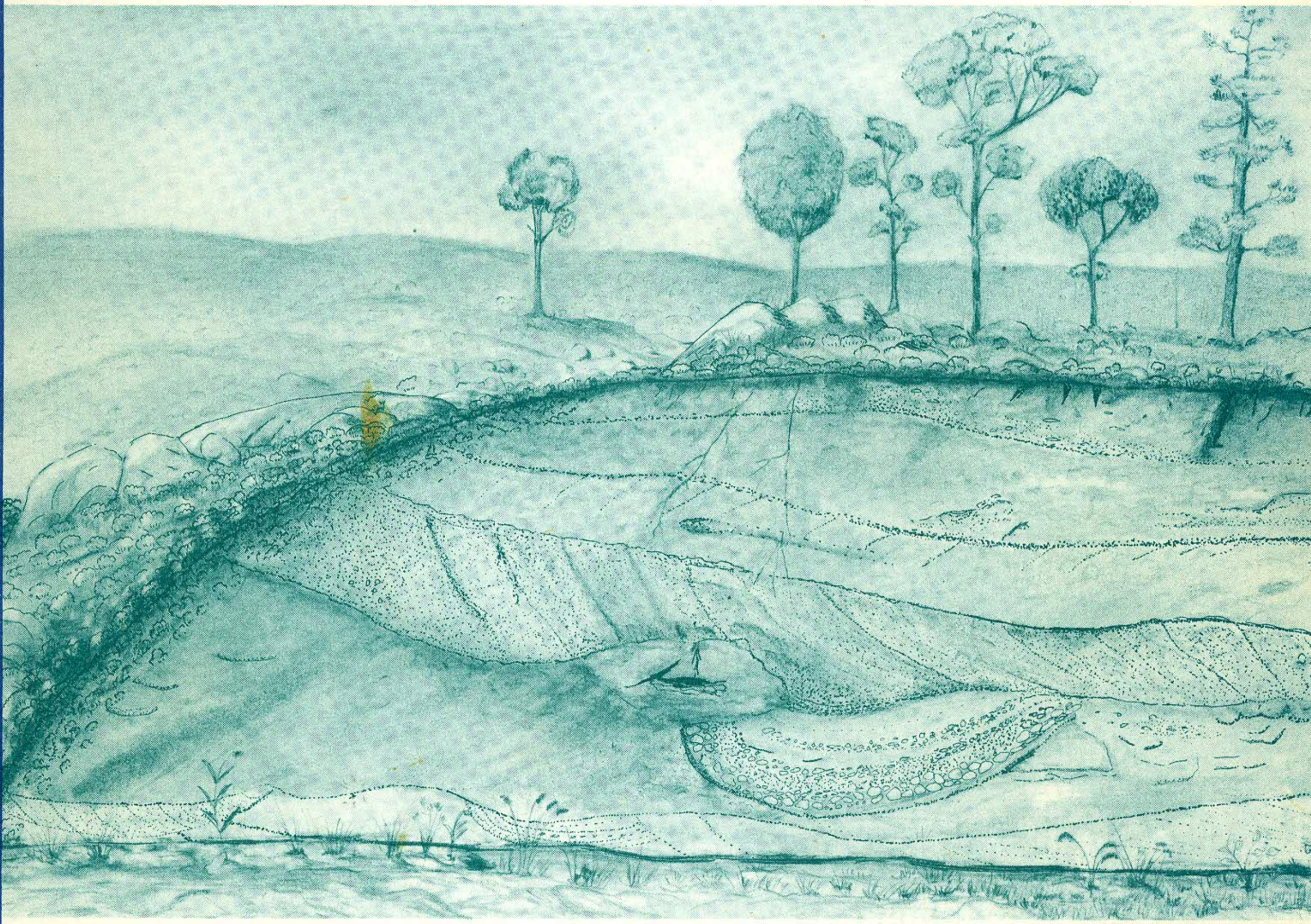
HYDROGEOLOGY OF THE GORDON AQUIFER SYSTEM OF EAST-CENTRAL GEORGIA

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



Prepared as part of the
ACCELERATED GROUND-WATER PROGRAM
in cooperation with the
DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

DEPARTMENT OF NATURAL RESOURCES
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GEORGIA GEOLOGIC SURVEY

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ROGEOLOGY OF THE GORDON AQUIFER SYSTEM OF EAST-CENTRAL GEOR ... rke, and R. E. Faye INFORMATION CIRCULAR 75

Geologic Units

In this report several geologic formations of the Coastal Plain of Georgia and adjacent areas in South Carolina have been combined into regional stratigraphic units based on their similar lithology, stratigraphic position, and geologic age. Each regional unit has been assigned an informal name taken from the established geologic formations of the southeastern Coastal Plain that best represent the lithologic character of the unit. For example, the lower Huber-Ellenton unit of this report includes strata of the lower part of the Huber Formation of eastern Georgia and the Ellenton Formation of South Carolina.

Front Cover: Schematic drawing of cross-bedded sand and clay in the kaolin district, east-central Georgia.

Drawing by: Ellie Black

John S. Clarke

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Department of Natural Resources
J. Leonard Ledbetter, Commissioner

Environmental Protection Division
Harold F. Reheis, Assistant Director

Georgia Geologic Survey
William H. McLemore, State Geologist

Atlanta, Georgia

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TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

PLATES

In pocket

TABLES

CONVERSION FACTORS

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

Multiply	By	To obtain
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 gallons per day (Mgal/d)	0.04381	cubic meters per second (m^3/s)
	43.81	liter per second (L/s)
	Concentration	
part per million	1	milligrams per liter (mg/L)
	1000	micrograms per liter (μg/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]	0.207	liter per second per meter [(L/s)/m]
	Specific conductance	
micromho per centimeter at 25° Celsius (μmho/cm at 25°C)	1	microsiemens per centimeter at 25° Celsius (μS/cm at 25°C)
	Temperatures	
degrees Fahrenheit (°F)	°C = 5/9(°F-32)	degrees Celsius (°C)
degrees Celsius (°C)	°F = 9/5(°C+32)	degrees Fahrenheit (°F)

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ABSTRACT

Interlayered sand, silt, and clay of middle Eocene to late Paleocene age in east-central Georgia form the Gordon aquifer system which ranges in thickness from about 20 to 180 feet. Estimated transmissivities range from 620 to 13,000 feet squared per day.

During 1980, approximately 24 million gallons per day was withdrawn from the Gordon aquifer system, of which about 70 percent was used for irrigation. Water levels in the aquifer throughout the study area generally showed little change during 1934-68; however, during 1969-81, local declines as great as 33 feet have occurred in areas of increased irrigation or large-scale municipal and industrial pumping.

The Gordon aquifer system is recharged by precipitation in the outcrop area and in interstream drainage divides in and near the outcrop area, and by leakage through adjacent confining units. Discharge from the aquifer occurs predominantly as flow into streams or as leakage into underlying and overlying units.

Water from the Gordon aquifer system is generally a calcium bicarbonate type that ranges from soft to hard, and in most areas has constituent concentrations that are within the Georgia Environmental Protection Division recommended drinking water standards.

INTRODUCTION

Purpose and Scope

Recent increases in agricultural, industrial, and municipal ground-water use in the Coastal Plain of Georgia and resulting decreases in water levels of up to 33 feet since 1969, have caused concern about the availability and management of ground-water supplies. Definition of major aquifer systems and their characteristics in this area is needed to understand the effects of man's activities on the ground-water system.

This study, conducted by the U.S. Geological Survey in cooperation with the Georgia Department of Natural Resources, Environmental Protection Division, Geologic Survey, is one of a series that describes areally extensive aquifer systems within Upper Cretaceous and lower Tertiary sediments of Georgia, being done as part of the Georgia Accelerated Ground-Water Program. In this series, two reports describe aquifers in southwest Georgia and this report is one of three that describe aquifer systems in east-central Georgia (fig. 1).

This report defines the Gordon aquifer system which consists of sediments of late Paleocene to middle Eocene age. The purpose of the report is to describe the geology and the hydrologic characteristics of the aquifer system. The general area of study covers about 9,200 mi^2

in 26 counties in the east-central part of the Coastal Plain of Georgia, and is generally bordered on the west by the Ocmulgee River, on the east by the Savannah River, and on the north by the inner margin of the Coastal Plain (fig. 1).

Previous Investigations

The general geology and hydrology of the Coastal Plain sediments of Georgia have been discussed in early publications by Stephenson and Veatch (1915), Cooke (1943), and Herrick and Vorhis (1963). Geohydrologic reports primarily concerned with the study area include LaMoreaux (1946), LeGrand and Furcron (1956), LeGrand (1962), Siple (1967), Marine and Root (1978), Faye and Prowell (1982), and Vincent (1982).

Recent detailed geologic investigations of sediments in the study area are provided by Cramer and Arden (1980), Gohn and others (1982), and Prowell and others (1985). Stratigraphic interpretations include definition of the Huber Formation by Buie (1978), the Barnwell Formation by Huddlestun and Hetrick (1979), and the Baker Hill Formation by Gibson (1982). Time-stratigraphic interpretations from paleontological data are provided by Tschudy and Patterson (1975), Prowell and others (1985), and L.E. Edwards and N. O. Frederickson (U.S. Geological Survey, written commun., 1982-83). Lithologic descriptions of selected wells in the Coastal Plain of Georgia are included in Herrick (1961) and Applin and Applin (1964). Studies pertinent to faulting or structural anomalies in the Coastal Plain include a discussion of the Belair Fault by Prowell and O'Connor (1978). Other publications which provided useful information in the study area include guidebooks by Herrick and Counts (1968), Pickering (1971), Huddlestun and others (1974), and Nystrom and Willoughby (1982) and several consultants' reports.

Methods of Study

During 1980-81, four test wells were drilled in the central part of the study area along a line approximating the strike of the inner margin of the Coastal Plain (fig. 2). The Arrowhead test well (18T1) is in northern Pulaski County, the Laurens test well 3 (21U4) is southeast of Dudley in Laurens County, the Wrightsville firetower test well 1 (24V1) is southwest of Wrightsville in Johnson County, and the Midville test well 1 (28X1) is northeast of Midville in Burke County. Each of the wells completely penetrates Tertiary sediments and all except the Arrowhead test well completely penetrate Upper Cretaceous sediments. Each well is screened in the lower part of Upper Cretaceous strata. Drill cuttings, cores, samples for paleontologic analysis, geophysical logs, and water samples for chemical analysis were collected from each well. After well construction was completed, water-level recorders were installed, and the test wells became part of a statewide network of ground-water monitoring stations.

Geologic interpretations were based on (1) examination of drill cuttings, cores, and geophysical logs collected in the four test wells and other boreholes in the study area, (2) lithologic descriptions of drill cuttings and cores, (3) paleontological data, and (4) field observations of exposures along roadcuts and in kaolin mines. These data provided a basis for construction of the hydrogeologic sections and contour maps showing the top, base, and thickness of the aquifer system.

Hydrologic investigations utilized historical and modern water-level data obtained from wells throughout the study area. Historical water-level data for the period 1944-50 were acquired from reports by LaMoreaux (1946), LeGrand and Furcron (1956), and LeGrand (1962). Well

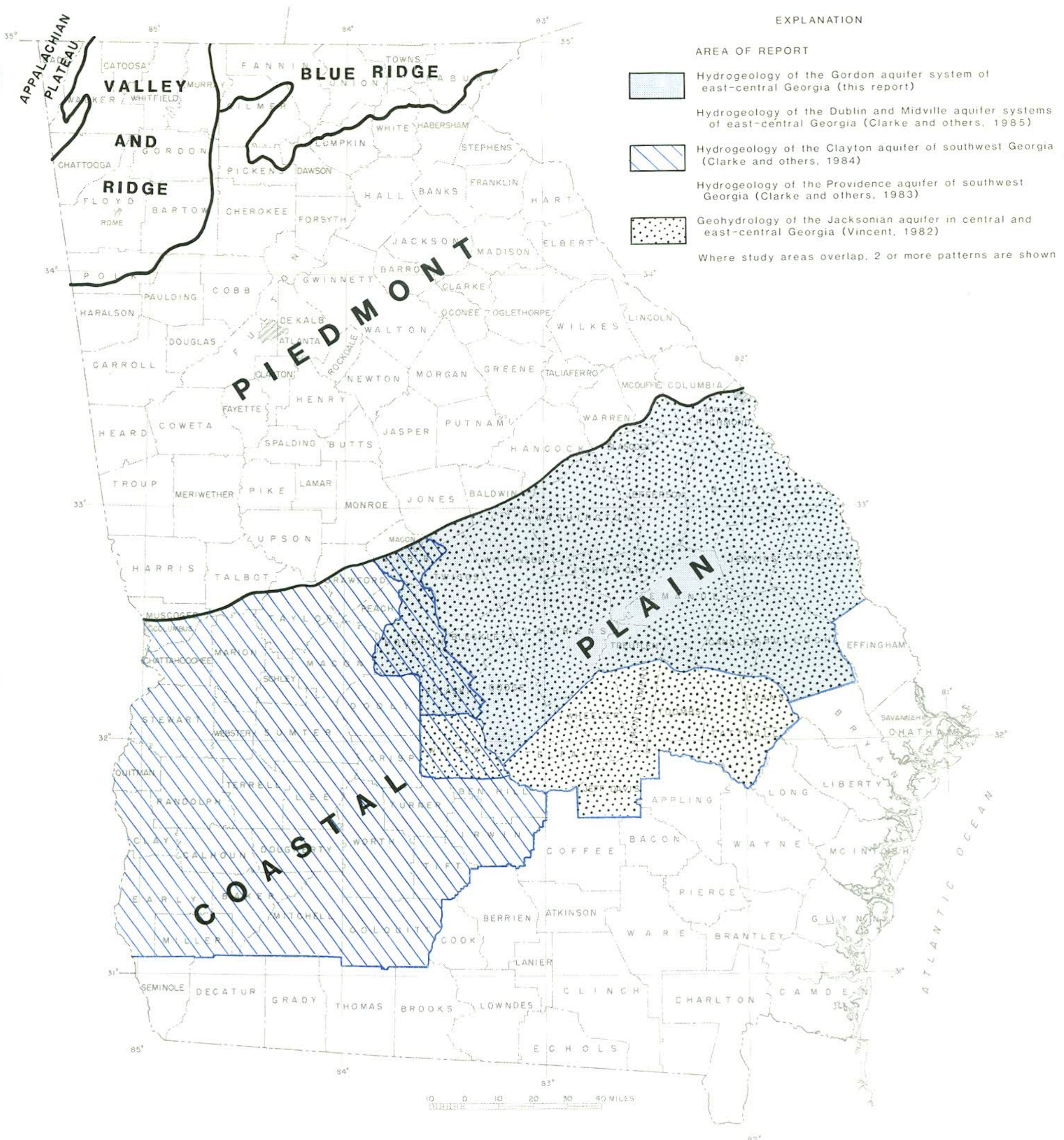
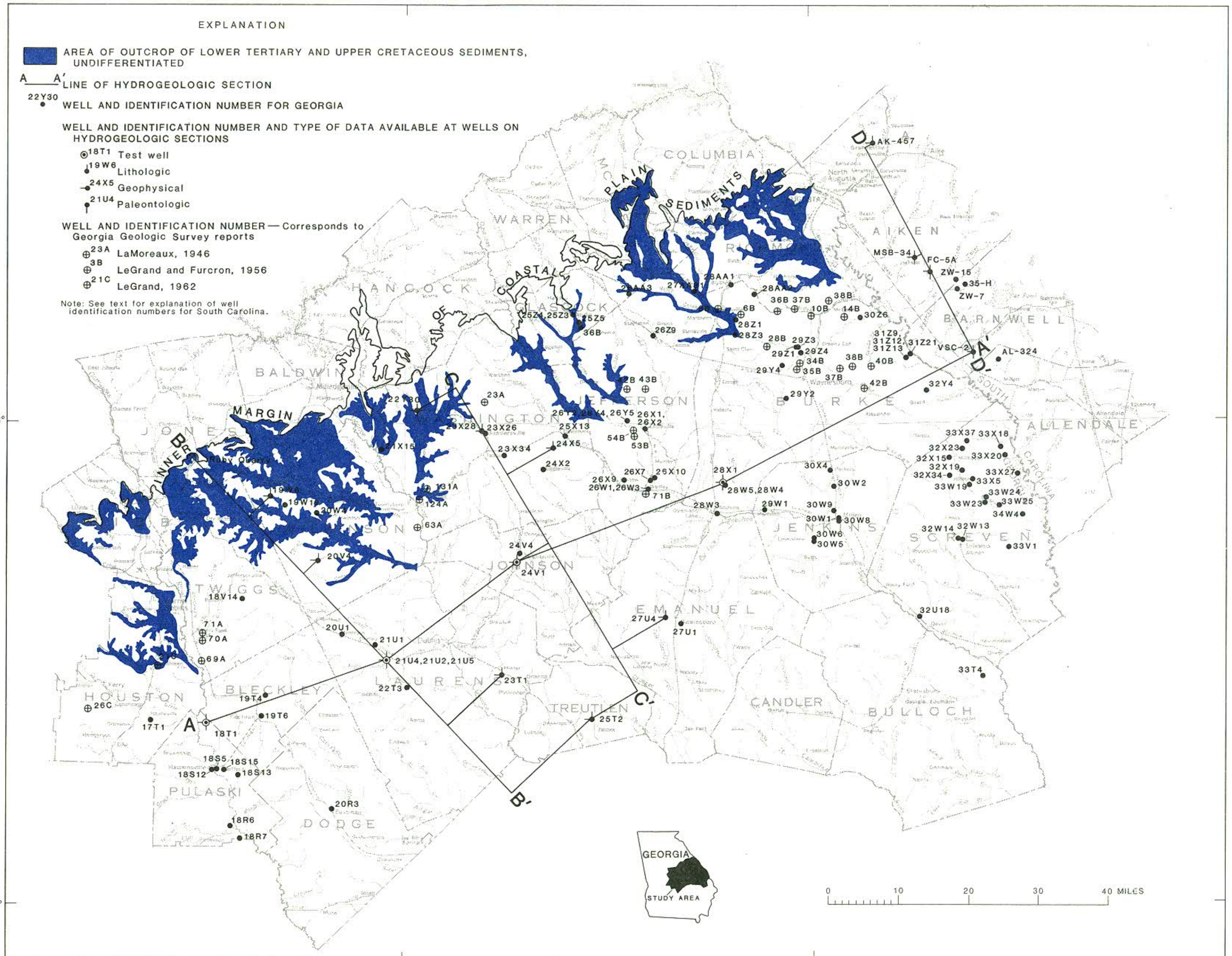


Figure 1.—Location of study area, physiographic provinces, and areas covered by investigations as part of the Upper Cretaceous-lower Tertiary aquifer study.



Base from U.S. Geological Survey State base maps, 1:500,000

Outcrop area from Geologic Map of Georgia, 1976

Figure 2.—Location of wells and hydrogeologic sections.

locations in those reports were taken from original field maps, field checked where possible, and plotted on 7.5-minute topographic maps from which altitudes were estimated. These data were used to construct the estimated 1934-68 potentiometric surface. Water-level measurements collected in more than 100 wells in the study area during November 1981 (Appendix A) and data obtained from files of the U.S. Geological Survey, and from consultants' reports and kaolin companies were used to define the November 1981 potentiometric surface. Aquifer transmissivities and specific capacities were calculated from aquifer-test data in U.S. Geological Survey files and from data in Siple (1955) and Marine and Root (1976; 1978). Water-use data were obtained from municipal and industrial water-use reports submitted quarterly to the Georgia Environmental Protection Division, and agricultural water-use surveys conducted by the U.S. Soil Conservation Service during 1979-80. Water-quality data were obtained mainly from analyses by the U.S. Geological Survey Central Laboratory. (See Appendix B.)

Well Numbering System

In this report, wells located in Georgia are numbered according to a system based on the U.S. Geological Survey Index to Topographic Quadrangle Maps (fig. 3). Each 7.5-minute quadrangle in the State has been given a number and letter designation according to its location based on a Cartesian pattern with the origin at the southwest corner of the State. Numbers increase eastward and letters increase alphabetically northward, excluding the letters "I" and "O". Quadrangles beginning in the northeastern part of the Coastal Plain are designated by double letters. Wells inventoried in each quadrangle are numbered consecutively beginning with 1. Thus, the third well scheduled in the Riddleville quadrangle in Washington County is designated 24X3. Additional information regarding these wells may be obtained from the District Chief, U.S. Geological Survey, 6481-B Peachtree Industrial Boulevard, Doraville, GA 30360.

In areas where modern water-level data were unavailable, wells were used from reports by the Georgia Geologic Survey (LaMoreaux, 1946; LeGrand and Furcron, 1956; and LeGrand, 1962). Because these wells are not included in the modern data base and, thus, were not assigned grid numbers, the sequential well numbers from the reports were retained. Additional data for these wells may be acquired from the respective reports.

Wells in South Carolina are numbered according to a county designation. The numbers consist of a county name abbreviation followed by consecutive numbers indicating the order in which wells were inventoried in the county. For example, well AK-437 was the 437th well inventoried in Aiken County. Wells at the Savannah River Plant are numbered as designated by the facility (wells MSB-34, FC-5A, ZW-7, ZW-15, 35-H and VSC-2).

Acknowledgments

The authors extend their appreciation to the numerous well owners, drillers, kaolin companies, and municipal and industrial employees for their cooperation and assistance in supplying information on wells. Appreciation is also extended to Douglas M. Dangerfield of M.R. Chasman and Associates, Athens, Ga.; Gerald S. Grainger of the Southern Company, Birmingham, Ala.; Robert Massey of Layne-Atlantic Co., Savannah, Ga.; Sam M. Pickering of Yara Engineering, Deepstep, Ga.; and Dan Zeigler of Southeast Exploration and Production Co., Dallas, Tex., for providing hydrologic and geologic data. Laurel M. Bybell, Raymond A. Christopher, Lucy E. Edwards, and Norman O. Frederiksen of the U.S. Geological Survey, Geologic Division, provided paleontological and palynological identifications of core samples from test wells in the study area. Lin D. Pollard (U.S. Geological Survey, Doraville, Ga.) organized and monitored the test-well-drilling program. The authors particularly acknowledge the assistance provided by David C. Prowell (U.S. Geological Survey, Geologic Division, Doraville, Ga.), whose

Modified from index to topographic maps of Georgia
U.S. Geological Survey

Figure 3.— Number and letter designations for 7.5-minute quadrangles covering east-central Georgia.

knowledge provided a basis for the geological framework used in this study. Special appreciation is extended to Willis G. Hester and Ellie R. Black for preparing the illustrations in this report.

GEOLOGY

Regional Setting

The Coastal Plain province of Georgia consists of a southeastward-thickening wedge of poorly consolidated sand, clay, and limestone of Late Cretaceous to Holocene age. This sedimentary sequence unconformably overlies Paleozoic crystalline rocks or lower Mesozoic sedimentary and igneous rocks throughout the study area (Chowns and Williams, 1983). In the northern part of the study area, the Coastal Plain sediments crop out in narrow belts that become progressively younger seaward.

In this report, stratigraphic correlations are based mainly on paleontological, geophysical, and lithologic data from the four cored test wells and from other wells in the study area. This information helped clarify the stratigraphic and lithologic relations between strata of the Coastal Plain in Georgia and South Carolina.

Geologic Units

Changing depositional environments in the Gulf and the Atlantic Coastal Plains resulted in a wide range of sediment types that have been divided into numerous age-equivalent geologic formations. Because no formal geologic units have been previously defined in the study area, in this report several geologic formations of the Coastal Plain of Georgia and adjacent areas in South Carolina have been combined into regional stratigraphic units based on their similar lithology, stratigraphic position, and geologic age. Each regional unit has been assigned an informal name taken from the established geologic formations of the southeastern Coastal Plain that best represent the lithologic character of the unit. For example, the lower Huber-Ellenton unit of this report includes strata of the lower part of the Huber Formation of eastern Georgia and the Ellenton Formation of South Carolina. These informal geologic units comprise the Gordon aquifer system and its confining units. The stratigraphic correlations of the informal units, the units comprising the Gordon aquifer system, and the established geologic formations in the Coastal Plain of Georgia and adjacent parts of South Carolina are shown in table 1.

Upper Cretaceous Strata

Upper Cretaceous sediments of Santonian through Maestrichtian age overlie Paleozoic crystalline rocks or lower Mesozoic sedimentary rocks throughout most of the study area. The sediments are well exposed near the inner margin of the Coastal Plain, but to the south they are overlain by younger sediments of Tertiary age. The sediments are of deltaic and shallow marine origin, and they attain a known maximum thickness of 1,840 ft (Clarke and others, 1985) in the southern part of the study area.

The Cretaceous sediments within the study area generally consist of poorly consolidated, kaolin-rich, fine to medium sand, sandy clay, and gravel (Faye and Prowell, 1982). In most of the area, the top of the Upper Cretaceous strata is characterized by silty, kaolinitic clay that locally contains deposits of commercial-grade kaolin. For a more detailed discussion of Upper Cretaceous strata, see Clarke and others (1985).

Paleocene Strata

Lower Huber-Ellenton Unit

The lower Huber-Ellenton unit of early and middle Paleocene (Midwayan) age unconformably overlies Upper Cretaceous strata throughout most of the study area. This unit is the age equivalent of the Porters Creek and Clayton Formations in

Table 1.— Generalized correlation of geologic and hydrologic units of Late Cretaceous and Tertiary age in Georgia. (Modified from Prowell and others, 1985)

Series	European Stage	Provincial Stage	Alabama (W–E)	Western Georgia	Lithologic Unit	Eastern Georgia	South Carolina (W–E)	This Report: Geologic Unit	This Report: Thickness (feet)	This Report: Hydrologic Unit
Miocene	Undifferentiated	Undifferentiated			M_1	Hawthorn Formation	Hawthorn Formation; Edisto Formation	Post-Eocene strata		
Oligocene	Chattian	Chickasawhayan	Paynes Hammock Sand; Chickasawhay Formation		O_1	Suwanee Limestone	Chandler Bridge Fm.; Cooper Formation (Ashley Member)			
Oligocene	? — ? Rupelian	Vicksburgian	Byram Formation; Marianna Limestone; Red Bluff Clay/ Bumpnose Formation					Barnwell unit	0-230	Jacksonian aquifer[1]
Eocene	Priabonian	Jacksonian	Yazoo Clay; Ocala Limestone	Ocala Limestone	E_8; E_7	Barnwell Formation	Barnwell Formation; Cooper Formation (Parkers Ferry and Harleyville Members) ?			
Eocene	Bartonian	Claibornian	Moodys Branch Fm.; Gosport Sand	Moodys Branch Fm.	E_6	? ?	?			
Eocene	Lutetian		Lisbon Formation	Lisbon Formation	E_5; E_4	Lisbon/McBean Formations	McBean Formation; Santee Limestone	Lisbon-McBean unit	0-80	Upper confining unit
Eocene	Ypresian		Tallahatta Formation	Tallahatta Formation	E_3; ? — E_2 — ?	Huber Formation	Congaree Formation	Upper Huber-Tallahatta unit	0-140	Gordon aquifer system
Eocene		Sabinian	Hatchetigbee/Bashi Fms.	Hatchetigbee/Bashi Fms.	E_1		Lishburne Formation			
Paleocene	Thanetian		Tuscahoma Formation; Nanafalia/Baker Hill Fm.	Tuscahoma Formation; Nanafalia/Baker Hill Fms.	P_2		Black Mingo Formation; Black Mingo Group	Baker Hill-Nanafalia unit	0-130	Lower confining unit
Paleocene	Danian	Midwayan	Naheola Fm.; Porters Creek Formation; Clayton Formation	Porters Creek Formation; Clayton Formation	P_1		Ellenton Formation; of Van Nieuwenhuise and Colquhoun	Lower Huber-Ellenton unit	0-200	Dublin aquifer system[2]
Upper Cretaceous	Maestrichtian	Navarroan	Prairie Bluff Chalk; Ripley Formation	Providence Sand; Ripley Formation	UK_6	Unnamed rocks	Peedee Formation	Upper Cretaceous	0-1840	
Upper Cretaceous	Campanian	Tayloran	Demopolis Chalk	Cusseta Sand	UK_5; UK_4		Black Creek Formation			Confining unit
Upper Cretaceous		Austinian	Mooreville Chalk	Blufftown Formation	UK_3		Unnamed rocks			Midville aquifer system[2]
Upper Cretaceous	Santonian		Eutaw Formation	Eutaw Formation	UK_2	Middendorf Formation	Middendorf Formation			
Upper Cretaceous					UK_1	Cape Fear Formation	Cape Fear Formation			Confining unit
Upper Cretaceous	Coniacian									
Upper Cretaceous	Turonian ? — ?	Eaglefordian								
Upper Cretaceous	Cenomanian		Tuscaloosa Formation	Tuscaloosa Formation		Unnamed rocks	Unnamed rocks			
Upper Cretaceous		Woodbinian								

[1] Vincent, 1982.

[2] Clarke and others, 1985.

western Georgia, the lower part of the Huber Formation (Buie, 1978) and the P1 lithologic unit of Prowell and others (1985) in central and eastern Georgia, and the Ellenton Formation (Siple, 1967) in South Carolina.

The unit includes a basal layer of fine to coarse, poorly sorted, angular, silty, quartz sand in a kaolin matrix. The remainder of the unit consists of locally carbonaceous, kaolinitic clay containing a diverse assemblage of pollen and marine microfauna of early and middle Paleocene (Midwayan) age (Prowell and others, 1985). The lithology and the presence of marine fauna indicate that the unit was deposited in a deltaic environment under marine influence.

In the southern part of the study area (well 25T2, pls. 1, 2), the basal sand grades into a relatively porous, medium-gray, very fossiliferous, glauconitic limestone interlayered with fine to coarse sand. The upper part of the unit also becomes calcareous, grading into marl and limestone. This lithofacies formed in a predominantly open marine shelf environment, largely lacking an influx of clastic sediments. In this area, the unit reaches a maximum thickness of 200 ft (well 25T2, pls. 1, 2).

Baker Hill-Nanafalia Unit

The Baker Hill-Nanafalia unit of late Paleocene (early Sabinian) age overlies the lower Huber-Ellenton unit throughout most of the study area and pinches out in the subsurface north of well 20V4 in Wilkinson County (pl. 1), well 24V1 in Johnson County (pl. 2), and well FC-5A in Aiken County, S.C. (pl. 2). The unit is the age equivalent of the Tuscahoma, Nanafalia, and Baker Hill Formations in western Georgia, the P2 lithologic unit of Prowell and others (1985) in central and eastern Georgia, and the Black Mingo Formation in South Carolina.

In the northern part of the study area, the unit consists of thinly laminated, silty clay locally containing layers of medium to dark-gray carbonaceous clay. This lithology is indicative of a marginal marine (lagoonal to shallow shelf) environment of deposition. In most of the study area, the clayey part of this unit is characterized on geophysical logs as a zone of low electrical resistivity and relatively high gamma radiation. These geophysical responses are useful indicators of the top of Paleocene strata.

In southern areas, the Baker Hill-Nanafalia unit becomes increasingly calcareous and consists mainly of highly fossiliferous, light-gray, finely crystalline, glauconitic limestone interlayered with very coarse, well-sorted quartz sand. This lithology indicates a transition to open marine shelf deposition. At well 25T2 (pls. 1, 2), the unit reaches a maximum thickness of about 130 ft.

Eocene Strata

Upper Huber-Tallahatta Unit

The upper Huber-Tallahatta unit of early and middle Eocene age uncomformably overlies the Baker Hill-Nanafalia unit in most of the study area and crops out in the northern part of the area near well 19W6 in Wilkinson County (pl. 1) and well 22Y30 in Washington County (pl. 2). In the northernmost part of the area, where Paleocene sediments are missing, the upper Huber-Tallahatta unit directly overlies strata of Late Cretaceous age (pls. 1, 2). The upper Huber-Tallahatta unit includes sediments equivalent to the Hatchetigbee, Bashi, and Tallahatta Formations and the lower part of the Lisbon Formation in western Georgia; the upper part of the Huber Formation (Buie, 1978), and the E1, E2, E3, and E4 lithologic units of Prowell and others (1985) in central and eastern Georgia; and the Congaree Formation (Pooser, 1965) and Fishburne Formation (Gohn and others, 1983) in western South Carolina.

The upper Huber-Tallahatta unit consists of fine to medium, subangular to subrounded, well-sorted, clayey quartz sand that locally includes thin layers of carbonaceous clay containing marine microfossils (Prowell and others, 1985). Mica, dark heavy minerals, and lignite are present in some of the sand layers. Extensive animal burrows and small- and large-scale cross-bedding characterize the unit in outcrop and in core samples. These features and the abundance of marine microfauna suggest a deltaic environment of deposition.

In the northern part of the study area, the uppermost part of the unit is characterized by beds of relatively pure, massive kaolin that has a hackly fracture. In Twiggs, Wilkinson, and Washington Counties, these kaolin deposits increase in thickness from 10 ft (well 24V1; pls. 1, 2) to about 60 ft (well 20V4, pl. 1; well 23X28, pl. 2) and are of commercial value.

In the southern part of the study area, the unit has a thickness of about 140 ft and becomes more calcareous, suggesting a transition to a more open marine depositional environment. For example, at well 25T2 in Treutlen County (pls. 1, 2) the unit consists of light-gray, slightly glauconitic, fossiliferous, sandy limestone.

Lisbon-McBean Unit

The Lisbon-McBean unit is comprised of marine sediments of latest middle Eocene (Claibornian) age. The unit overlies the sandier phases of the upper Huber-Tallahatta unit and pinches out in the subsurface between wells 20V4 and 21U4 in Wilkinson and Laurens Counties, respectively (pl. 1), and wells 23X28 and 24X5 in Washington County (pl. 2). The Lisbon-McBean unit is the age equivalent of the upper part of the Lisbon Formation in western and central Georgia, the E5 lithologic unit of Prowell and others (1985) in eastern and central Georgia, and the McBean Formation of eastern Georgia and western South Carolina.

Throughout most of the study area, the unit consists of massive, gray-green glauconitic marl interlayered with calcareous, clayey quartz sand and fossiliferous limestone. It has a maximum thickness of about 80 ft in well 24V1 in Johnson County (pls. 1, 2). The lithology and abundance of marine microfossils (Prowell and others, 1985) in this unit indicate that the sediments were deposited in an open marine, shallow shelf environment. The Lisbon-McBean unit is characterized on geophysical logs by low resistivity and high gamma radiation, probably because the unit contains more clay than the overlying and underlying units. In the southern part of the study area, the unit becomes more calcareous and consists of slightly sandy, finely crystalline fossiliferous limestone. At the Midville test well (well 28X1, pl. 1), the Lisbon-McBean unit is unusually sandy and consists largely of calcareous quartz sand and minor amounts of clay and glauconite.

Barnwell Unit

The Barnwell unit is generally continuous throughout the study area and unconformably overlies the Lisbon-McBean unit or, where the Lisbon-McBean unit is absent, older sediments of Eocene age (pl. 1). The Barnwell unit is the age equivalent of the late Eocene (Jacksonian) to early Oligocene (?) Barnwell Group of Huddlestun and Hetrick (1979), and the E6, E7, and E8 lithologic units of Prowell and others (1985) in central and eastern Georgia; the Moodys Branch Formation and Ocala Limestone in western Georgia; and the lower part of the Cooper Formation in coastal South Carolina (Hazel and others, 1977).

The Barnwell unit consists of an ascending sequence of calcareous sand, thinly bedded fossiliferous limestone, well-laminated clay, and cross-bedded sand. The sequence represents the cyclic deposition of sediments during transgression and regression of a late Eocene to early Oligocene (?) sea (Prowell and O'Connor, 1978; Willoughby and others, 1984). Depositional environments vary from nearshore marine to open marine shelf (David C. Prowell, U.S. Geological Survey, oral commun., 1983). The unit has a maximum thickness of about 230 ft in the southern part of the study area (well 27U4, pl. 2). The calcareous sand and limestone at the base of the Barnwell unit is limited to the southern part of the study area. In northern areas, laminated clay marks the base of the unit.

Relation of Lithology to Depositional Environments

The geologic units defined herein were deposited either in deltaic or shallow, open marine environments. Deltaic environments occur where sediment-laden rivers or streams empty into larger bodies of water such as the sea. Sediment carried by the river is deposited along and between a complex network of small stream channels, or along the delta front in shallow marine water. The resulting deposits form a complexly interbedded network of sand and clay layers of highly variable thicknesses that commonly contain organic material. Sands are deposited along the stream channels and at the delta front; clays are deposited in interstream or bay areas. In the study area, most sediments of the upper Huber-Tallahatta unit and the lower Huber-Ellenton unit were deposited in a lower delta plain or delta front environment (Coleman and Prior, 1980; Reineck and Singh, 1980, p. 324-328), which accounts for the presence of poorly sorted sand containing local, laterally discontinuous clay layers whose vertical boundaries may be sharp or gradational.

Sediments deposited in marine environments, as characterized by the Baker Hill-Nanafalia, Lisbon-McBean, and Barnwell units, maintain a more uniform thickness and lithologic character over a larger area than do deltaic deposits. Nearshore or shallow marine sands generally are well sorted and form extensive bar-like or sheet-like beds that can be traced for long distances. Beds of silt and clay are deposited farther offshore in deeper water. In an open marine environment, deposits are typically thicker and consist largely of limestone and carbonate-rich sand and clay, which is characteristic of most of the geologic units in the southern part of the study area.

The areal extent and lithologic character (particularly the grain-size distribution) of the strata, and thus their water-bearing characteristics, are largely determined by the depositional environments in which they accumulated. In the study area, the most permeable rocks in the Gordon aquifer system generally are the stream channel and delta-front sands of the upper Huber-Tallahatta unit. The confining units consist mainly of the interstream or shallow marine clays of the Lisbon-McBean unit and the Baker Hill-Nanafalia unit.

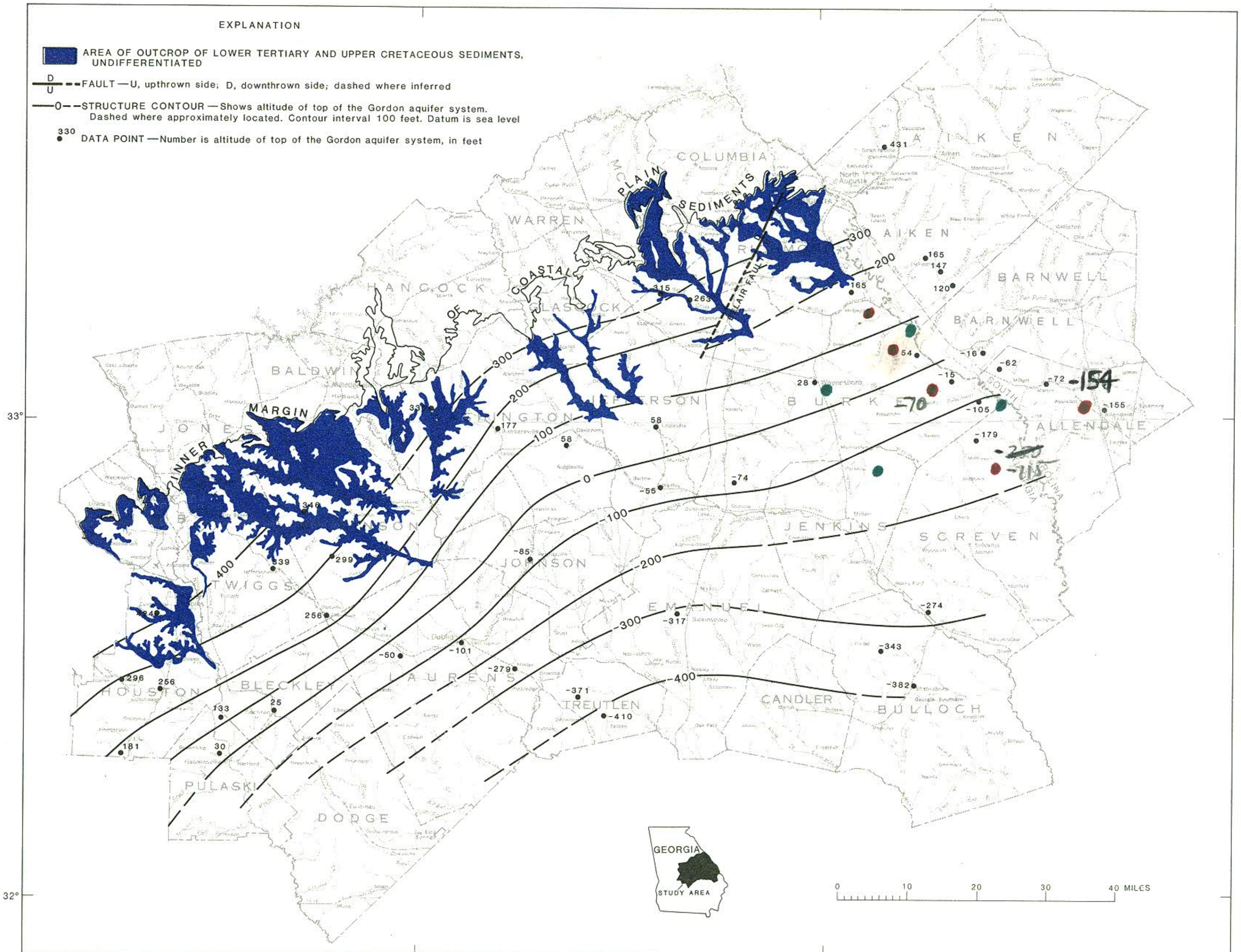
Structure

The study area is generally part of a southeastward-sloping homocline that has an average dip of about 15 ft/mi. A major structural feature occurring in the northeastern part of the area (fig. 4) is the Belair fault zone (Prowell and O'Connor, 1978), a northeast-trending, high-angle reverse fault, upthrown on the southeast side. Maximum vertical displacement in upper Eocene sediments is about 40 ft.

HYDROLOGY

Aquifer Nomenclature

Aquifers in the Georgia Coastal Plain are generally named for stratigraphic units or given letter and number designations. For example, the Clayton aquifer (Hicks and others, 1981) was named for sediments belonging primarily to the Clayton Formation, although other sediments are included. The A1 aquifer of Faye and Prowell (1982) represents an aquifer of Late Cretaceous age. In the present study, formation names were con-



Base from U.S. Geological Survey
State base maps, 1:500,000

Outcrop area from Geologic Map of Georgia, 1976

Projected site
Active site

Figure 4.— Structural features, outcrop area, and altitude of the top of the Gordon aquifer system.

sidered inappropriate for aquifer units, because facies changes are common throughout the study area and aquifer units do not everywhere coincide with formation boundaries. Letter and number designations are not utilized because the same symbols have been used by several authors for different aquifer units (Pollard and Vorhis, 1980; Faye and Prowell, 1982). Therefore, to avoid confusion, the Gordon aquifer system described in this report, was named for the city of Gordon, in Wilkinson County, where the sediments that typify the aquifer system are well exposed.

Definition of the Gordon Aquifer System

An aquifer system is herein defined as a body of material of varying permeability that acts as a water-yielding hydraulic unit of regional extent. Throughout most of the study area, the upper Huber-Tallahatta unit meets the definition of an aquifer system, and hereafter it is referred to as the Gordon aquifer system.

Although the Gordon aquifer system can generally be treated as a single water-bearing unit throughout the study area, it contains discontinuous clay layers that locally separate it into two or more aquifer units. These clay layers are not considered to be hydrologically significant in a regional evaluation, but they increase the complexity of the hydrologic framework.

Geophysical and lithologic logs show that the base and top of the Gordon aquifer system are distinguished by regionally extensive clay units. These clay units form the upper and lower boundaries of the aquifer system. The base of the Gordon aquifer system generally is marked by silty, kaolinitic clay of the Baker Hill-Nanafalia unit. In southern areas, the Baker Hill-Nanafalia unit loses its effectiveness as a confining unit because of a lithologic transition to more permeable, calcareous, clastic sediments and limestone (well 25T2, pls. 1, 2). In these areas, the basal confining unit of the Gordon aquifer system is comprised of kaolinitic clay in the upper part of the lower Huber-Ellenton unit. In the northern part of the study area, the Baker Hill-Nanafalia unit pinches out (wells 24X5 and AK-457, pl. 2), and the Gordon aquifer system may be hydraulically connected with sediments of the underlying Dublin aquifer system of Clarke and others (1985).

The clay unit overlying the aquifer system generally consists of massive, glauconitic marl of the Lisbon-McBean unit and in most areas it forms the upper confining unit. Locally, the Lisbon-McBean unit is a clayey sand and does not confine the aquifer. For example, at the Midville test well (well 28X1, pl. 1), the Lisbon-McBean unit consists of glauconitic sand and is an ineffective confining unit. In this area, laminated clays of the Barnwell unit form the upper confining unit of the Gordon aquifer system. In the northern part of the study area, between wells 23X28 and 24X5 in Washington County (pl. 2), and in the central part between wells 20V4 and 21U4 in Wilkinson and Laurens Counties, respectively (pl. 1), the Lisbon-McBean unit pinches out. Here, the kaolin in the uppermost part of the upper Huber-Tallahatta unit increases in thickness and forms the upper confinement for the Gordon aquifer system.

Aquifer System Geometry

Altitude of Aquifer System Boundaries

Geophysical and lithologic logs of 42 wells were used to determine the approximate altitudes of the base and top of the Gordon aquifer system (figs. 4, 5). In the southeastern part of the study area, in Screven and Bulloch Counties, it was not possible to determine the altitude of the base of the aquifer system because of sparse geologic control. In this area, contours shown in figure 5 are dashed and represent an approximation of the base of the Gordon aquifer system. Depths to the top of the aquifer system may be estimated by subtracting the altitude of the

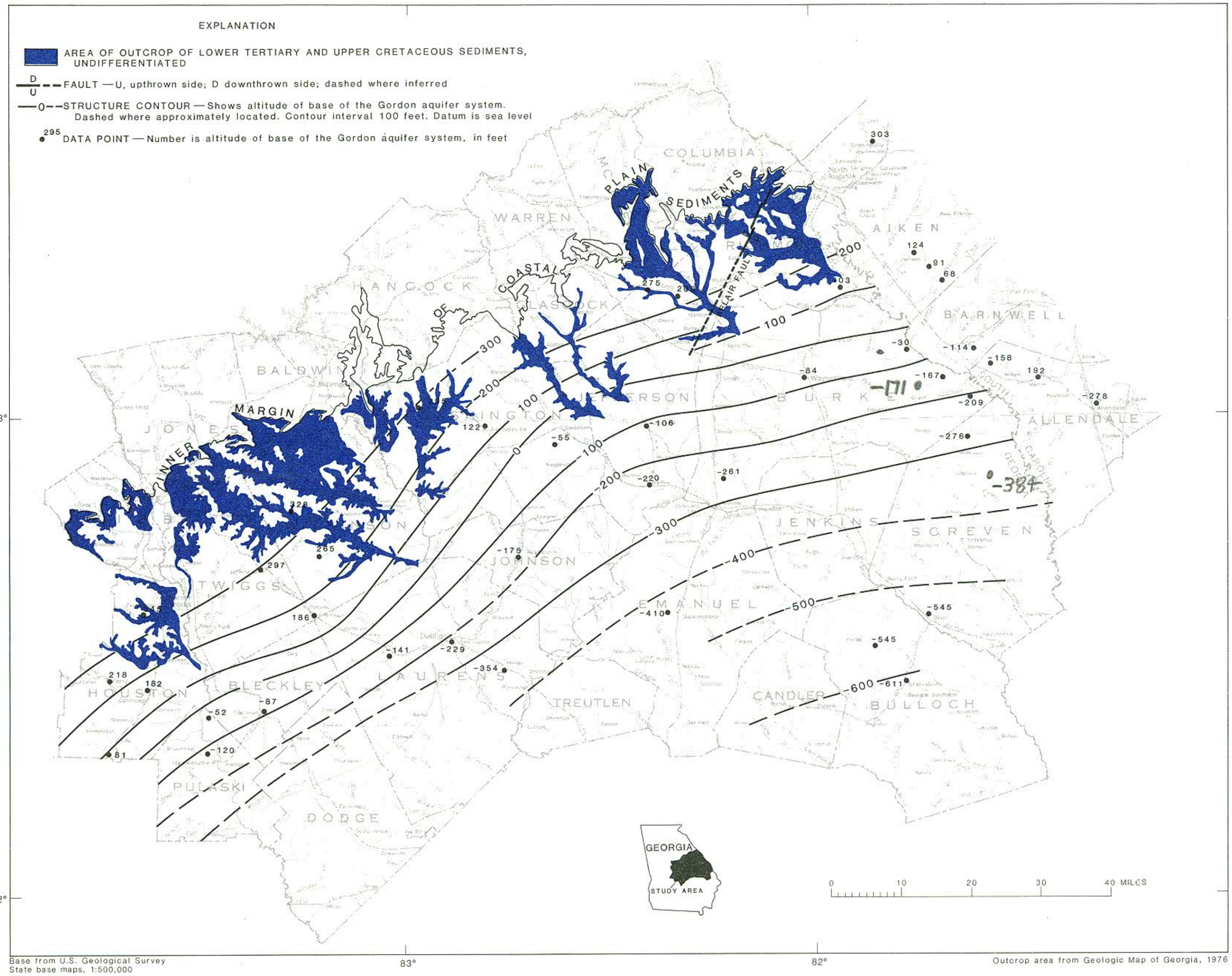


Figure 5.— Structural features, outcrop area, and altitude of the base of the Gordon aquifer system.

top (fig. 4) from the altitude of land surface (available on U.S. Geological Survey 7.5-minute topographic quadrangle maps).

Thickness

The thickness of the Gordon aquifer system was estimated by comparing the altitudes of the base (fig. 5) with the altitudes of the top (fig. 4). The aquifer system ranges in thickness from about 20 ft in northern Wilkinson County in the western part of the study area, to more than 180 ft in Pulaski County in the southwest, and to more than 190 ft in southern Burke and Jefferson Counties in the central part of the area (fig. 6).

Aquifer and Well Properties

Transmissivity and Specific Capacity

The transmissivity and specific capacity of an aquifer system are two properties that help define the hydraulic aspects of ground-water flow. Transmissivity is a measure of an aquifer's ability to transmit water and is derived from analysis of time-drawdown data obtained during aquifer tests or from calculations using specific-capacity data. In this study, time-drawdown data were available for only two wells tapping the Gordon aquifer system: well 18S12 in Pulaski County and well 33X37 in Screven County (fig. 7). The transmissivity of the Gordon aquifer system was calculated as 9,800 ft^2/d at the Pulaski County well and as 3,500 ft^2/d at the Screven County well.

Specific-capacity values for wells tapping the Gordon aquifer system range from 2.5 (gal/min)/ft at well 25Z3 in Glascock County to 50.4 (gal/min)/ft at well 32U18 in Screven County (fig. 7).

Transmissivity values from the Gordon aquifer system, as computed from specific-capacity data using Jacob's modified nonequilibrium formula (Ferris and others, 1962), are shown on figure 7, and range from 620 ft^2/d in Glascock County (well 25Z3) to 13,000 ft^2/d in Screven County (well 32U18). Transmissivity values computed from specific-capacity data were 10 percent lower at well 18S12 and 30 percent lower at well 33X37 than values computed from the time-drawdown data. Accordingly, transmissivity values computed from specific-capacity data may be low throughout the study area.

The transmissivity of the Gordon aquifer system is generally greatest in the southern part of the area where the aquifer system is thickest (figs. 6, 7). Transmissivity values obtained from specific-capacity data in multiaquifer wells that tap both the Gordon aquifer system and the overlying Jacksonian aquifer (Vincent, 1982) are higher than those of nearby wells that tap only the Gordon. In these wells the transmissivity ranges from 2,400 ft^2/d at well 23X34 in Washington County to 14,900 ft^2/d at well 19T6 in Bleckley County.

Well Yields

Wells tapping the Gordon aquifer system have yields ranging from 87 gal/min (well 26AA3) in Glascock County to 1,815 gal/min (well 32U18) in Screven County (fig. 7). Yields exceeding 1,000 gal/min are obtained from well 26W1 near Wadley and wells 26Y2 and 26X2 near Louisville in Jefferson County, and well 32U18, north of Dover in Screven County. Yields of multiaquifer wells tapping the Gordon aquifer system and the overlying Jacksonian aquifer (Vincent, 1982) exceed 500 gal/min at Cochran, Bleckley County (well 19T6), and southwest of Waynesboro, in Burke County (well 29Y2). Some wells in the study area do not penetrate the full thickness of the Gordon aquifer system and therefore probably yield less water than a fully penetrating well.

Recharge

The Gordon aquifer system is recharged directly by precipitation in the

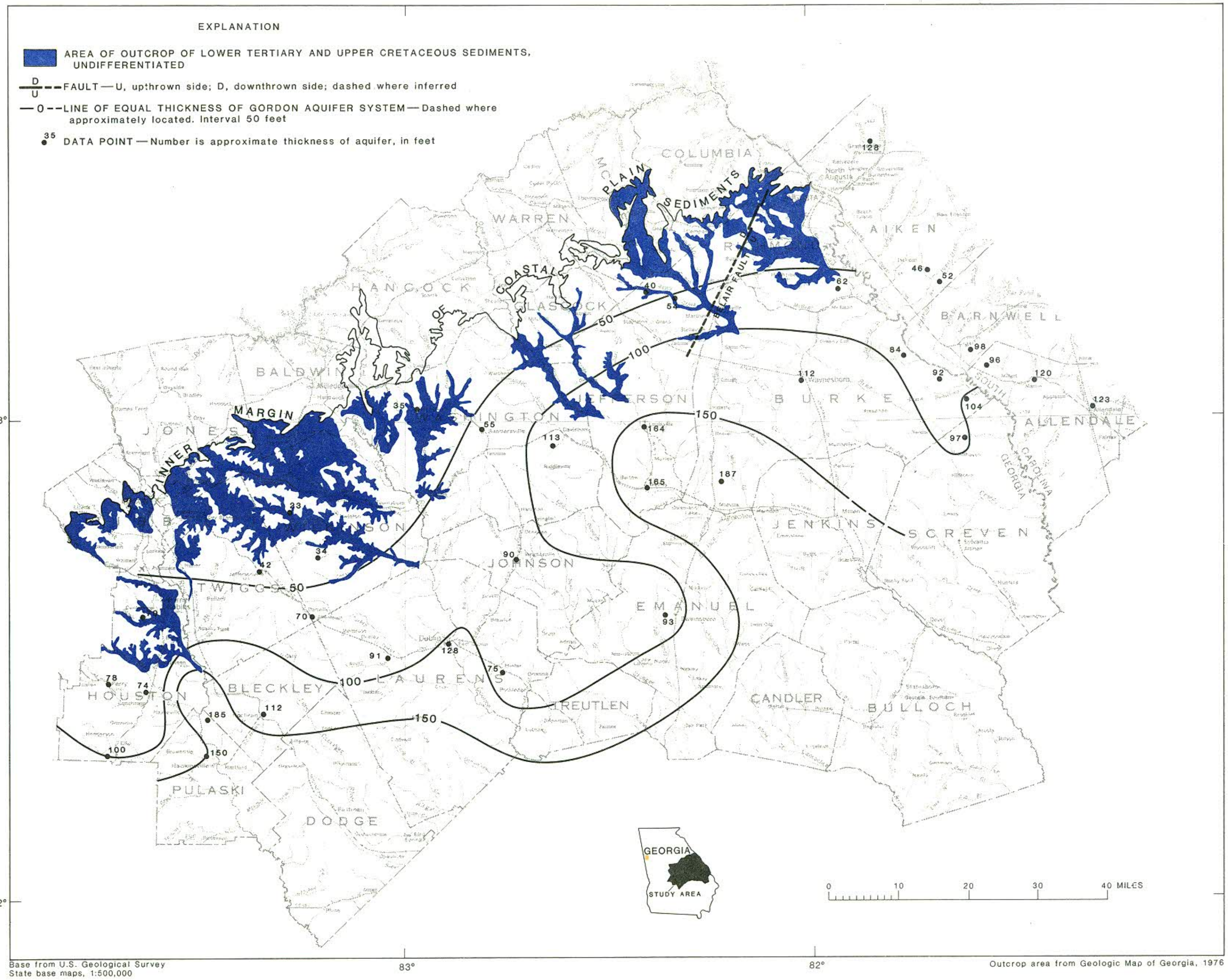


Figure 6.—Approximate thickness of the Gordon aquifer system.

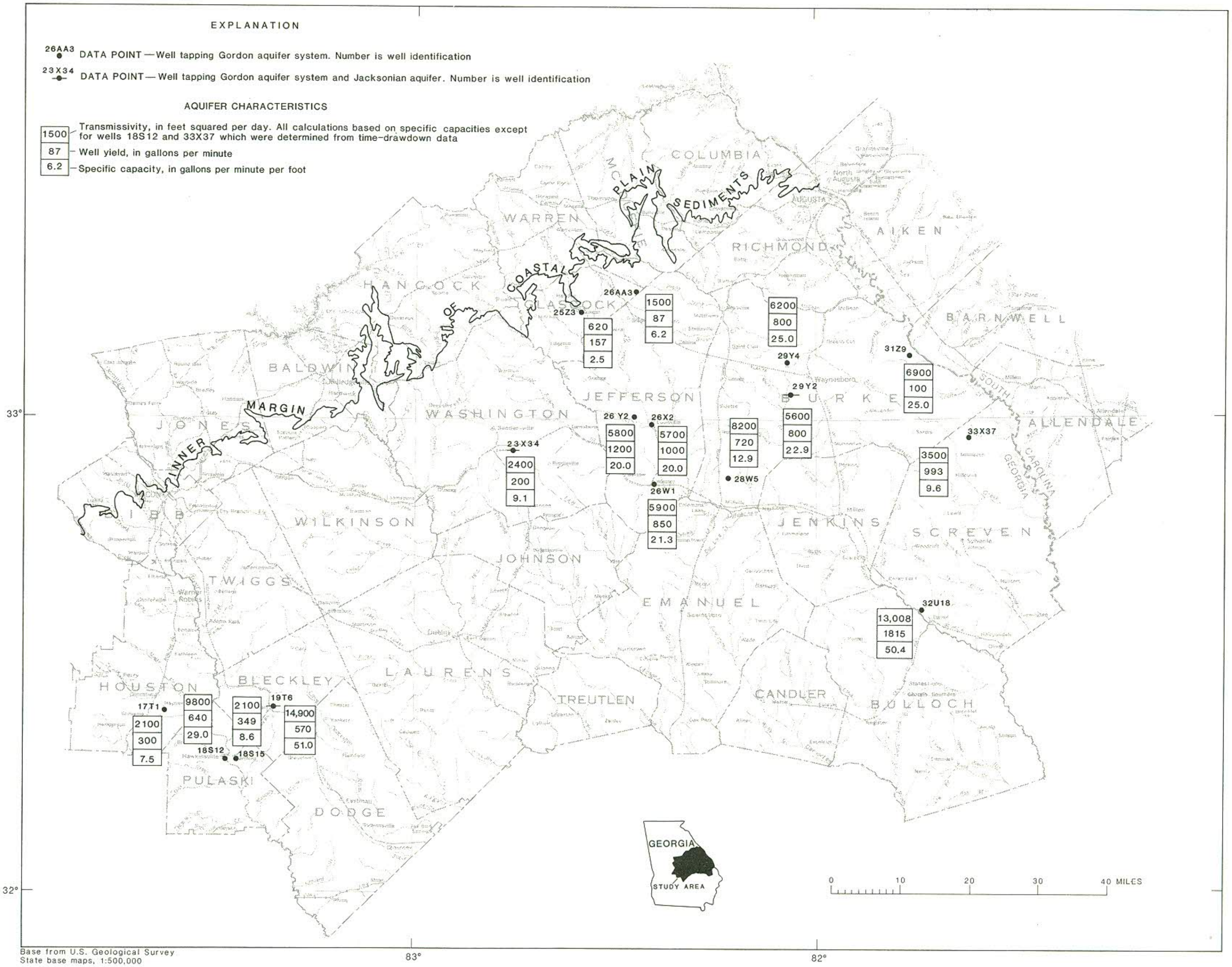


Figure 7.— Aquifer transmissivity, and yield and specific capacity of wells tapping the Gordon aquifer system.

outcrop area (fig. 2) and in interstream drainage divides in and near the outcrop area. Most recharge by precipitation occurs during January through May when rainfall is abundant and evapotranspiration is minimal. During the summer months, although rainfall is heavy, evapotranspiration is high. Therefore, most rainfall is evaporated or retained in the unsaturated zone as soil moisture and little water is available for recharge. Direct recharge to the Gordon aquifer system also occurs where it crops out near well 22Y30 (pl. 2), and between well 20V4 and the Ruby Quarry (pl. 1).

South of the outcrop area, the Gordon aquifer system is recharged by leakage from overlying and underlying aquifers. Downward leakage occurs in the area between the Midville test well (well 28X1) and well VSC-2 (pl. 1) where the upper confining unit of the Gordon aquifer system is sandy and where the hydraulic head in the Gordon aquifer system is lower than the head in the Jacksonian aquifer. Recharge also may occur where water under greater hydraulic head leaks upward into the Gordon aquifer system from the underlying Dublin and Midville aquifer systems of Clarke and others (1985). Water-level data in Burke and Laurens Counties (fig. 8) show that the hydraulic heads in the Dublin and Midville aquifer systems are higher than the head in the Gordon aquifer system.

Head differences between the Gordon aquifer system and overlying and underlying aquifers are shown in figure 8. During 1980-82, head differences of 6.3 ft were observed between the Gordon aquifer system and the overlying Jacksonian aquifer in Jefferson County, 18.8 ft between the Gordon aquifer system and the Dublin aquifer system in Laurens County, and 11.7 ft and 16.5 ft between the Gordon aquifer system and the Midville aquifer system in Burke and Laurens Counties, respectively.

In Laurens County, well 21U2 taps the Jacksonian aquifer, the Gordon aquifer system, and the Dublin aquifer system. A comparison of water levels in this well and nearby well 21U5, which taps the Dublin aquifer system, showed a head difference of about 18 ft (fig. 8). This difference suggests that the water level in well 21U2 is more representative of the Gordon aquifer system and Jacksonian aquifer than the Dublin aquifer system. Also, well 28W4, in Burke County, taps both the Gordon aquifer system and the Jacksonian aquifer, and exact head differences between the two may be more representative of composite head values.

Discharge

Discharge from the Gordon aquifer system occurs mainly as flow into major streams. Ground-water discharge to these streams was estimated from streamflow measurements made during the drought of October-November 1954 (Thomson and Carter, 1955) (fig. 9). During this drought, streams in the northeastern and northwestern parts of the study area continued to flow. In other parts of the area, possibly because the drought was more severe, no discharge occurred and streams ceased flowing, indicating that the water level in the aquifer had declined below the altitudes of the stream beds.

Discharge from the Gordon aquifer system possibly may occur as leakage to the underlying Dublin aquifer system (Clarke and others, 1985). This leakage is most likely to occur where the basal confining unit is sandy or absent and where water-level declines in the underlying Dublin and Midville aquifer systems have changed the head relations between the aquifer systems and increased the possibility for downward flow. A comparison of water-level data (fig. 10) from observation and pumping wells near Four Mile Branch Creek in western South Carolina (Siple, 1967, p. 79) (fig. 2) indicates that water levels in strata herein assigned to the Gordon aquifer system (wells ZW-15 and ZW-7, fig. 10) responded to nearby pumping from wells tapping Cretaceous aquifers (well 35-H, fig. 10). This shows

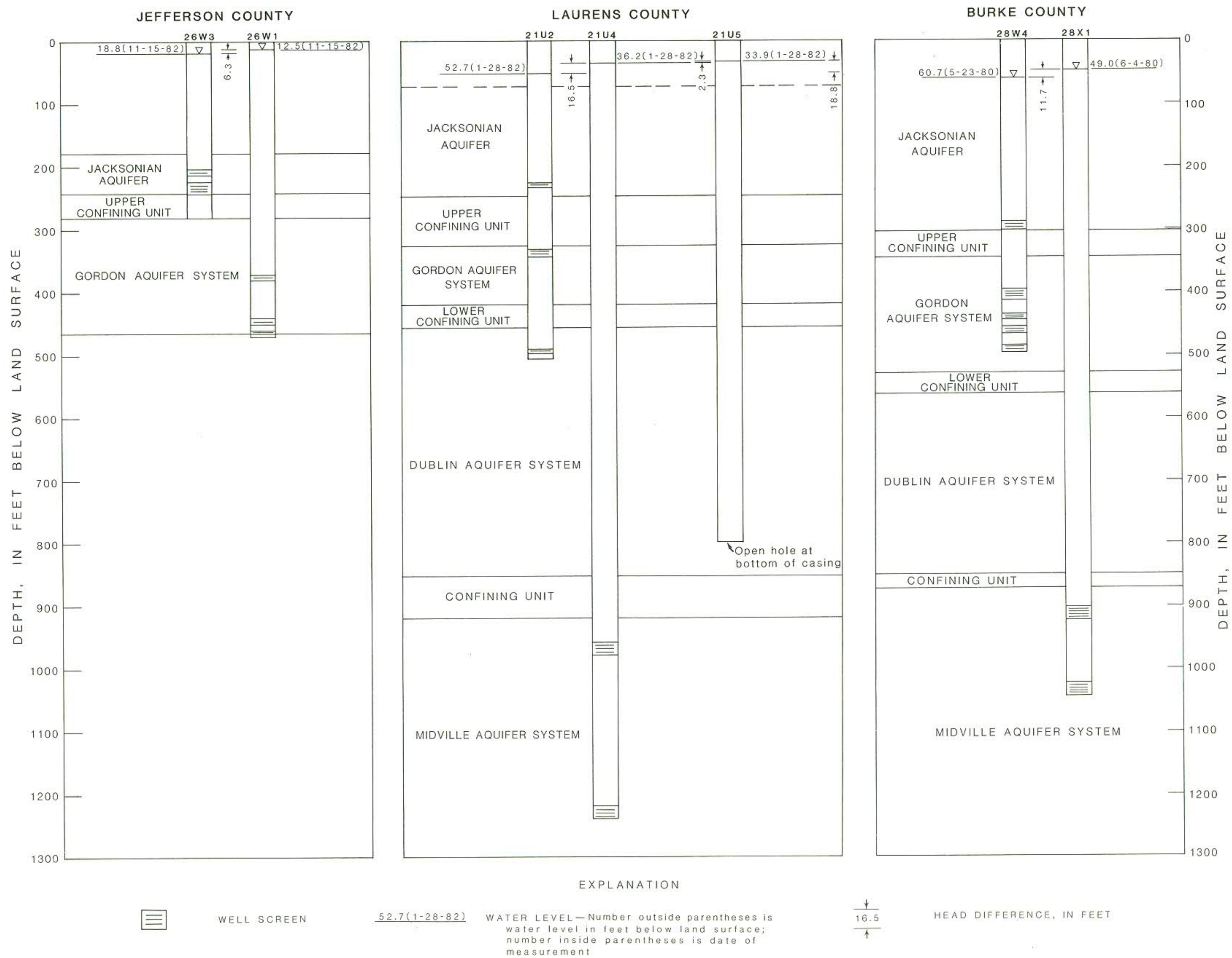
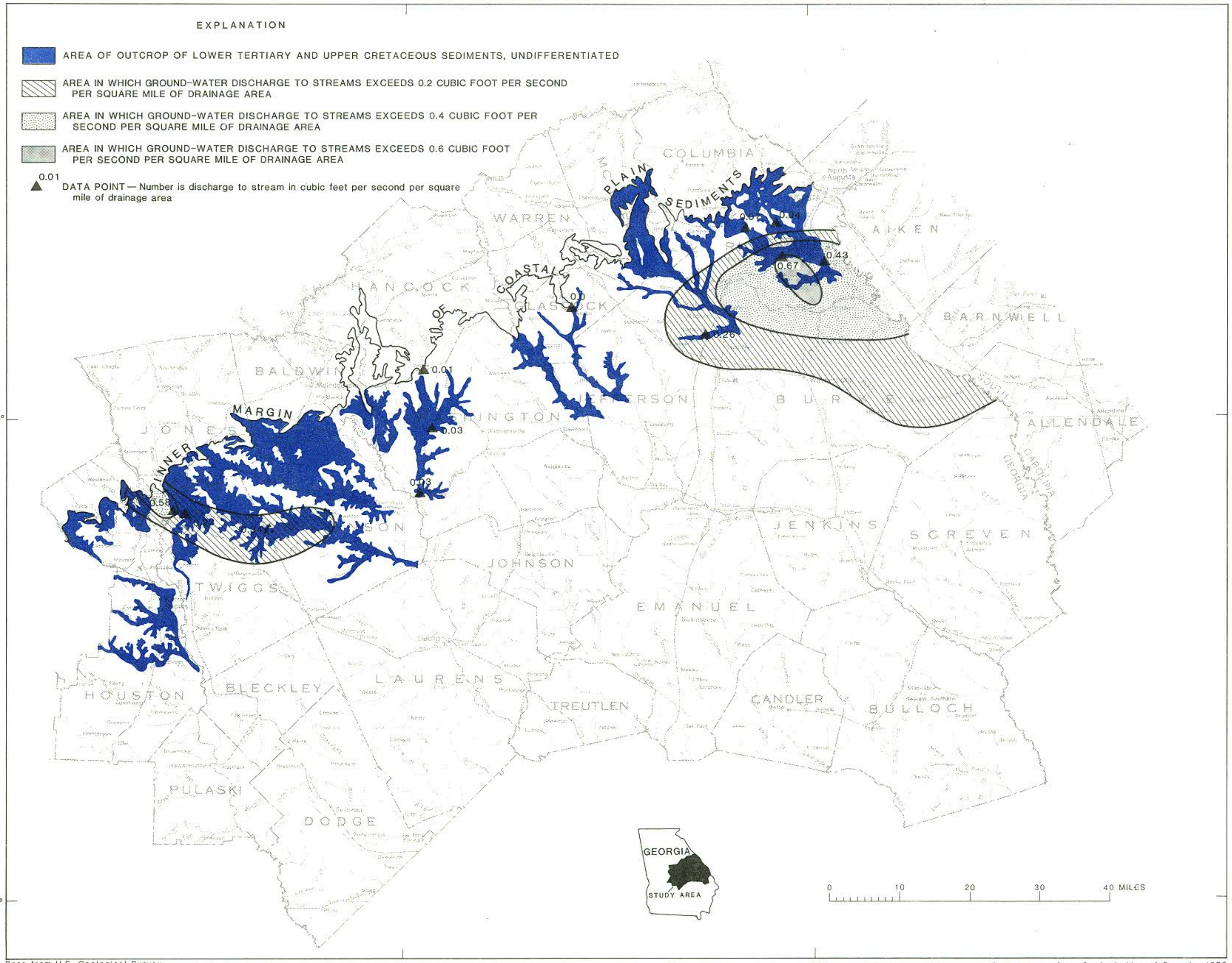


Figure 8.— Head differences between the Jacksonian aquifer and Gordon aquifer system in Jefferson County; between the Gordon and Midville aquifer systems in Burke County; and between the Gordon, Dublin, and Midville aquifer systems in Laurens County.



Base from U.S. Geological Survey
State base maps, 1:500,000

Outcrop area from Geologic Map of Georgia, 1976

Figure 9.— Estimated ground-water discharge to streams from aquifers in east-central Georgia, October-November 1954.

that there is hydraulic connection between the Gordon aquifer system and underlying aquifers and that discharge from the Gordon aquifer system occurs in this area.

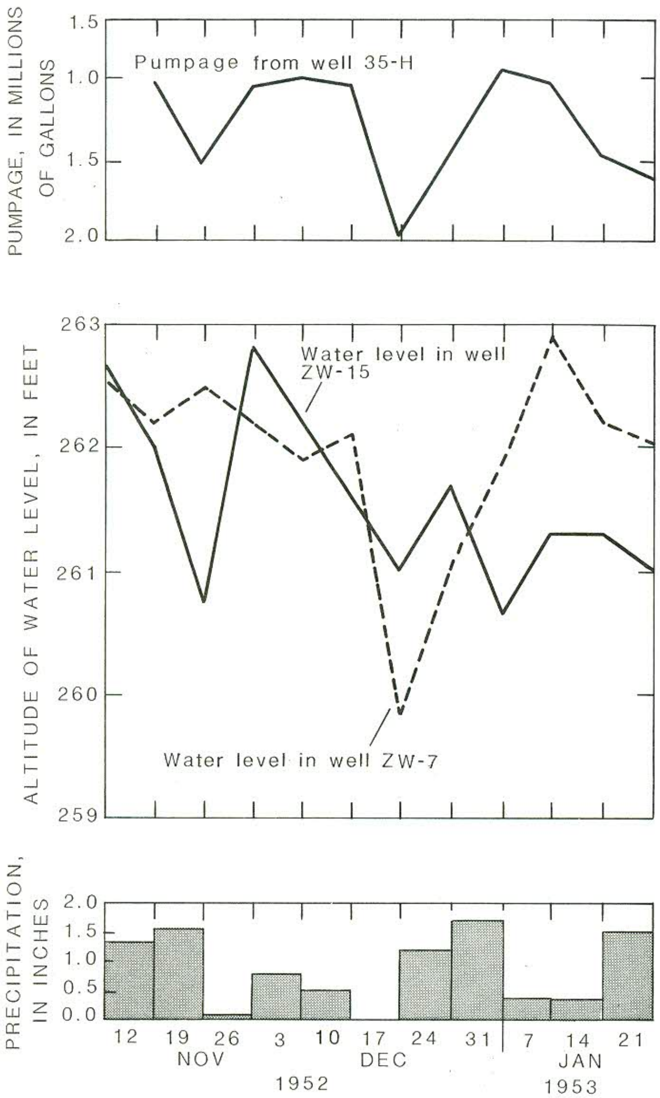


Figure 10.— Relation of water-level fluctuations in wells herein assigned to the Gordon aquifer system (wells ZW-15 and ZW-7) to pumping from a Cretaceous well (well 35-H) and to precipitation, Aiken and Barnwell Counties, South Carolina, November 1952 to January 1953. (Modified from Siple, 1967)

Ground-Water Levels

Water-Level Fluctuations

Water-level fluctuations in the Gordon aquifer system are the result of ground-water recharge to or discharge from the aquifer system. In and near the outcrop area, water-level fluctuations reflect seasonal changes in recharge from precipitation, discharge to streams, and evapotranspiration. In this area, water levels generally are highest from March through May, a period of abundant rainfall and minimum evapotranspiration, and lowest from August through November, a period of decreasing rainfall and significant evapotranspiration. Periodic water-level measurements from July 1971 to July 1972 in well 31Z13 (Appendix A) at Vogtle Nuclear Plant south of the outcrop area in Burke County showed no response to precipitation in September 1971 but nearly a direct response to rainfall during January 1972 (fig. 11). The comparatively heavy rainfall in June had no effect on the July water level, possibly owing to the high rate of evapotranspiration during the summer months and to the effects of pumping.

South of the outcrop area, the Gordon aquifer system is confined by overlying clay units, and water-level fluctuations result mainly from regional and local pumping. For example, water-level fluctuations in strata herein assigned to the Gordon aquifer system at the Savannah River Plant at the Georgia-South Carolina State line (wells ZW-15 and ZW-7, fig. 10) are more directly related to pumping from wells tapping the Cretaceous aquifer (well 35-H, fig. 10) than to recharge by precipitation (Siple, 1967). (See section on Discharge.)

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). Two poten-

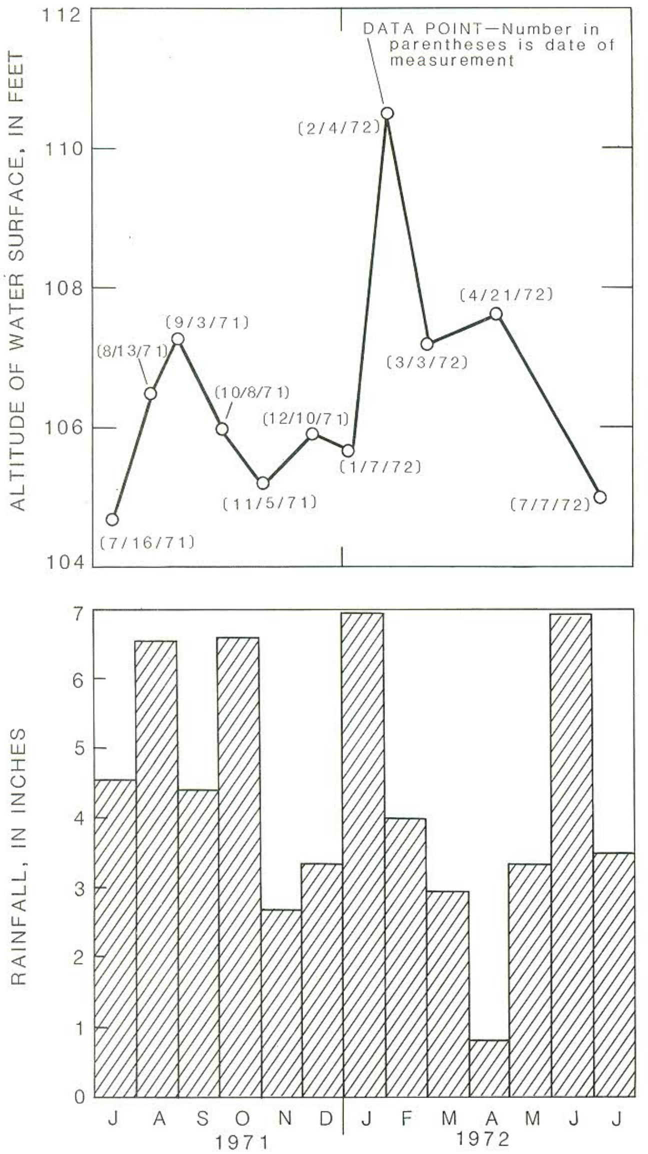


Figure 11.— Relation of water-level fluctuations at observation well 31Z13 at Vogtle Nuclear Plant, Burke County, to monthly precipitation at National Weather Service station 9194 (Waynesboro 2 NE), July 1971 to July 1972.

tiometric surfaces are mapped in this report: an estimated 1934-68 potentiometric surface intended to portray the approximate predevelopment surface (fig. 12), and a November 1981 surface that shows the effects of pumping stress (fig. 13).

Potentiometric levels are highest in areas of recharge and lowest in areas of discharge. Thus, the general direction of ground-water flow is southward from recharge areas to discharge areas. Locally, pumping can lower the potentiometric surface and form a cone of depression.

The potentiometric maps show that within the study area there are three major ground-water divides: (1) a western divide bordered by the Ocmulgee and Oconee Rivers, (2) a central divide bounded by the Oconee and Ogeechee Rivers, and (3) an eastern divide bordered by the Ogeechee and Savannah Rivers. These three ground-water divides generally correspond to interstream drainage divides and in and near the outcrop area are regions of greatest recharge. The major rivers bordering the ground-water divides are areas of regional aquifer discharge and form boundaries to the ground-water flow system. Naturally occurring discharge into the rivers is indicated by potentiometric contours that bend upstream in an inverted "V" pattern where they cross the rivers.

Predevelopment flow directions within the Gordon aquifer system were generally southward from the outcrop area, toward major rivers and streams. Therefore, corresponding potentiometric gradients were consistently toward the larger rivers and streams and generally were greatest within the outcrop area and near streams. Thus, the regional potentiometric surface in and near the outcrop area of the Gordon aquifer system generally was symmetrical to the major rivers and was, in effect, a subdued replica of surface topography (Faye and Prowell, 1982, p. 37).

Estimated 1934-68 Potentiometric Surface

The estimated 1934-68 potentiometric surface of the Gordon aquifer system was contoured from water-level data collected during this period (fig. 12), most of the data being collected in 1946 and 1963. This surface is thought to resemble the

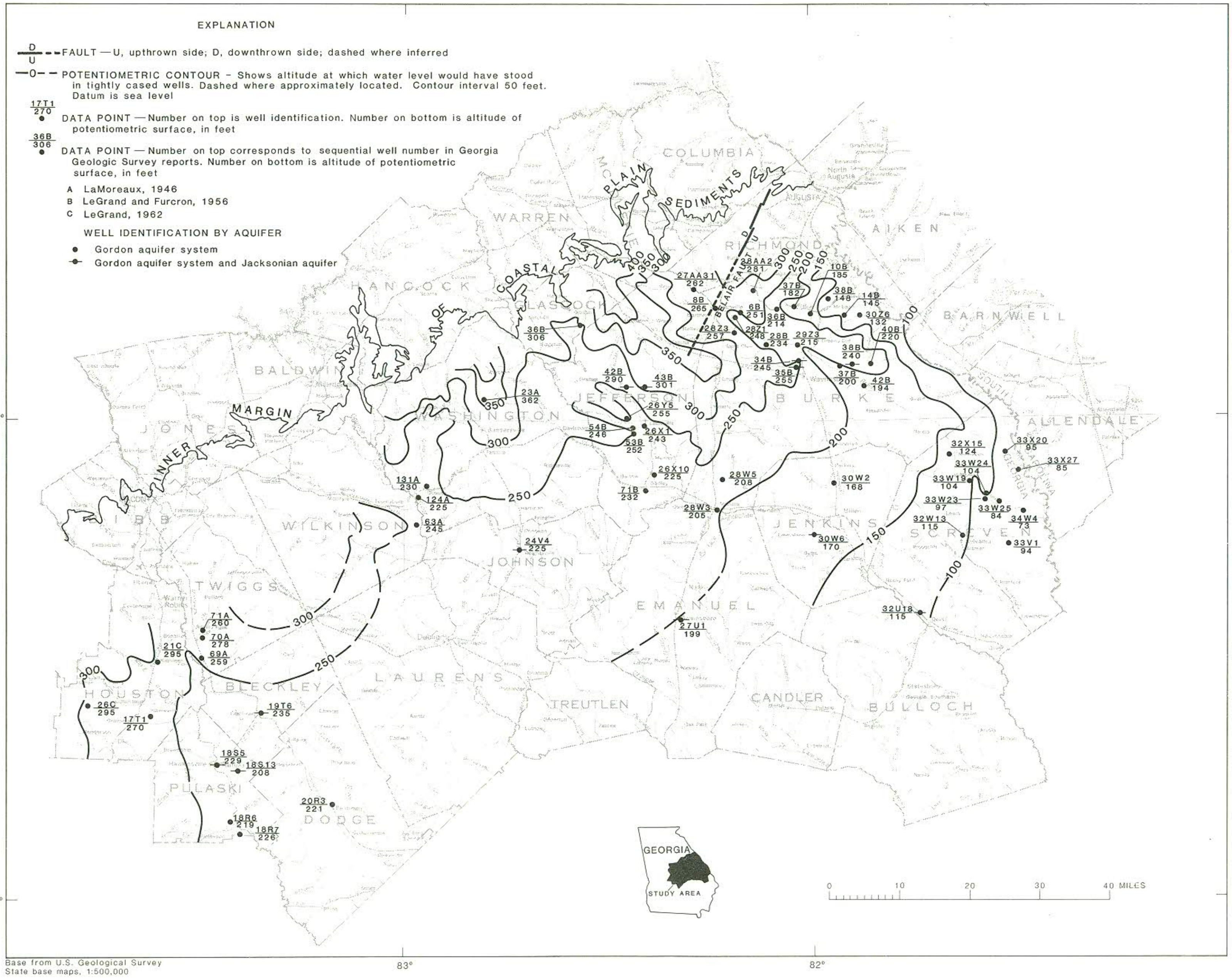


Figure 12.— Estimated potentiometric surface of the Gordon aquifer system, 1934-68.

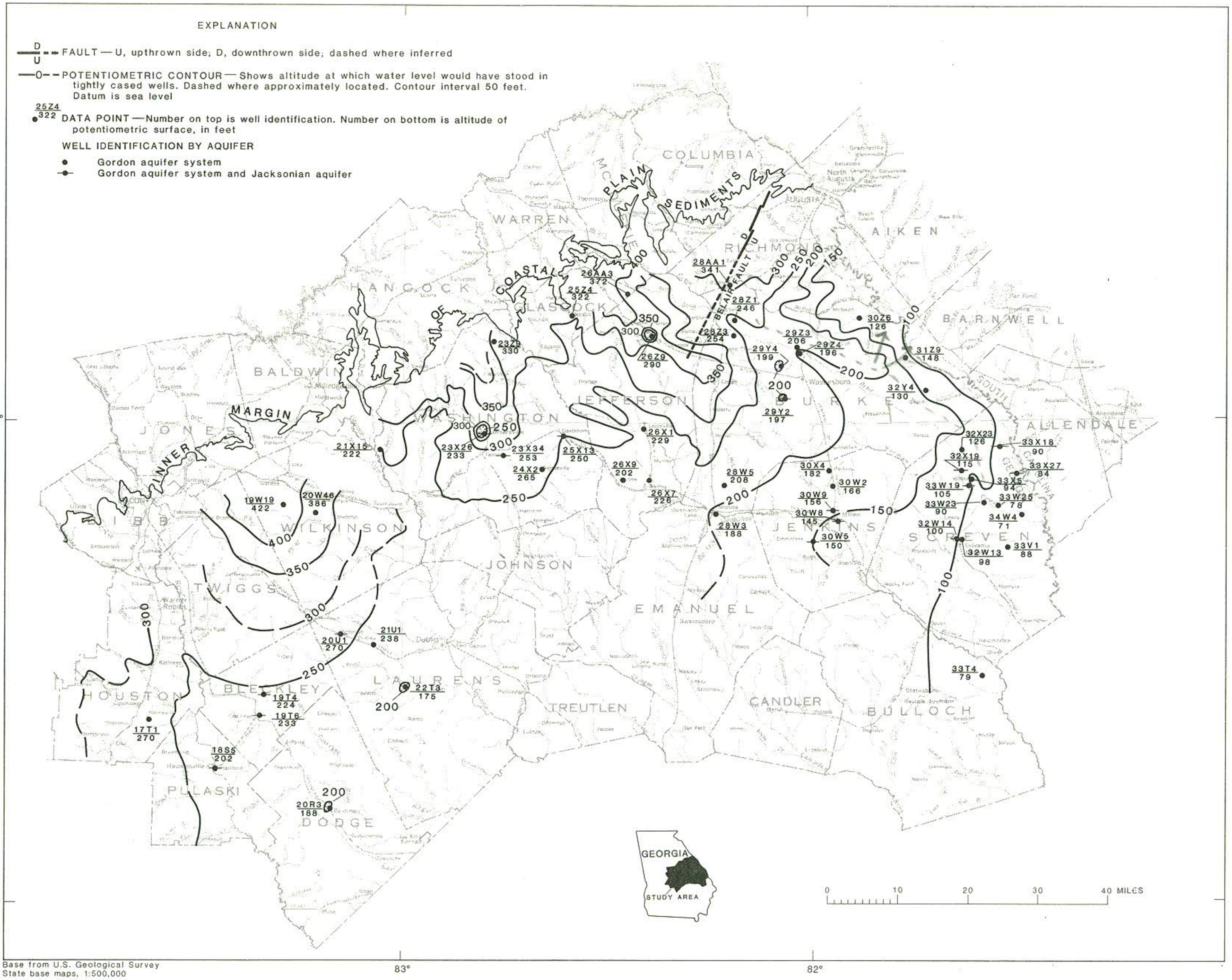


Figure 13.— Potentiometric surface of the Gordon aquifer system, November 1981.

approximate predevelopment surface before local pumping stresses were applied. Unpublished water-level data indicate that, except in major pumping centers, potentiometric heads in the Gordon aquifer system have changed little since 1935 when man-induced stresses (pumping) were applied. This statement is supported by Siple (1967) and Root and Marine (1978) who published hydrographs for 1951-60 and 1973-77 showing seasonal fluctuations of only about 10 ft in sediments that are part of the Gordon aquifer system at the Savannah River Plant.

In the western part of the study area, potentiometric heads range in altitude from about 300 ft near the outcrop area in western and central Houston and southern Twiggs and Wilkinson Counties to about 200 ft in southern Laurens County (fig. 12). Heads in the eastern part of the area range in altitude from about 400 ft in southern Glascock County and northern Washington and Jefferson Counties to about 100 ft in eastern Burke, Screven, and Bulloch Counties.

November 1981 Potentiometric Surface

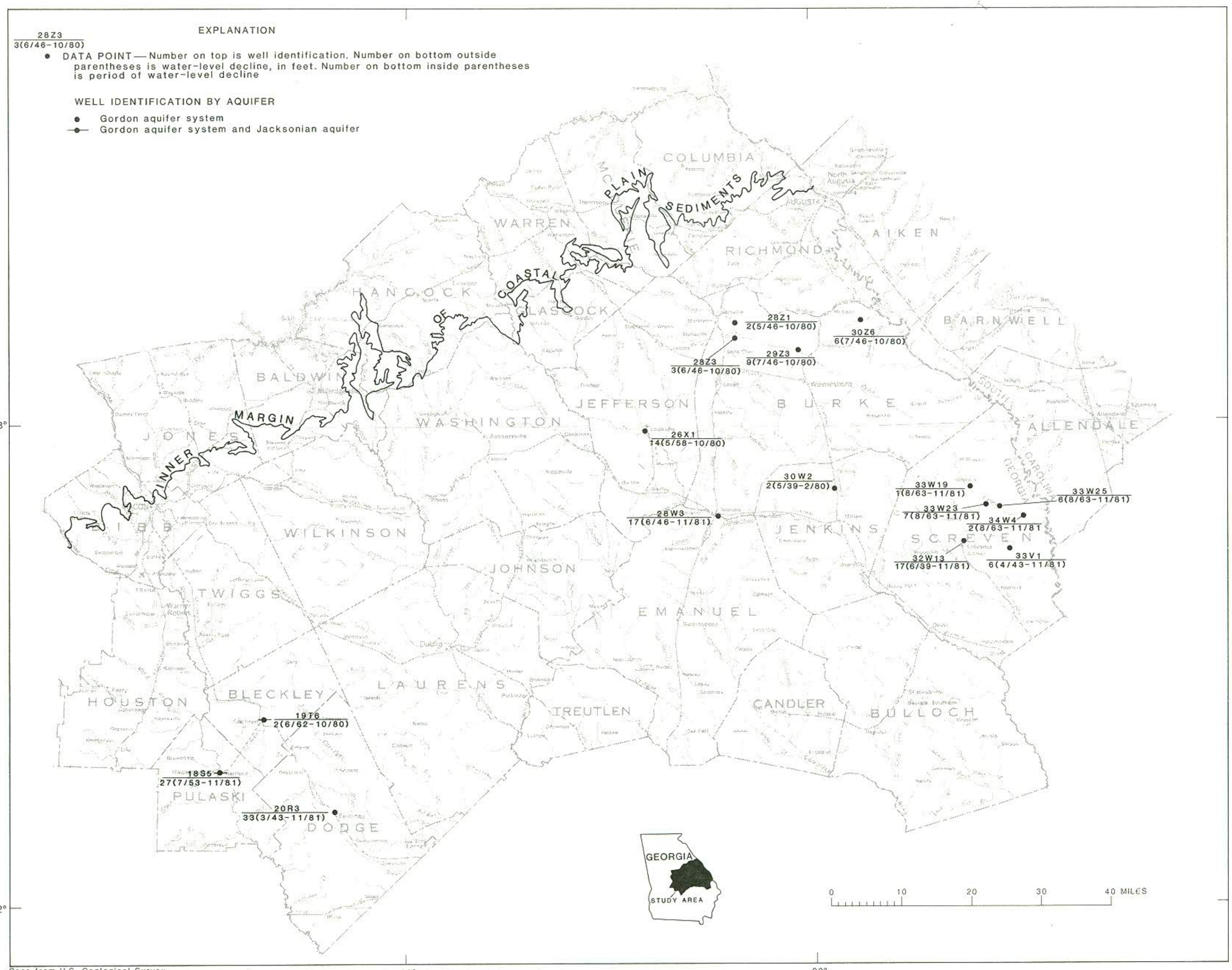
The November 1981 potentiometric surface of the Gordon aquifer system was constructed from water-level data collected from 1976 to 1982, most of the data being collected in November 1981 (fig. 13). This surface is similar to the estimated 1934-68 potentiometric surface except in local areas affected by increased ground-water withdrawals. Declines in the potentiometric surface based on water levels measured at different times of the year may be partly attributed to seasonal fluctuations.

Water-level data indicate that localized declines, which formed small cones of depression, occurred near Hartford in Pulaski County, Eastman in Dodge County, Sandersville in Washington County, Wrens in Jefferson County, and in central Laurens County and western Burke County. Other declines that changed the configuration of the potentiometric surface occurred at Louisville in Jefferson County, at and near Sylvania in Screven County, and at Midville and northwest of Waynesboro in Burke County (fig. 14).

Long-Term Water-Level Declines

Water levels in the Gordon aquifer system generally remained constant during the period 1934-81, as recharge and discharge maintained equilibrium. The only exceptions were local areas that had significant increases in ground-water withdrawals. In these areas, increased pumping caused reductions in compressive aquifer storage and corresponding declines in the water level (Lohman, 1972, p. 8). Water-level records for eastern Georgia show that localized declines as great as 33 ft occurred in the potentiometric surface during 1939-81 in downdip areas (fig. 14; Appendix A). Declines in water levels in or near the outcrop area may partly be attributed to seasonal fluctuations.

Water-level declines ranging from about 10 to 33 ft have formed small, localized cones of depression near cities where increased municipal or industrial pumping has occurred. (See section on November 1981 Potentiometric Surface.) For example, the decline in Sandersville in Washington County is probably due to increased pumping for kaolin processing in that area (fig. 13). Siple (1967) reported that at the Savannah River Plant, local pumping and long-term stress from 1952 to 1960 resulted in total water-level declines ranging from about 10 to 18 ft in sediments herein assigned to the Gordon aquifer system. Other localized cones of depression developed in central Laurens County and western Burke County mainly because of large withdrawals for irrigation. In Louisville, Jefferson County, the water level in well 26X1 remained steady from 1958 to 1975 when it began to decline (fig. 15). Because ground-water withdrawals by the city of Louisville increased only slightly during 1975-80, it is likely that the decline was due to increased pumping for irrigation.



Base from U.S. Geological Survey
State base maps, 1:500,000

Figure 14.— Water-level declines in the Gordon aquifer system, 1939-81.

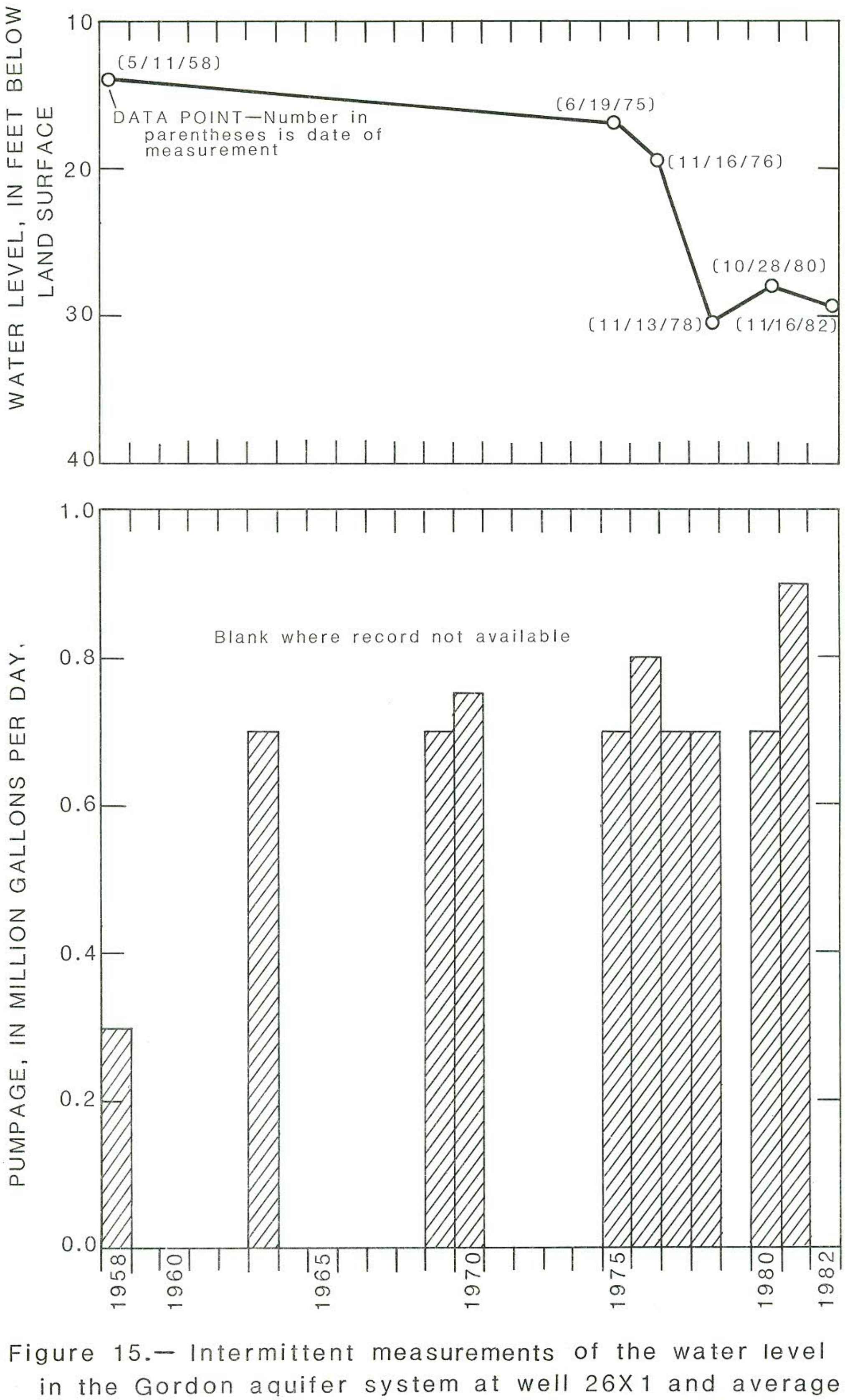


Figure 15.— Intermittent measurements of the water level in the Gordon aquifer system at well 26X1 and average daily ground-water withdrawals by the city of Louisville, Jefferson County, 1958-82.

WATER QUALITY

Chemical analyses of water from the Gordon aquifer system show that constituent concentrations in most of the study area are within the Georgia Environmental Protection Division (1977) standards and recommended limits for drinking water. An exception occurs in Jefferson County where iron concentrations exceed the 300 μg/L standard and range from 600 μg/L at well 26X1 in Louisville to 1,900 μg/L at well 26W1 in Wadley. (See Appendix B.)

Generally, concentrations of dissolved solids and most other constituents increase from the outcrop area southward (fig. 16). This increase is due to material being dissolved as the ground water flows through the aquifer. Concentrations of dissolved solids range from 32 mg/L at well 28AA1 in Richmond County near the outcrop area, to 193 mg/L at well 34W4 in Screven County.

Variations in hardness as $CaCO_3$ in the Gordon aquifer system are related to changes in the lithology of aquifer sediments. (See section on Definition of the Gordon Aquifer System). In the northeastern part of the study area, water generally has a $CaCO_3$ hardness of less than 60 mg/L and is classified as "soft" (fig. 17; Appendix B). In this area, aquifer sediments consist primarily of sand and contain low concentrations of carbonate and bicarbonate. Although water-quality analyses are unavailable for the Gordon aquifer system in the northwestern part of the study area, the aquifer lithology is similar and it is likely that water in that area also is "soft." In the central part of the study area, water has a $CaCO_3$ hardness greater than 100 mg/L and is classified as "moderately hard" to "hard." This increase in hardness probably results from higher percentages of carbonate in the aquifer material. Water having a $CaCO_3$ hardness greater than 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 using lime and soda ash.

In this report, water-quality data are from wells tapping the Gordon aquifer system and from multiaquifer wells tapping the Gordon aquifer system and the Jacksonian aquifer. Comparison of these data may be misleading in that some of the analyses for multiaquifer wells may not be representative of the Gordon aquifer system.

WATER USE

The Gordon aquifer system supplied an estimated 24 Mgal/d during 1980, of which about 70 percent was used by agriculture, 16 percent by municipalities, and 14 percent by industries (table 2). Agriculture utilized 17.0 Mgal/d with major withdrawals occurring in Burke (7.7 Mgal/d), Pulaski (2.2 Mgal/d), Houston (1.6 Mgal/d), and Jefferson (1.5 Mgal/d) Counties. Agricultural water-use values represent estimated growing-season withdrawals averaged over a 365-day period. In recent years, agricultural use has increased dramatically and in 1980 it was almost eight times greater than in 1975 (Robert R. Pierce, U.S. Geological Survey, written commun., 1982). This increase in use is supported by water-level declines at Louisville, Jefferson County, that can be attributed to pumping for irrigation. (See section on Long-Term Water-Level Declines.)

Overall municipal and industrial water use in the Coastal Plain of Georgia gradually increased from 1960 to 1980 (Pierce and others, 1982). During 1980, municipal water use from the Gordon aquifer system totaled 4.0 Mgal/d and industrial water use was 3.4 Mgal/d. Major municipal users were Louisville in Jefferson County (1.1 Mgal/d) and Midville in Burke County (0.8 Mgal/d). The major industrial users were kaolin companies in Washington County (0.9 Mgal/d) and industries in Screven County (1.0 Mgal/d).

WELL CONSTRUCTION

Wells tapping the Gordon aquifer system use open-hole or screenline construc-

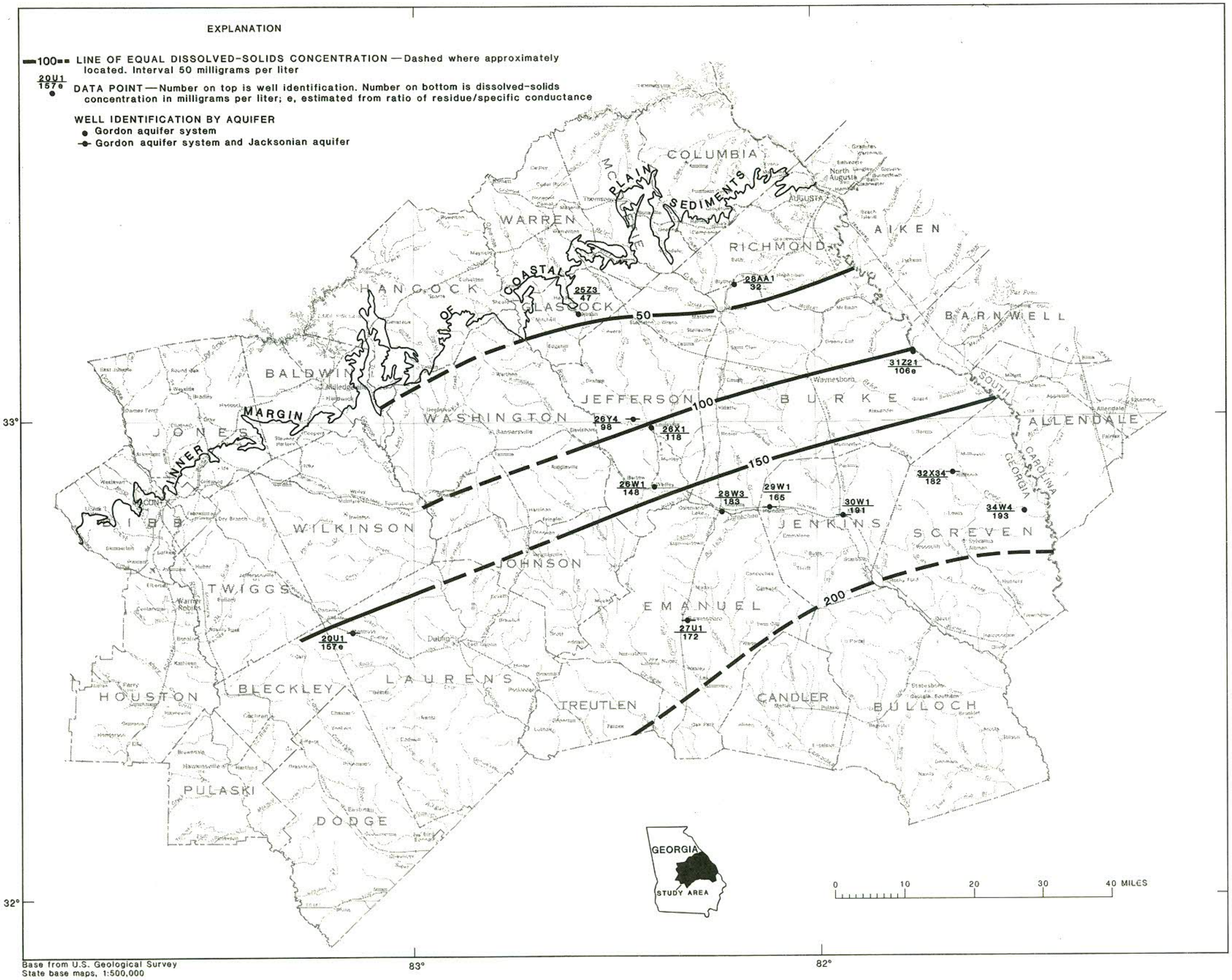


Figure 16.— Dissolved-solids concentrations in ground water from the Gordon aquifer system.

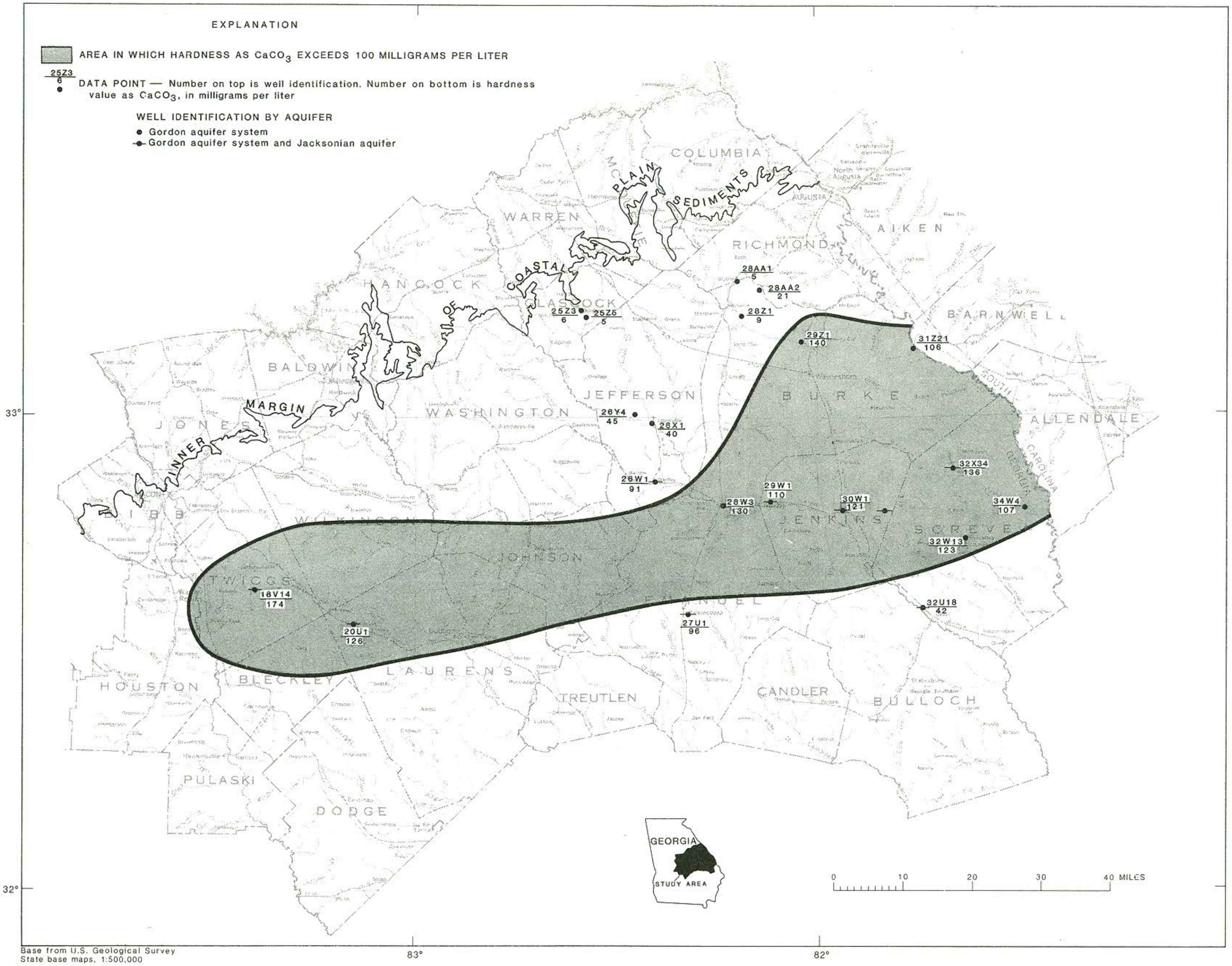


Figure 17.— Distribution of hardness as $CaCO_3$ in ground water from the Gordon aquifer system.

Table 2.--Estimated water use for the Gordon aquifer system, 1980
[<, less than]

County	Ground-water use (Mgal/d)			
	Agricultural[1]	Industrial	Municipal	County total[2]
Bibb	--	--	--	--
Bleckley	0.4	--	0.1	0.5
Bulloch	.4	--	--	.4
Burke	7.7	<0.1	.8	8.6
Columbia	--	--	--	--
Dodge	--	--	--	--
Emanuel	--	--	.1	.1
Glascock	--	.1	.1	.2
Houston	1.6	--	.3	1.9
Jefferson	1.5	.7	1.1	3.3
Jenkins	1.0	.1	.2	1.3
Johnson	.4	--	.1	.5
Jones	--	--	--	--
Laurens	.6	.1	.2	.9
Pulaski	2.2	.3	.5	3.0
Richmond	--	--	<.1	<.1
Screven	.9	1.0	.3	2.2
Twiggs	--	--	--	--
Washington	.3	.9	.1	1.3
Wilkinson	--	.1	--	.1
Total	17.0	3.4	4.0	24.4

[1]Values are estimated growing-season withdrawals averaged over a 365-day period.
[2]Totals do not include domestic use.

tion (Appendix A). Open-hole construction is used where the aquifer system consists of consolidated materials, such as limestone (well 28W3, Burke County; Appendix A). Screenline construction is generally used where the Gordon aquifer system consists of unconsolidated sediments such as sand or sandy units (well 28W5, Burke County; Appendix A). Figure 18 shows an example of screenline construction and the relation of geophysical and lithologic properties to water-bearing zones at well 28W4 in Burke County.

In areas where the Gordon aquifer system does not provide sufficient yields, multiaquifer wells are used (fig. 18). These wells tap the Gordon aquifer system and either the overlying Jacksonian aquifer of Vincent (1982) or the underlying Dublin and Midville aquifer systems of Clarke and others (1985).

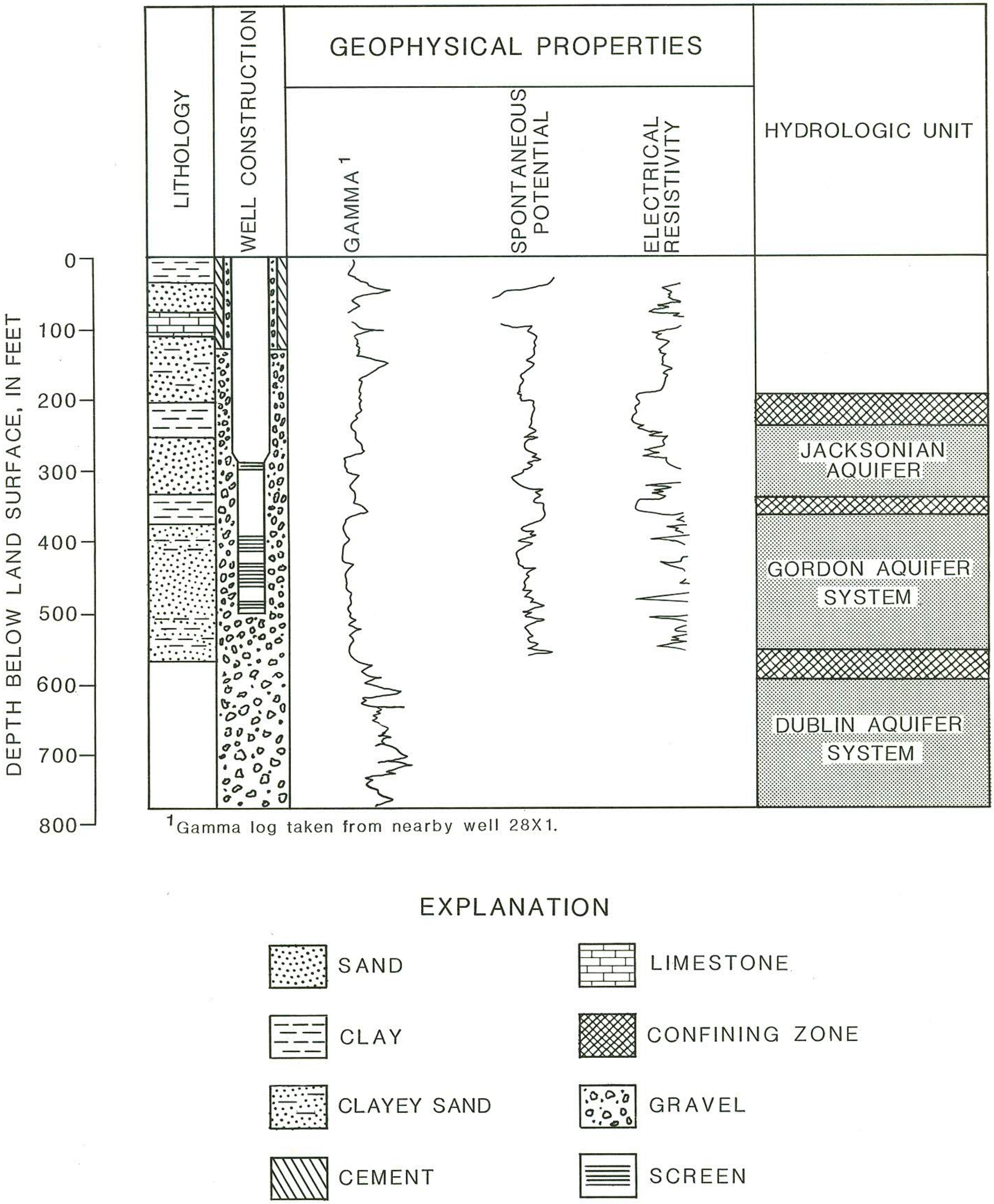
SUMMARY

Interlayered sand, silt, and clay of late Paleocene to middle Eocene age in the Coastal Plain physiographic province of east-central Georgia form the Gordon aquifer system. The aquifer system ranges in thickness from about 20 ft in Wilkinson County in the central part of the study area to more than 180 ft in Pulaski and Burke Counties in the western and eastern parts of the area, respectively. Estimated transmissivities range from 620 ft^2/d at well 25Z3 in Glascock County to 13,000 ft^2/d at well 32U18 in Screven County. Transmissivity values obtained from multiaquifer wells tapping both the Gordon aquifer system and the Jacksonian aquifer range from 2,400 ft^2/d at well 23X34 in Washington County to 14,900 ft^2/d at well 19T6 in Bleckley County.

During 1980, approximately 24 Mgal/d was withdrawn from the Gordon aquifer system, about 70 percent of which was used by agriculture. Water levels in the study area generally showed little change during 1934-68. Small cones of depression on the November 1981 potentiometric surface resulted from localized declines ranging from about 10 to 33 ft in areas of large-scale municipal, industrial, and irrigation pumping.

The Gordon aquifer system is recharged mainly by precipitation in the outcrop area and in interstream drainage divides in and near the outcrop area, and by leakage where potentiometric heads in overlying or underlying aquifers are higher. Discharge from the Gordon aquifer system occurs predominantly as flow into streams or as leakage where potentiometric heads in overlying and underlying aquifer systems are lower.

Water from the Gordon aquifer system is generally a calcium bicarbonate type that ranges from soft to hard, and in most areas has constituent concentrations that are within the Georgia Environmental Protection Division (1977) standards for drinking water.



[1]Gamma log taken from nearby well 28X1.

Figure 18.— Relation of well construction to geophysical and lithologic logs in well 28W4, near Midville, Burke County.

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APPENDICES

Appendix A.--Record of selected wells

[Aquifer: G, Gordon aquifer system; J, Jacksonian aquifer; D, Dublin aquifer system. Use: A, agricultural; D, domestic; I, industrial; P, public supply; O, observation. Water level: reported levels are given in feet, measured levels are given in feet and tenths; Yield: F, flowing. Depth of well: >, greater than]

County	Well numbers	Georgia Geologic Survey number	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 (ft)	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
Bleckley	19T4	--	322544-0832044	Theo Williams, Jr.	--	300	--	6	372	G,J	-148.0	11-06-81	170	--	A	
	19T6	1015	322340-0832108	Cochran, 2 (new)	--	417	220	--	353	G,J	-118.0 -120.0	06-02-62 11-06-81	510	51.0	P	Screen 220-235, 345-370, 380-385, 395-400 ft. Transmissivity = 14,900 ft^2/d.
Bulloch	33T4	--	322834-0813513	Cardell Dyches	1977	800	600	6	147	G	-67.6	11-03-81	400	--	A	
Burke	28W3	--	324859-0821401	Midville, 1	06-24-46	482	200	--	185	G,J	+20 +3.5	06-24-46 11-17-81	400	--	P	Open hole 200-482 ft. Well 67 in GGS Bulletin 64. Water-quality analysis, 08-20-81.
	28W4	--	325227-0821301	Midville Expmt. Sta., 2 (Va. Supply and Well, 2)	--	500	292	--	269	G,J	-60.7	05-23-80	--	--	A	Screen 292-302, 395-415, 434-444, 455-465, 484-494 ft.
	28Z3	--	321128-0821127	Oliver Clure	--	175	--	3	251	G	+5.9 +2.6	06-28-46 11-12-81	--	--	D	Well 30 in GGS Bulletin 64.
	28Z1	--	331328-0821127	C. F. Morris	--	95	--	2.5	241	G	+6.6 +4.6	05-26-46 11-12-81	37	--	D	Well 7 in GGS Bulletin 64. Water-quality analysis, 08-08-46.
	29Z3	--	330951-0820210	F. P. Saxon (old J. C. Stockman)	--	170	--	3	207	G	+8 +1.3	07-03-46 11-11-81	--	--	D	Well 23 in GGS Bulletin 64.
	30Z6	--	331305-0815234	Miller's Pond	--	92	42	4	117	G	+14.9 +8.7	07-01-46 10-23-80	--	--	--	Well 16 in GGS Bulletin 64.
	28W5	--	325227-0821311	SE Ga.Exprmt.Sta. (Layne-Atlantic 1)	1968(?)	535	454	8	268	G	-59.4	09-19-68	720	12.9	A	Screen 454-464, 474-524 ft. Transmissivity = 8,200 ft^2/d. Well destroyed.
	31Z9	--	330821-0814535	Ga. Power Plant Vogtle constr., 8	1976	251	220	--	255	G	-107	10-16-76	100	25.0	I	Screen 220-240 ft. Transmissivity = 6,900 ft^2/d.
	29Y2	--	330310-0820354	Irby Cochran, 1	1979	422	181	13.5	290	G,J	-93	01-08-79	800	22.9	A	Open hole 181-422 ft. Transmissivity = 5,600 ft^2/d.
	29Y4	--	320715-0820432	Paul Dye, 1	1979	364	244	13.5	305	G	-106	01-10-79	800	25.0	A	Open hole 244-364 ft. Transmissivity = 6,200 ft^2/d.
	28W4	--	325227-0821301	SE Ga.Exprmt.Sta. Va. Supply and Well, 2	--	500	292	--	269	G,J	-60.7	05-23-80	--	--	A	Screen 292-302, 395-416, 434-444, 454-465, 484-494 ft.
	32Y4	--	330417-0814305	William Cox, 2	06- -79	415	360	6	221	G	-85 -90.5	06- -79 04-26-82	--	--	A	Screen 365-415 ft.
	31Z13	--	330837-0814527	Ga. Power Plant Vogtle obsrv., 31	04-03-71	--	200	3	211	G	-106.3 -106.0	07-06-71 07-07-72	--	--	I	Perforated casing 200-210 ft.
	31Z12	--	330848-0814548	Ga. Power Plant Vogtle obsrv., 32	04-01-71	--	200	--	214	G	-113.6 -111.0	07-06-71 07-07-72	--	--	I	Perforated casing 200-210 ft.
	29Z4	--	330853-0820209	W. T. Stone (old D. O. Smith)	--	225	127	3	251	G	-80 -55.5	07-03-46 11-11-81	--	--	D	
Dodge	20R4	--	321209-0831047	Eastman, 2	1927	705	705	12,10, 8	360	G	-138.6 -171.6	03-16-43 11-05-81	--	--	P	
Emanuel	27U1	--	323513-0821915	Swainsboro, 5	11- -63	725	--	--	320	G,J	-121	11- -63	895	--	P	Water-quality analyses, 04-11-67, 09-28-71.
Glascock	25Z4	--	331350-0823538	Kent Canning Co.	06- -60	150	75	18	355	G	-31 -32.8	04-16-73 10-20-80	60	.5	I	Screen 75-85, 95-100, 110-115, 145-150 ft.
	26AA3	--	331546-0822711	Thiele Kaolin, W-1	--	153	145	--	440	G	-66 -68.3	06-10-71 10-20-80	87	6.2	I	Screen 145-150 ft. Transmissivity = 1,500 ft^2/d.
	25Z3	--	331335-0823604	Gibson, 3	1970(?)	203	--	--	435	G	-115	1970	157	2.5	P	30 ft of screen-spacing unknown. Transmissivity = 620 ft^2/d. Water-quality analysis, 09-04-81.
Houston	17T1	--	322259-0833718	Houston Co. Brd. of Commissioners, Haynesville	--	347	278	11,10 8	425	G	-155 -155	10- -64 02-14-79	300	7.5	P	Screen 278-289, 334-344 ft. Transmissivity = 2,100 ft^2/d.
Jefferson	26W3	--	325148-0822357	Wadley, 2	--	280	203	9	230	J	-18.8	11-15-82	150	--	P	Screen 203-213, 222-242 ft.
	26X1	554	325947-0822442	Louisville, 1	04- -58	367	70	8	257	G	-14 -28.1	05-11-58 10-20-80	860	--	P	Water-quality analyses, 03-11-63, 12-01-75.
	26X7	--	325242-0822408	Wadley, 3	--	491	233	8	278	G,J	-63 -51.6	12-02-75 10-20-80	703	13.5	P	Screen 233-253, 411-431, 461-481 ft. Transmissivity = 5,700 ft^2/d.

Appendix A.--Record of selected wells--Continued

[Aquifer: G, Gordon aquifer system, J, Jacksonian aquifer; D, Dublin aquifer system. Use: A, agricultural; D, domestic; I, industrial; P, public supply; O, observation. Water level: reported levels are given in feet, measured levels are given in feet and tenths; Yield: F, flowing. Depth of well: >, greater than]

County	Well numbers	Georgia Geologic Survey number	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 (ft)	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
Jefferson	26X10	532	325354-0822322	Mrs. W. P. Smith, 1	06- -57	410	165	8	265	G	-40	06- -57	535	--	D	
	26X9	--	325323-0822754	Wally Evans	--	425	266	13.5	270	G,J	-68	08- -79	1251	--	D	Screen 266-322, 322-425 ft.
	26X2	--	325945-0822443	Louisville, 4	--	308	220	--	238	G	-30	09-09-77	1000	20.0	P	Screen 220-300 ft. Transmissivity = 5,700 ft^2/d. Water-quality analysis, 05-03-78.
	26Y2	--	330015-0822730	J. P. Stevens, 2	--	375	214	--	285	G	-40	1962	1200	20.0	I	Screen 214-219, 242-247, 290-295, 318-328, 370-375 ft. Transmissivity = 5,800 ft^2/d.
	26Y5	--	330024-0822729	J. P. Stevens, 1	1962(?)	450	254	--	310	G	-55	1962	1200	--	I	Screen 254-275, 315-325, 367-372, 395-400, 445-450 ft.
	26Z9	--	331133-0822359	Wrens, Ga., 3 (old 4)	1978	185	135	--	411	G,J	-112.7 -122.0	11-13-78 11-15-82	105	--	P	Screen 135-145, 165-185 ft.
	26W1	--	325134-0822419	Wadley, 1 (Ruby St. well)	1951	473	370	8	227	G	F -13.6	1951 10-20-80	75F	21.3	P	Screen 370-380, 440-450, 460-465 ft. Transmissivity = 5,900 ft^2/d. Water-quality analyses, 10-19-63, 10-06-70, 08-20-81.
Jenkins	30X4	--	325434-0815734	Perkins	--	446	400	6	250	G	-54 -68	07-24-79 11-13-81	200	--	P	Screen 400-440 ft.
	30W5	--	324510-0815948	John Cleve Newton	--	460	200	12	195	G,J	-44.7	11-17-81	--	--	D	Screen 200-360, 360-460 ft.
	30W6	--	324536-0815956	Carl Mons	1938	385	220	4	205	G,J	-35	1938	--	--	D	
	30W2	--	325226-0815707	Magnolia State Park, 1	05- -39	357	--	6	218	G,J	-50 -57.2	05- -39 11-13-81	30	--	P	
	30W8	--	324822-0815608	Millen, 2 (Walnut St. well)	--	400	230	8	182	G,J	-32 -36.9	07-06-77 11-11-81	--	--	P	Screen 230-352, 352-400 ft.
	30W9	--	324923-0815700	Jockey International, 1	07- -74	401	155	10	169	G,J	-13.5	02-04-80	580	--	I	
Johnson	24V4	--	324351-0824314	Wrightsville, Ga., 3(?)	1970(?)	525	250	10	355	G,J	-130	04-15-70	400	--	P	Screen 50 ft. Intervals unknown.
Laurens	21U1	317	323215-0830431	Dudley, 1	1952	369	--	--	325	G	-85.4 -87.4	05-29-75 11-10-78	--	--	P	Screen 339-369 ft.
	21U2	--	323030-0830246	Ga. D.O.T. 87 Rest stop well	09- -68	509	229	--	282	D,G,J	-48 -52.7	09-03-68 01-28-82	160	--	P	Screen 229-234, 335-346, 495-500 ft.
	21U5	--	323030-0830240	USGS TW-1	11-05-80	800	800	6,4	282	D	-33.9	01-28-82	--	--	O	Broken drill stem in well.
	20U1	--	323342-0830915	Montrose, Ga., 2	--	353	116	8	391	G,J	-75 -121.4	10- -46 11-06-81	40	--	P	Water-quality analysis, 02-18-66.
	22T3	--	322647-0825955	Albert S. Mercer	--	420	300	10	220	G	-44.7	11-06-81	700	--	A	Open hole 300-420 ft.
Pulaski	18S5	339	321702-0832749	Opelika Mfg. Co.	--	319	150	--	227	G,J	+2.1 -25.3	07-17-53 11-03-81	500	--	I	Screen 150-170, 285-315 ft.
	18R6	--	320941-0832529	N. J. Bozman	1910	367	350	--	215	G	+17 +3.8	1910 07-20-50	17.5	--	D	
	18R7	--	320827-0832409	Elmer Trist	--	397	--	--	220	G	+6	08-23-51	--	--	D	
	18S13	--	321605-0832438	Old Pulaski Co. High School	--	385	150	--	252	G,J	-11 -44.5	1934 06-29-50	75-100	--	P	Screen 150-302, 302-385 ft.
	18S12	--	321652-0832757	Opelika Mfg. Co., 2	--	390	306	--	245	G	-12.6	07-29-71	638	29.0	I	Screen 306-367 ft. Transmissivity = 9,800 ft^2/d.
	18S15	--	321652-0832624	Hartford, 2	1973(?)	420	374	8	230	G	-3	1973	349	5.6	P	Screen 374-414 ft. Transmissivity = 2,100 ft^2/d.
Richmond	27AA3	--	331647-0821747	Fort Gordon test well 3	--	41.5	--	--	265	G	-2.6	02-26-57	--	--	O	
	28AA1	--	331730-0821209	Blythe, 1	1966(?)	140	120	--	450	G	-108.87	10-21-80	174	--	P	Screen 120-140 ft. Water-quality analysis, 06-17-68.

Appendix A.--Record of selected wells--Continued

[Aquifer: G, Gordon aquifer system, J, Jacksonian aquifer; D, Dublin aquifer system. Use: A, agricultural; D, domestic; I, industrial; P, public supply; O, observation. Water level: reported levels are given in feet, measured levels are given in feet and tenths; Yield: F, flowing. Depth of well: >, greater than]

County	Well numbers	Georgia Geologic Survey number	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 (ft)	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
Screven	32X19	--	325422-0813746	Millhaven Co.	--	361	124	4	109	G,J	+5.6 +5.8	07-16-63 11-09-81	--	--	I	Screen 124-209, 209-361 ft.
	33W25	--	325009-0813245	Louis Pfeiffer	--	400	--	4	74	G	+9.8 +4.1	08-13-63 11-10-81	--	--	D	
	33V1	--	324442-0813108	Mrs. Cassie Bazemore	--	480	--	6,3	107	G	-12.8 -19.2	04-09-43 11-03-81	--	--	D	
	32X23	--	325723-0813758	Millhaven Co.	--	375	--	4	180	G	-54.2	11-09-81	--	--	I	
	33X5	--	325236-0813600	Ralph Dixon	1942	300	--	4	102	G	F +8.5	07-12-63 11-10-81	--	--	D	
	33X18	638	325724-0813218	W. S. Morris, III (old Wade Plantation)	1959	326	201	8	110	G,J	F +20.7	06-06-63 11-10-81	--	--	D	
	34W4	--	324839-0812904	Ga. Dept. of Transportation	--	434	220	4	70	G,J	+2.6 +1.1	08-15-63 11-09-81	--	--	--	Screen 220-374, 374-434 ft. Water-quality analysis, 03-16-70.
	33W19	--	325232-0813612	Ralph Dixon	11- -62	368	220	4	98	G,J	+6.6 +7.4	08-14-63 11-10-81	--	--	D	
	33W23	--	325041-0813405	S. A. Jenkins	--	411	200	4	84	G,J	+12.7 +6.2	08-13-63 11-09-81	--	--	D	Screen 200-254, 254-411 ft.
	32W13	--	324500-0813822	Sylvania, 1	06-08-39	490	--	10,8	225	G	-109.9 -127.2	06-08-39 11-04-81	--	--	P	Water-quality analysis, 05-21-45.
	32X14	295	324510-0813838	Sylvania, 3	--	490	125	12	199	G,J	-99.5	11-04-81	--	--	P	Screen 125-151, 151-490 ft.
	33X27	--	325504-0813005	R. H. Taylor	--	400	200	4	73	G,J	+12.4 +11	08-13-63 11-10-81	--	--	D	
	32X15	1047	325555-0814008	Millhaven Co.	--	310	260	6	169	G,J	-45	09- -58	70	--	I	
	33X37	--	325726-0813722	Millhaven Plantation Buena Vista well	--	565	370	10	188	G	-68	05-02-79	1000	9.6	D	Screen 370-460, 477-502, 550-565 ft. Transmissivity = 3,500 ft^2/d.
	32U18	--	323612-0814425	King Finishing Co., 2	--	670	253	--	149	G,J	-34	08- -65	1815	50.4	I	Open hole 253-670. Transmissivity = 13,000 ft^2/d. Water-quality analysis, 08-19-81.
	33W24	--	325137-0813409	A. S. Mills Co.	1963(?)	535	--	4	95	G	+9.2	08-13-63	--	--	I	
	33X20	--	325619-0813149	Wade Plantation	1963(?)	369	205	9	91	G	+4.3	08-13-63	--	--	A	
Washington	25X13	--	335845-0823635	Davisboro, 1	1966(?)	400	200	--	302	G,J	-50.6 -52.2	04-20-66 10-23-80	175	--	P	Well no longer used.
	23X26	--	325858-0824814	Sandersville, 7	--	467	140	--	455	G,J	-222 -220.1	10-23-80 11-16-82	165	--	P	Screen 140-150, 282-287, 307-317 ft.
	23X34	--	325624-0824502	Holmes Canning Co., 2	--	335	182	--	385	G,J	-140 -141.9	08-06-73 11-04-81	183	19.8	I	Screen 182-187, 250-255, 325-330 ft. Transmissivity = 2,400 ft^2/d.
	24X2	--	325428-0823954	Riddleville	--	408	--	--	411	G	-84 -146.1	12-01-66 11-06-81	316	--	P	
	23Z9	--	330942-0824717	Herman Snider	--	131	--	--	350	G	-20.5	10-22-80	--	--	D	
Wilkinson	19W19	--	324954-0831743	Yara Engineering, G-13	--	40	--	4	440	G	-17.8	05-27-79	--	--	O	
	20W46	--	324823-0831316	Hollingsworth	--	23	--	24	390	G	-3.6	05-14-79	--	--	D	

Appendix B.—Chemical analyses of water from the Gordon aquifer system

[Aquifer: G, Gordon aquifer system; J, Jacksonian aquifer. <, less than]

Well number	Owner or name	Aquifer(s)	Date sampled	Milligrams 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 (Fl)	Nitrate (NO_3)	Nitrite (NO_2)
Georgia Environmental Protection Division standards for safe drinking water, 1977													[3] 3		
28W3	Midville, Ga., 1	G	08-20-81	43	47	2.7	3.5	2.3	140	115	8.9	2.1	0.1	1.9	—
28AA2	S.T. Corley	G	08-08-46	—	—	—	—	—	20	16	2.0	2.0	.0	4.3	—
28Z1	C.F. Morris	G	08-08-46	—	—	—	—	—	8	7	3.0	2.0	.1	.00	—
29Z1	J. Thompson	G	08-08-46	—	—	—	—	—	176	144	9.0	3.0	.0	.00	—
31Z21	Vogtle Observation well 135	G	[4]10-14-71	9.2	28.8	8.3	16.3	2.8	115	106	17.4	4.0	.0	1.4	—
27U1	Swainsboro, Ga., 5	G,J	04-11-67	26	46	4.0	3.8	2.4	152	125	4.0	3.0	.2	.10	—
			09-28-71	—	—	—	—	—	—	—	4.0	—	.2	—	—
25Z3	Gibson, Ga., 3	G	09-04-81	9.6	.6	1.2	2.8	.2	1	1	—	—	—	—	—
25Z5	Gibson, Ga., 2	G	[5]02-27-79	—	—	—	—	—	7	—	—	—	—	—	—
26X1	Louisville, Ga., 1	G	03-11-63	37	18	1.2	1.3	.5	52	43	8.8	2.8	.2	.00	—
			[6]12-01-75	—	—	—	—	—	—	54	—	—	—	—	—
26Y4	J. P. Stevens, 4	G,J	08-20-81	41	16	1.2	1.6	.57	—	46	—	—	—	—	—
26W1	Wadley, Ga., 1	G	10-19-63	—	60	10	20	—	—	64	22	4.0	—	—	—
			08-20-81	46	33	2.0	2.3	1.8	105	86	—	—	—	—	—
29W1	J. M. Johnson, 1	G,J	04-11-67	39	40	2.1	2.5	2.1	128	105	11	2.0	.1	.00	—
30W1	Millen, Ga.	G,J	11-17-59	39	44	2.7	3.6	2.8	146	120	9.6	3.5	.2	.20	—
20U1	Montrose, Ga., 2	G,J	02-18-66	20	47	2.1	1.8	.8	144	118	11	3.0	.1	.00	—
28AA1	Blythe, Ga., 1	G	06-17-68	11	1.0	.6	3.6	.2	1	1	.0	3.0	.1	5.4	—
32W13	Sylvania, Ga., 1	G	05-21-45	—	—	—	—	—	158	130	8.0	3.0	.2	—	—
34W4	Ga. D.O.T. Roadside Park	G	03-16-70	34	30	7.7	13	3.4	148	121	9.6	3.0	.2	.00	.01
32X34	Hilltonia, Ga.	G,J	05-04-64	34	46	5.1	4.9	2.5	152	125	8.0	5.0	.3	.00	—
32U18	King Finishing Co., 2	G,J	08-19-81	16	13	2.5	27	4.5	107	—	—	—	—	—	—
18V14	J. M. Gettys	G,J	12-20-44	—	—	—	—	—	230	189	—	3.0	.2	.10	—

Well number	Date sampled	Dissolved solids: Residue, at 180°C	Dissolved solids: Sum of constituents	Hardness[1]: Calcium, magnesium	Hardness[1]: Noncarbonate	Specific conductance, in micromhos at 25°C	Field pH	Temperature, in degrees Celsius	Color, in platinum-cobalt units	Carbon dioxide,[2] mg/L as CO_2
Standards, 1977		500								
28W3	08-20-81	183	181	130	15	248	7.7	20.6	—	4.3
28AA2	08-08-46	—	—	21	5	—	—	18.5	—	—
28Z1	08-08-46	—	—	9	2	—	—	19.5	—	—
29Z1	08-08-46	—	—	140	0	—	—	18.5	—	—
31Z21	[4]10-14-71	—	106	106	—	180	8.2	—	—	0
27U1	04-11-67	172	165	132	8	272	7.8	23	0	3.9
	09-28-71	—	—	96	—	260	7.9	22	—	—
25Z3	09-04-81	47	—	6	5	60	4.6	19.3	—	40
25Z5	[5]02-27-79	—	—	5	—	—	—	—	—	56
26X1	03-11-63	118	96	50	8	112	6.7	20.0	3	17
	[6]12-01-75	—	—	40	—	—	—	—	—	9.0
26Y4	08-20-81	98	—	45	—	110	6.3	20.4	—	39
26W1	10-19-63	—	—	190	6	—	—	—	—	—
	08-20-81	148	—	91	5	[2]174	[2]6.9	21.0	—	18
29W1	04-11-67	165	162	110	4	245	7.9	20.0	0	2.6
30W1	11-17-59	191	178	121	2	254	8.0	21.5	2	2.3
20U1	02-18-66	—	157	126	8	238	7.8	—	5	3.7
28AA1	06-17-68	32	29	5	4	31	5.8	—	0	2.5
32W13	05-21-45	—	—	123	0	—	—	—	—	—
34W4	03-16-70	193	174	107	0	252	7.8	19.5	5	3.8
32X34	05-04-64	182	181	136	12	250	7.8	20.0	0	—
32U18	08-19-81	127	—	42	—	182	8.1	26.4	—	1.3
18V14	12-20-44	—	—	174	0	—	—	18.5	—	—

Well number	Date sampled	Micrograms per liter: Aluminum (Al)	Arsenic (As)	Cadmium (Cd)	Chromium (Cr)	Copper (Cu)	Iron (Fe)	Lead (Pb)	Manganese (Mn)	Mercury (Hg)	Selenium (Se)	Strontium (Sr)	Zinc (Zn)
Standards, 1977			50	10	50	1,000	300	50	50	2.0	10		5,000
28W3	08-20-81	<10	—	3	—	<10	39	<10	18	<0.1	<1	240	<4
28AA2	08-08-46	—	—	—	—	—	—	—	—	—	—	—	—
28Z1	08-08-46	—	—	—	—	—	—	—	—	—	—	—	—
29Z1	08-08-46	—	—	—	—	—	—	—	—	—	—	—	—
31Z21	[4]10-14-71	—	—	—	—	—	120	—	—	—	—	—	—
27U1	04-11-67	0	—	—	—	0	160	10	0	—	—	350	0
	09-28-71	50	0	0	0	0	30	0	0	—	—	—	—
25Z3	09-04-81	100	—	3	<10	10	130	10	19	—	<1	—	26
25Z5	[5]02-27-79	—	—	—	—	—	180	—	—	—	—	—	—
26X1	03-11-63	—	—	—	—	—	—	—	—	—	—	—	—
	[6]12-01-75	—	—	—	—	—	600	—	—	—	—	—	—
26Y4	08-20-81	400	—	<1	—	<10	1,200	<10	37	<.1	<1	61	7
26W1	10-19-63	—	—	—	—	—	—	—	—	—	—	—	—
	08-20-81	200	—	<1	—	<10	1,900	<10	130	<.1	<1	150	<4
29W1	04-11-67	—	—	—	—	—	—	—	—	—	—	150	—
30W1	11-17-59	—	—	—	—	—	—	—	—	—	—	—	—
20U1	02-18-66	—	—	—	—	—	—	—	—	—	—	—	—
28AA1	06-17-68	—	—	—	—	—	—	—	—	—	—	0	—
32W13	05-21-45	—	—	—	—	—	—	—	—	—	—	—	—
34W4	03-16-70	[5]300	[5]10	—	—	0	90	20	0	—	—	240	300
32X34	05-04-64	—	—	—	—	—	—	—	—	—	—	—	—
32U18	08-19-81	<10	—	2	—	<10	30	<10	16	<.1	<1	270	<4
18V14	12-20-44	—	—	—	—	—	—	—	—	—	—	—	—

1 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."
2 Carbon dioxide concentration calculated from measured values of pH and bicarbonate ion.
3 State standards for fluoride are set according to temperature.
4 Analysis by Bechtel Corporation, San Francisco, California.
5 Total recoverable solids.
6 Analysis by Georgia Environmental Protection Division.

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