	390	—	369	Pc	-96 -214.1	12- -54 08- -81	260	7.6	P	Open hole, 390-453 ft.
	10N15	—	314819-0842441	Vernon Copeland	—	500	385	—	369	Pc	-217	03- -81	—	—	A	Open hole, 385-500 ft.
	10N5	—	314802-0842404	Webb, 1	—	465	407	—	356	Pc	-180.1 -196.3	03-22-74 03- -81	500	18	A	Open hole, 407-465 ft.
	10N1	213	314650-0842647	Dawson, 3	1950	496	345	—	350	Pc	-107 -200	01-25-51 03- -81	955	26	P	Open hole, 345-495 ft. Well backfilled, 495-1,028 ft. Water-quality analysis, 7-31-61.
	9N5	—	314628-0843419	T. Bentley	—	380	231	—	350	Pc	-125 -110.5	1978 03- -81	—	—	A	Open hole, 231-380 ft.
	10N3	2251	314623-0842854	Cocke Fish Hatchery, 3	—	500	378	—	375	Pc	-162 -182	04-10-70 03- -81	548	24	A	Open hole, 378-500 ft. Transmissivity = 6,000 ft^2/d.
	10N11	994	314606-0842612	Dawson, 4	—	553	355	—	330	Pc	-140 -207.2	11-14-63 03- -81	1,176 720	39	P	Open hole, 355-553 ft. Transmissivity = 10,000 ft^2/d.
	10M2	—	314412-0842423	Browns Dairy	—	496	394	—	312	Pc	-95 -168.5	1956 03- -81	—	—	A	Open hole, 394-496 ft.
	11M2	3100	314315-0842059	Sasser, 3	—	620	475	—	312	Pc	-154 -172.6	09-26-73 03- -81	—	—	P	Open hole, 475-620 ft. Transmissivity = 11,000 ft^2/d.
	10M6	—	314053-0842330	Bill Whittaker, 2	—	520	400	—	268	Pc	-133 -135	11-21-78 03- -81	—	—	A	Open hole, 400-520 ft.
	11M4	—	314001-0841804	Piedmont Plant Co.	—	626	515	—	272	Pc	-118 -148	02-23-77 03- -81	1,000	—	A	Open hole, 515-626 ft.
	10M5	—	313855-0842956	Jimmy Bangs, 2 Irrigation well	—	500	400	—	298	Pc	-135	03- -81	—	—	A	Open hole, 400-500 ft.
	9P4	—	315340-0843045	Parrott	—	300	—	—	460	Pc	-65	1915	—	—	P	
	11M9	—	314300-0842100	Sasser	—	540	—	—	315	Pc	-60	1908	—	—	P	
	9N6	—	314610-0843105	J. B. Graves Station	—	321	—	—	360	Pc	-50	1915	—	—	D	
Webster	8P2	—	325725-0843807	Raymond Goodman	—	240	—	—	530	Kp-Pc	-141.5	03- -81	—	—	D	
	9R3	—	321027-0843342	South River Farms	—	170	—	—	602	Kp-Pc	-130 -130.3	12/79 3/81	—	—	A	
	9P3	—	315842-0843644	Weston, 1	268	238	6	—	533	Pc	-135 -110	04-01-71 711-09-76	257	3.4	P	Screen 238-268 ft. Transmissivity = 660 ft^2/d.

1/ Location approximate.
2/ Transmissivity computed from time-drawdown or time-recovery data.

Appendix B.— Chemical analyses of water from the Clayton and other aquifers

(Analyses by U.S. Geological Survey except as noted. Aquifers: Ec, Claiborne; Pc, Clayton; Kp, Providence. <, less than)

Site No.	Owner or name	Aquifer(s)	Date sampled	Milligrams per liter												Dissolved solids		Hardness		Specific conductance, in micromhos at 25°C	Field pH	Temperature, in degrees Celsius	Color, in platinum cobalt units	Carbon dioxide (CO_2)	Micrograms per liter											
				Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Alkalinity, as $CaCO_3$	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Nitrite (NO_2)	Residue at 180°C	Sum of constituents	Calcium, magnesium	Noncarbonate						Aluminum (Al)	Arsenic (As)	Cadmium (Cd)	Chromium (Cr)	Copper (Cu)	Iron (Fe)	Lead (Pb)	Manganese (Mn)	Mercury (Hg)	Selenium (Se)	Strontium (Sr)	Zinc (Zn)
Georgia Environmental Protection Division recommended limits (R) and standards (S) for safe drinking water, 1977											250 (R)	250 (R)	1/			500 (S)	500 (R)	2/					15 (R)	3/		50 (S)	10 (S)	50 (S)	1,000 (R)	300 (R)	50 (S)	50 (R)	2.0 (S)	10 (S)		5,000 (R)
9L4	Morgan, 1	Pc,Kp	02-02-54	16	11	2.1	46	1.8	156	128	7.2	2.8	0.2	0.40	--	161	164	36	0	264	7.7	--	2	--	--	--	--	--	--	--	--	--	--	--	--	--
9L5	Morgan, 2	Pc	03-03-59	14	9.2	4.9	48	1.5	160	138	8.0	3.0	.3	.00	--	161	172	43	0	266	8.6	21.0	5	--	--	--	--	--	--	--	--	--	--	--	--	--
8L1	Edison	Pc	05-19-55	21	36	3.8	12	2.0	149	122	9.7	1.0	.1	1.0	--	157	160	106	0	246	7.9	21.5	6	--	--	--	--	--	--	--	--	--	--	--	--	--
			05-09-58	23	35	5.0	12	1.9	149	122	9.5	.0	.1	.20	--	161	160	108	0	251	7.7	21.5	1	--	--	--	--	--	--	--	--	--	--	--	--	--
			07-31-61	23	35	6.9	10	2.0	148	121	10	4.0	.2	.00	--	167	164	116	0	249	7.6	22.0	0	--	--	--	--	--	--	--	--	--	--	--	--	--
12L20	USGS TW 6	Pc	07-03-78	20	12	6.0	33	2.8	140	110	13	1.5	.2	.04	0.00	160	158	55	0	231	7.2	22.8	10	14	20	0	0	0	0	180	11	10	<.5	0	360	0
13L13	USGS TW 7	Pc	05-31-73	25	8.6	2.4	80	3.1	230	190	4.2	4.5	.7	.00	.00	241	243	32	0	284	8.0	21.7	10	--	40	2	0	0	7	110	0	10	<.5	0	380	0
12L21	USGS TW 10	Kp	11-21-78	12	1.7	.4	85	1.6	200	190	7.6	2.4	.6	.09	.00	214	223	6	0	358	9.2	24.0	0	.2	40	0	3	1	0	50	10	0	.6	0	--	0
12L4	Albany, 9	Ec,Pc	12-01-51	32	32	6.5	--	--	176	144	8.6	3.2	.2	.20	--	194	--	107	0	297	7.8	22.0	1	4.5	--	--	--	--	--	--	--	--	--	--	--	--
			05-15-57	34	31	5.5	24	2.4	178	146	6.8	2.8	.2	.30	--	192	195	100	0	287	8.0	--	2	2.8	--	--	--	--	--	--	--	--	--	--	--	--
13L2	Turner City, 2	Pc	08-16-55	21	11	5.7	40	2.8	149	122	12	2.5	.2	.40	--	162	169	50	0	256	7.6	23.5	8	--	--	--	--	--	--	--	--	--	--	--	--	--
			04-28-76	18	11	5.1	39	3.3	146	120	12	2.7	.3	.00	.03	170	164	49	0	183	6.7	24.0	0	47	0	0	0	0	0	170	0	0	.1	0	270	0
			06-21-78	18	10	4.9	39	2.8	140	110	9.4	1.7	.2	.09	.00	163	156	45	0	229	6.6	24.0	5	56	20	1	1	0	0	250	8	10	<.5	0	260	10
7J1	W. J. Howell	Pc,Kp	04-21-71	--	--	--	--	--	--	--	8.0	--	.2	--	--	--	--	108	--	310	8.1	20.0	0	--	--	--	0	--	0	90	0	20	--	--	--	50
6K5	Blakely, 1	Pc,Kp	10-01-40	--	5.6	1.3	4.8	1.4	23	19	10	4.1	.1	.99	--	--	--	19	0	--	--	--	7	--	--	--	--	--	--	--	--	--	--	--	--	--
			05-16-46	16	5.8	2.7	74	--	191	157	16	8.8	.4	1.6	--	218	--	26	0	--	--	25.0	3	--	--	--	--	--	--	6	--	--	--	--	--	--
12M2	USGS TW 9	Pc	09-28-78	19	15	6.0	30	2.9	140	110	14	1.9	.2	.00	.00	157	159	63	0	170	7.7	21.9	5	4.5	0	0	1	0	0	120	13	10	<.5	0	410	0
12M5	James Wingfield	Pc,Kp	01-04-59	34	52	1.6	2.6	.8	164	135	.4	1.5	.0	.10	--	184	174	136	2	267	7.5	19.0	5	8.3	--	--	--	--	--	--	--	--	--	--	--	--
7N5	Cuthbert, 2 (Site 1)	Pc	04-21-71	17	50	3.5	1.5	1.3	156	128	13	2.0	.1	.00	.01	170	166	140	12	270	8.1	20.0	0	--	--	--	0	--	0	620	0	30	--	--	160	90
7N3	Cuthbert, 3 (Site 2)	Pc	04-08-58	17	39	8.4	1.4	1.1	147	121	12	2.5	.1	.00	--	153	154	132	12	254	7.8	20.0	5	--	--	--	--	--	--	--	--	--	--	--	--	--
			07-31-61	16	48	3.9	1.2	1.2	146	120	14	2.0	.2	.00	--	161	159	136	16	255	7.7	20.0	0	--	--	--	--	--	--	--	--	--	--	--	--	--
7N1	Cuthbert, USGS obsrv. well	Pc	06-22-78	20	56	3.7	1.8	1.5	170	140	8.0	2.1	.0	.00	.00	200	178	160	16	270	6.8	22.0	5	43	20	1	0	0	0	530	3	40	<.5	0	170	10
7M1	Max Sheppard	Pc	05-03-66	36	54	4.2	6.9	1.4	200	164	6.0	1.0	.1	.00	--	--	209	152	0	305	7.4	--	5	--	--	--	--	--	--	--	--	--	--	--	--	--
6M1	Coleman, 1983 well	Pc	[4] 02-17-83	--	1.5	--	223.0	--	--	110	48	6.0	.3	<.01	--	193	--	176	--	--	[5] 6.98	--	<5	20	--	<1	<1	<1	<1	300	<1	<1	<.2	<1	--	<1
			[6] 02-17-83	--	--	--	--	--	--	141	--	--	--	--	--	--	--	146	--	--	[5] 8.1	--	--	--	--	--	--	--	--	800	--	--	--	--	--	--
11Q3	Bowen	Pc	01-09-59	33	48	3.6	3.5	1.5	149	--	18	1.0	.1	.1	--	194	182	135	13	276	7.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
10N1	Dawson, 3	Pc	07-31-61	26	40	3.6	6.8	2.2	143	--	14	2.0	.1	.0	--	170	165	115	0	252	7.8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
10N8	Dawson, 1	Pc	02-02-38	24	39	4.9	7.5	2.0	142	--	14	2.1		.0	--	164	11	118	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

1 State standards for fluoride are set according to temperature.
2 Water having a $CaCO_3$ hardness of 0 to 60 mg/L is classified "soft"; 61 to 120 mg/L, "moderately hard"; 121 to 180 mg/L, "hard"; and more than 181 mg/L, "very hard."
3 Carbon dioxide concentration calculated from measured values of pH and bicarbonate ion.
4 Analysis by Tribble and Richardson, Inc., Macon, Ga.
5 Analysis by Georgia Environmental Protection Division.
6 Laboratory value.