Geology and Hydrogeology of Cretaceous and Tertiary Strata, and Confinement in the Vicinity of the U.S. Department of Energy Savannah River Site, South Carolina and Georgia

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Sea level: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929--a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

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Abstract

Nine geologic units are defined in the Cretaceous and Tertiary section of east-central Georgia. Cretaceous geologic units include the Cape Fear Formation, the Middendorf Formation, the Black Creek Group, and the Steel Creek Formation. The Tertiary geologic units include the Ellenton Formation, the Snapp Formation, the Fourmile Branch/Congaree/Warley Hill unit, the Tinker/Santee unit, and the Barnwell unit. The Middendorf Formation and the Black Creek Group are divided into subunits. The geologic units provide a spatial framework for identification and correlation of the Upper Three Runs aquifer, the Gordon confining unit, the Gordon aquifer, five aquifers and five confining units in the Dublin and Midville aquifer systems, and a basal confining unit.

The clastic and mixed-clastic-carbonate sections of the Upper Three Runs and Gordon aquifers and the Gordon confining unit consist of sediments of Eocene and younger age in the updip and central part of the study area, and are correlated to the downdip carbonate section of the Floridan aquifer system. Fine-grained lithofacies within the Tinker/Santee unit are correlated as the Gordon confining unit from the updip clastic sections of the Tinker Formation to the downdip carbonate sections of the Santee Limestone to define the base of the Upper Three aquifer and the top of the Gordon aquifer.

To provide greater hydrogeologic resolution in the Savannah River Site area, the Dublin and Midville aquifer systems are revised for the investigation of trans-river flow. Aquifers are texturally differentiated in the Dublin aquifer system on the basis of grain size, sorting, the amount and distribution of clay matrix, and the amount of porosity. Aquifers in the Midville aquifer system are texturally similar and are correlated on the basis of their stratigraphic position relative to the Middendorf Formation.

The Millers Pond, lower Dublin, and lower Midville confining units are correlated to fine-grained, nonmarine lithofacies at the top of the Snapp Formation, the bottom of the Steel Creek Formation, and the top of the Middendorf Formation, respectively. These three hydrogeologic units are considered to be leaky confining units, locally impeding vertical flow between adjoining aquifers.

The fine-grained sediments of the Gordon confining unit were deposited in shallow near-shore and offshore marine environments. The fine-grained sediments of the upper Dublin and upper Midville confining units were deposited in

marine-influenced deltaic environments. The Gordon and upper Dublin confining units are regionally extensive in the study area. The upper Midville confining unit is an effective confining unit in middle and downdip sections, but leaky in the updip sections. Delineation of a regionally extensive confining unit separating the Millers Pond and upper Dublin aquifers necessitated revision of the previously defined Dublin aquifer system.

INTRODUCTION

In 1991, the U.S. Geological Survey (USGS), in cooperation with the U.S. Department of Energy (USDOE), initiated an investigation of ground-water flow in the Savannah River area of east-central Georgia and west-central South Carolina. The objectives of the study were to characterize and simulate ground-water flow in an 8-county study area adjoining the Savannah River, and to determine the potential for ground-water flow from one state to the other beneath the Savannah River valley, herein termed trans-river flow.

The study area predominantly encompasses five Georgia counties and three South Carolina counties in the Coastal Plain physiographic province of the southeastern United States, including the USDOE Savannah River Site (SRS). The SRS is a 310-mi^2 (square mile) facility in South Carolina adjacent to the Savannah River where nuclear materials are processed and stored (fig. 1). Organic solvents and radioactive isotopes, primarily tritium, exceed drinking water standards in the unconfined and shallow confined aquifers that underlie parts of the SRS, largely the result of waste disposal, processing of nuclear materials, and associated industrial activities (Westinghouse Savannah River Company, 1990).

The Savannah River forms most of the state-line boundary between South Carolina and Georgia. Potentiometric maps in the SRS area (Bechtel, 1982; Brooks and others, 1985; Clarke and others, 1985; Logan and Euler, 1989; Bledsoe and others, 1990; Faye and Mayer, 1990; Westinghouse Savannah River Company, 1990) suggest that the direction of ground-water flow within the deep confined aquifers that underlie the SRS roughly is perpendicular to the axis of the Savannah River and towards the Savannah River. The limited amount of geologic and hydrologic data available for the deeper confined aquifers that underlie the Savannah River create considerable uncertainty regarding the position of potentiometric contours and the direction of ground-water flow in the immediate vicinity of the Savannah River. Given the presence of contaminated ground water at SRS facilities, the study specifically evaluates the potential for ground water to move from SRS facilities to wells on the Georgia side of the Savannah River.

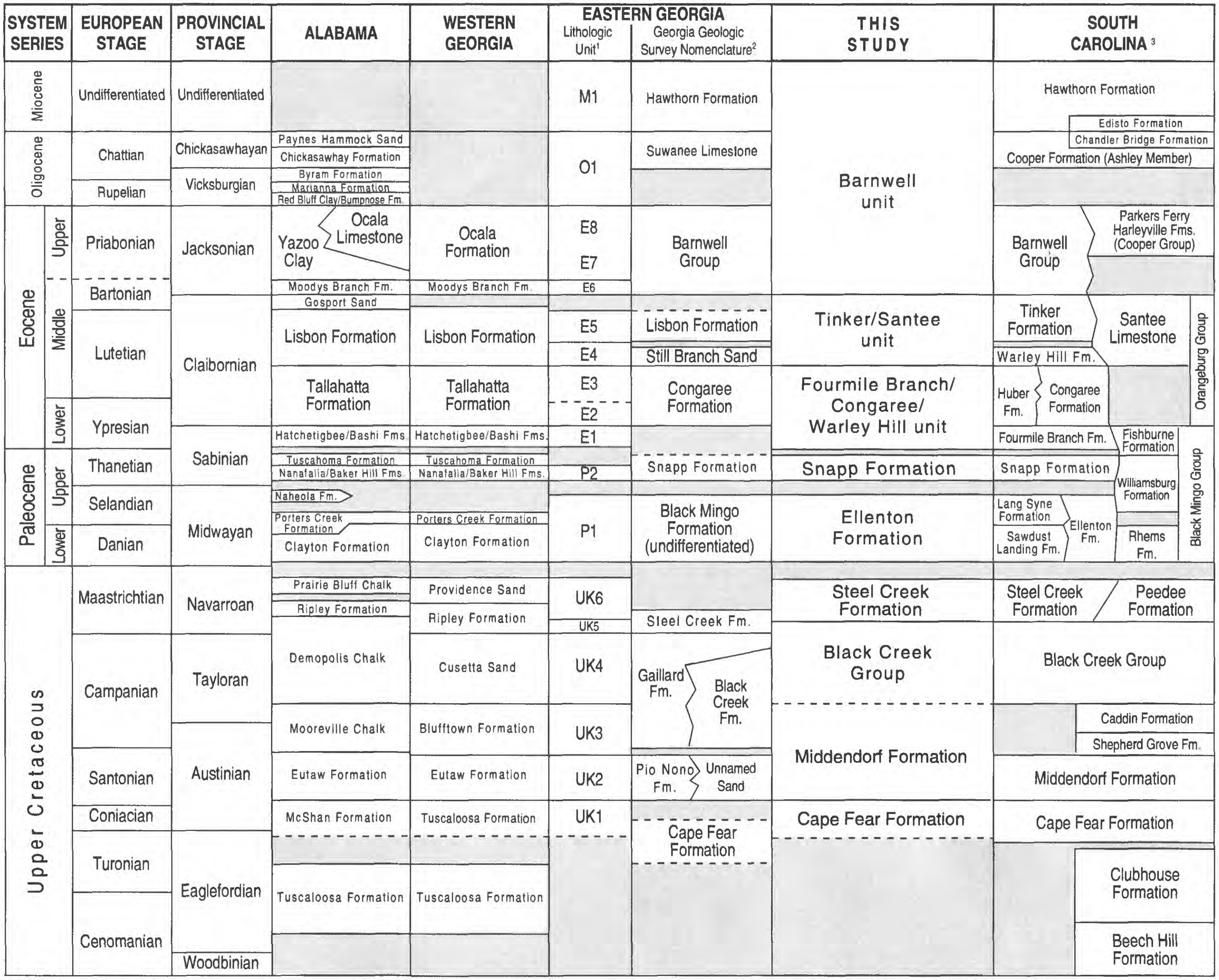
Prior to this investigation, most of the geologic and hydrologic data have been collected in the South Carolina part of the study area, and mostly near the SRS. There is considerably less geologic and hydrologic information in Burke and Screven Counties in Georgia to evaluate ground-water flow within the deep-confined aquifers in the Cretaceous strata. While an investigation of faulting near the Savannah River by the Bechtel Corporation (1982) supplied considerable information about the aquifers in the Tertiary section and the upper part of the Upper Cretaceous section, it did not supply any geologic or hydrologic data for the lower part of the Upper Cretaceous section in eastern Burke County. Hydrologic data for the deep aquifers of the Upper Cretaceous strata in Burke, Screven, and Jenkins Counties were limited to a few deep industrial and municipal wells.

The initial phase of this study included the collection of additional subsurface data on the Georgia side of the Savannah River near the SRS. Continuously cored testholes, located in Georgia along a line parallel to the Savannah River valley, provide information about the stratigraphy and hydrogeology in Burke and Screven Counties, Georgia (fig. 1). Four Cretaceous geologic units and five Tertiary geologic units are identified (fig. 2) and are differentiated into seven aquifers and seven confining units (fig. 3).

Purpose and Scope

The purpose of this report is to present the results of an investigation of the geology of Burke and Screven Counties, Georgia, and the hydrogeology of the east-central Georgia and west-central South Carolina Coastal Plain near the SRS. This report describes major geologic and hydrogeologic units as a spatial framework for the simulation of the movement of water from areas of recharge to areas of discharge.

Figure 1. Location of study area, selected monitoring-well sites, and studied testholes along sections from Millers Pond to Millhaven in Georgia and from Girard in Georgia to P-21/P5R in South Carolina.



[1] Prowell and others, 1985a
[2] Huddlestun and Hetrick, 1991; Summerour and others, 1994; Huddlestun and Summerour, 1996
[3] Colquhoun and others, 1983; Gohn, 1992; Fallaw and Price, 1995

Areas of shaded pattern indicate missing stratigraphic sections.
Dashed lines indicate formation boundary of uncertain stratigraphic position.
Abbreviations used: Fm, formation.

Figure 2. Generalized comparison of Cretaceous and Tertiary geologic units in the southeastern United States (modified from Clarke and others, 1994).

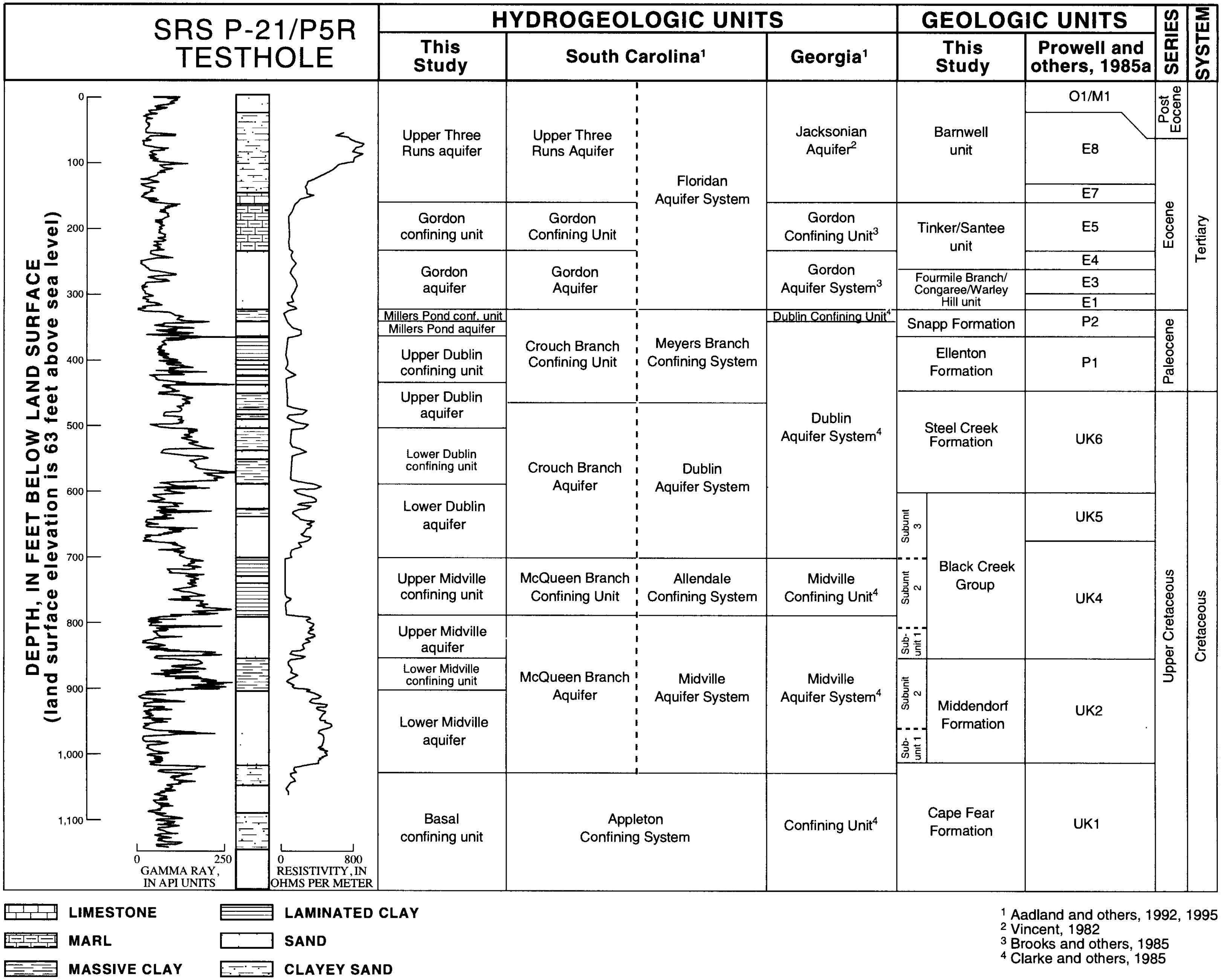


Figure 3. Comparison of hydrogeologic units and names applied to the P-21/P5R testhole on the U.S. Department of Energy Savannah River Site, South Carolina.

This study was conducted during 1991-97 and included the continuous coring of testholes at the Millers Pond and Girard sites in Burke County, and the Millhaven site in Screven County, Georgia. Samples of clay were collected from the cores for laboratory analysis of vertical hydraulic conductivity of confining units. Sediment samples were also collected for paleontologic analysis. Cores and geophysical logs for other testholes in Georgia and South Carolina were examined. Water-level data were collected for selected wells in Georgia and South Carolina, and test data were analyzed to determine hydraulic characteristics of aquifers. The top and thickness of each hydrogeologic unit were mapped across the 5 Georgia counties and 3 South Carolina counties in the study area.

Study Area

The study area is located in the Coastal Plain physiographic province of west-central South Carolina and east-central Georgia. The study area includes Burke, Jefferson, Jenkins, Richmond, and Screven Counties in Georgia, and Aiken, Allendale, and Barnwell Counties in South Carolina (fig. 1). The study area also includes Coastal Plain areas of Columbia, Warren, McDuffie, and Glascock Counties in Georgia, and Edgefield and Saluda Counties in South Carolina.

Poorly consolidated Cretaceous and Tertiary strata in the study area form a southeastward-thickening wedge of fluvio-deltaic and marine deposits (Colquhoun and others, 1983; Prowell and others, 1985; Logan and Euler, 1989; Huddlestun and Hetrick, 1991; Fallaw and Price, 1995; Gellici and others, 1995; Huddlestun and Summerour, 1996) underlain by Paleozoic crystalline rocks and Triassic-Jurassic sedimentary rocks (Marine, 1979; Wait and Davis, 1986; Snipes and others, 1993; Prowell, 1994). The Coastal Plain sediments are about 2,700 ft (feet) thick at the downdip end of the study area in Screven County (Wait and Davis, 1986).

Previous Studies

Previous reports on the geology of east-central Georgia include Veatch and Stephenson (1911), Brantley (1916), Cooke and Shearer (1918), Cooke (1943), LaMoreaux (1946a, 1946b), LeGrand and Furcon (1956), Herrick (1960, 1961, 1964, 1972), Herrick and Vorhis (1963), Herrick and Counts (1968), Bechtel Corporation (1972, 1973), Carver (1972), Buie (1978), Huddlestun and Hetrick (1978, 1979, 1986, 1991), Prowell and O'Connor (1978), Schroder (1982), McClelland (1987), Huddlestun (1988, 1992), Hetrick (1992), Clarke and others (1994, 1996), Huddlestun and Summerour (1996), Leeth and Nagle (1996), Leeth and others (1996), and Falls and others (1997). Geologic reports on Burke and Screven Counties and adjacent parts of South Carolina include Snipes (1965), Hurst and others (1966), Scrudato and Bond (1972), Daniels (1974), Marine and Siple (1974), Bechtel Corporation (1982), Faye and Prowell (1982), Huddlestun (1982), Prowell and others (1985), Faye and McFadden, (1986), Colquhoun (1991, 1992), Edwards (1992), Fallaw and Price (1992, 1995), Harris and Zullo (1992), and Prowell (1994). Geologic reports on the South Carolina part of the study area include Sloan (1908), Cooke (1936), Cooke and MacNeil (1952), Christl (1964), Siple (1967), Marine (1979), Smith (1979), Nystrom and Willoughby (1982, 1992), Zullo and others (1982), Colquhoun and others (1983), Bledsoe (1984, 1987, 1988), Colquhoun and Steele (1985), Prowell, Edwards, and Frederiksen (1985), Steele (1985), Nystrom and others (1986, 1991), Dennehy and others (1989), Logan and Euler (1989), Robertson (1990), Colquhoun and Muthig (1991), Price and others (1991, 1992), Fallaw and others (1992a, 1992b), Snipes and others (1993), Gellici and others (1995), and Stieve and Stephenson (1995).

Previous hydrologic reports of the study area include Siple (1967), Bechtel Corporation (1982), Cahill (1982), Faye and Prowell (1982), Vincent (1982), Brooks and others (1985), Clarke and others (1985), Miller (1986), Dennehy and others (1989), Logan and Euler (1989), Bledsoe and others (1990), Faye and Mayer (1990), and Aadland and others (1992, 1995). Site-specific hydrologic and hydrogeologic reports of monitoring-well sites include Bledsoe (1984, 1987, 1988) and Bledsoe and others (1990) on the SRS in South Carolina; Gellici and others (1995) in South Carolina counties adjacent to the SRS; and Clarke and others (1994, 1996), Summerour and others (1994), Snipes and others (1995, 1996), Leeth and others (1996), and Kidd (1996) in Burke and Screven Counties, Ga. A report by Harrelson and others (1997) includes well-location, well-construction, and water-level information, and aquifer assignments for an extensive inventory of the wells in the study area.

Acknowledgments

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METHODS

A two-fold approach was utilized to correlate hydrogeologic units in the study area. The first step involved detailed study and description of continuously cored Coastal Plain sediments recovered from testholes at Millers Pond, Girard, and Millhaven; these data were used to identify the principal aquifers and confining units and to establish their stratigraphic relations in east-central Georgia. The second step was to map the distribution and thickness of each of the confining units and the aquifers throughout the study area. Hydrogeologic unit maps were used to assign water-level and aquifer-test data to a specific aquifer or aquifers.

Correlation of Hydrogeologic Units in East-Central Georgia

Subsurface information for the stratigraphy and the hydrogeology in Burke and Screven Counties in Georgia primarily was obtained from three continuously cored testholes and correlated to an existing testhole at the P-21/P5R site in South Carolina (fig. 3). The P5R and P-21 testholes were drilled at the same Barnwell County site on the SRS as part of the bedrock waste storage exploration program in 1962 and as part of a baseline hydrogeologic investigation in the mid-1980's (Marine, 1979; Bledsoe, 1987). The P-21/P5R site serves as a common reference section for the comparison of the stratigraphy and the hydrogeology of this study with previous investigations (Vincent, 1982; Brooks and others, 1985; Clarke and others, 1985; Prowell and others, 1985; Aadland and others, 1992, 1995) (fig. 3).

The Millers Pond, Girard, and Millhaven testholes were continuously cored in 1991 and 1992 using a wireline-mud-rotary drilling system and were located along a dip-oriented section in eastern Burke and Screven Counties, Georgia (fig. 1). A fourth testhole was drilled and geophysically logged, but not cored, in 1994 at Brighams Landing in the Savannah River flood plain in Burke County; this well is used as part of a trans-river correlation of the stratigraphy and hydrogeology of Tertiary strata from the Girard testhole to the P-21/P5R reference well. The McBean and Thompson Oak testholes, cored in 1991 and 1993 by the Georgia Geologic Survey, were a source of additional lithologic and paleontologic information for the correlation of Coastal Plain strata of east-central Georgia (table 1 at end of report).

Borehole geophysical data that included single-point and triple-point electrical resistivity, spontaneous potential, natural gamma ray, and hole diameter (caliper log) were obtained from all Georgia testholes with the exception of the McBean testhole. Core samples were examined for texture, mineralogy, sedimentary structures, diagenetic features, and recognizable fossils. Selected samples were microscopically examined for dinoflagellates, pollen, foraminifers, ostracodes, and calcareous nannofossils to provide biostratigraphic control. Porosity in the aquifers was visually estimated during examination of the cores (Terry and Chilingar, 1955).

Regional Correlation of Units

Geophysical log data and descriptions of well cuttings and cores from 109 wells and testholes located in the 8-county study area were used to identify the top of hydrogeologic units (fig. 4; tables 2, 3 at end of report). Unit tops also were determined, but not mapped, in three wells in Hampton County and three wells in Bamberg County to further constrain the configuration of hydrogeologic units in the eastern parts of Barnwell and Allendale Counties. The total thickness of each unit was calculated by subtracting adjacent unit tops and mapped as an isopach of the unit (table 4 at end of report).

Geologic maps in the updip part of the study area (Nystrom and others, 1986; Hetrick, 1992; Prowell, 1994) were used to aid the correlation of hydrogeologic units. The altitude of Coastal Plain strata that crop out along alluvial valleys (Nystrom and others, 1986; Hetrick, 1992; Prowell, 1994); an investigation of alluvium thickness in the Savannah River valley (Leeth and Nagle, 1996); and information obtained from testholes AK-642 (SRS P4A), BW-893 (SRS PBF-6), 30Y030 (USGS Brighams Landing), and 33Y012 (USGS Stony Bluff Landing) in the alluvial valley were used to map incision by the Savannah River alluvial valley into the underlying hydrogeologic units.

The structural offset of the hydrogeologic units by two high-angle faults also is shown on the maps. The approximate position of the Pen Branch Fault on the Savannah River Site is largely based on work by Snipes and others (1993). The amount of structural offset is based on the altitude of various hydrogeologic units in wells and testholes immediately adjacent to the fault. The location of the Pen Branch fault in Burke County, Georgia, is inferred from the correlation of hydrogeologic units in several testholes drilled by the Georgia Department of Natural Resources (Huddlestun and Summerour, 1996). The approximate position of the Belair fault zone near the inner margin of the Coastal Plain in Richmond County, Georgia, is based on the work by Prowell and O'Connor (1978) and Hetrick (1992). Both are high-angle reverse faults that are down-thrown to the west.

Water Levels and Hydraulic Properties

Hydrologic data from monitoring wells installed at the Millers Pond, Thompson Oak, Girard, Brighams Landing, and Millhaven testhole sites in Georgia, and monitoring wells installed at six SRS testhole sites in South Carolina are used in the evaluation of the hydrogeologic units (fig. 1; tables 5, 6, 7 at end of report). Monitoring wells at these sites are closely spaced and assigned a P-well designation on the SRS. Each monitoring well is screened in either a separate aquifer, part of an aquifer, or laterally transmissive part of a confining unit. Water-level data under static conditions are used to identify vertical hydraulic gradients between aquifers in an evaluation of confining units. Water-level data at the Millers Pond site collected during several aquifer tests were used to test the degree of leakage across confining units.

Time-drawdown and time-recovery data were collected during aquifer tests at the Millers Pond, Thompson Oak, and Girard sites (Snipes and others, 1995, 1996; Kidd, 1996; Peter G. Luetkehans and Rex A. Hodges, written commun., Clemson University, April 1, 1996, and July 31, 1995). Transmissivity of selected screened intervals was determined by either the Theis nonequilibrium solution (Theis, 1935) or Jacob straight-line method (Cooper and Jacob, 1946). The hydraulic conductivity was calculated by dividing the reported transmissivity by the saturated thickness of the aquifer, as identified in this report.

Aquifer test data for other selected wells in South Carolina were analyzed using either the Theis nonequilibrium method (Theis, 1935) or modified nonequilibrium method (Lohman, 1979). Several of these wells are screened in more than one water-bearing unit.

The vertical hydraulic conductivity of selected core samples from the upper Dublin and upper Midville confining units in the Girard and Millhaven cores were determined using a flexible-wall permeameter (American Society for Testing and Materials, 1990). The vertical hydraulic conductivity was divided by the thickness of the confining unit to estimate leakance of these two confining units and are included in the descriptions of these units.

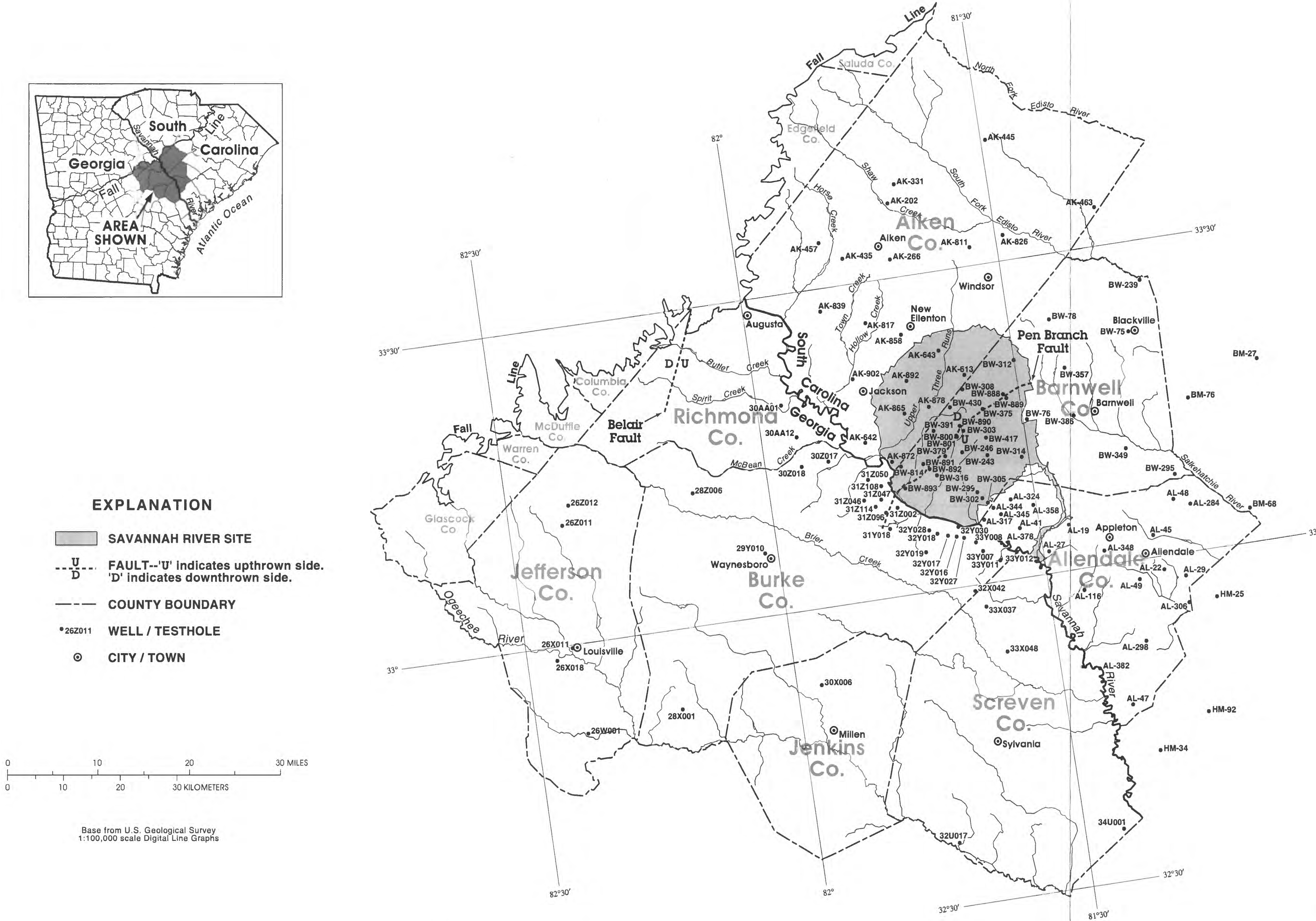


Figure 4. Location of testholes used in the regional correlation of the hydrogeologic units in the study area.

- page 11 follows -

GEOLOGY

Four Cretaceous and five Tertiary units are identified at Millers Pond, Girard, and Millhaven (figs. 5, 6, 7; table 1). Detailed descriptions of the sections at these three Georgia sites already are presented in reports by Clarke and others (1994, 1996) and Leeth and others (1996). A northwest to southeast cross section that parallels the Savannah River shows the correlation of the major stratigraphic units that underlie the Millers Pond, Girard, and Millhaven sites (figs. 1, 8).

Three previously reported stratigraphic frameworks that apply to this study area were used to devise an informal stratigraphy to aid in the correlation of hydrogeologic units in east-central Georgia and across the rest of the study area (fig. 2). Prowell and others (1985) correlated Cretaceous and Tertiary chronostratigraphic units from central Georgia to western South Carolina. Assigning an alpha-numeric designation to each unit because of a lack of existing nomenclature, they identified five Upper Cretaceous units, two Paleocene units, six Eocene units, and one Oligocene unit in the P-21/P5R testhole at the SRS (fig. 3). Fallaw and Price (1992, 1995) established a working nomenclature for the Coastal Plain units at the SRS and identified four Upper Cretaceous units, three Paleocene units, seven Eocene units, and one Miocene unit. Huddlestun and Hetrick (1991) and Huddlestun and Summerour (1996) proposed a separate stratigraphic nomenclature for the updip part of the study area in east-central Georgia.

The Tertiary stratigraphies of Prowell and others (1985), Fallaw and Price (1992, 1995), and Huddlestun and Summerour (1996) provide greater stratigraphic resolution than is necessary for the correlation of hydrogeologic units. Several of their Tertiary units are combined and assigned informal names. In contrast, the Cretaceous Middendorf Formation and Black Creek Group (Fallaw and Price, 1995) are revised to include subunits to aid in the correlation of hydrogeologic units in the Dublin and Midville aquifer systems (fig. 3).

The following sections on Cretaceous and Tertiary stratigraphy include generalized descriptions of the sedimentary and stratigraphic characteristics of each unit in the Millers Pond, Girard, and Millhaven cores in Georgia and discussions about the depositional environments and the correlative units in the study area.

Cretaceous Stratigraphy

The Cretaceous section of east-central Georgia and west-central South Carolina consists of siliciclastic sediments and is divided into the Cape Fear Formation, the Middendorf Formation, the Black Creek Group, and the Steel Creek Formation (fig. 2). Unconformable lag deposits are used to divide the Middendorf Formation into two informal subunits at the Millers Pond, Girard, and Millhaven testholes, and to divide the Black Creek Group into three subunits at the Girard and Millhaven testholes (table 1). Contacts between units and subunits are considered to be unconformable surfaces, possibly denoting hiatus in sedimentation, and are typically overlain by basal conglomeratic lags of very poorly sorted sand with granules, pebbles, and lithoclasts.

Biostratigraphic data (Christopher, 1978; Prowell and others, 1985) suggest that Cretaceous strata in east-central Georgia range in age from Coniacian to Maastrichtian. Prowell and others (1985) identified units UK1, UK2, UK4, UK5, and UK6 at P-21/P5R and did not correlate their unit UK3 to the study area (fig. 3). Each of these Cretaceous units was deposited as part of a large deltaic system that prograded across a paleo-continental shelf (Prowell and others, 1985; Fallaw and Price, 1995). Lithofacies observed in the Upper Cretaceous units of east-central Georgia accumulated in coarser grained proximal and finer grained distal deltaic settings.

Cape Fear Formation

The Cape Fear Formation consists of partially lithified to unlithified, poorly to very poorly sorted clayey sand and sandy clay. The sand is fine to very coarse with granules and pebbles, and is predominantly angular to subangular quartz with some feldspar. Cristobalite in the clay matrix contributes to harder and denser lithologies than in other Cretaceous units. The cristobalitic clay matrix imparts a yellowish-green to greenish-gray color and occludes most of the intergranular porosity in sand beds. Electrical logs display a characteristic low resistivity in both sand and clay of this unit. However, unlithified sand in the upper 10 to 20 ft of this unit in the Girard and P-21 cores has atypically high resistivity values on the electric logs.

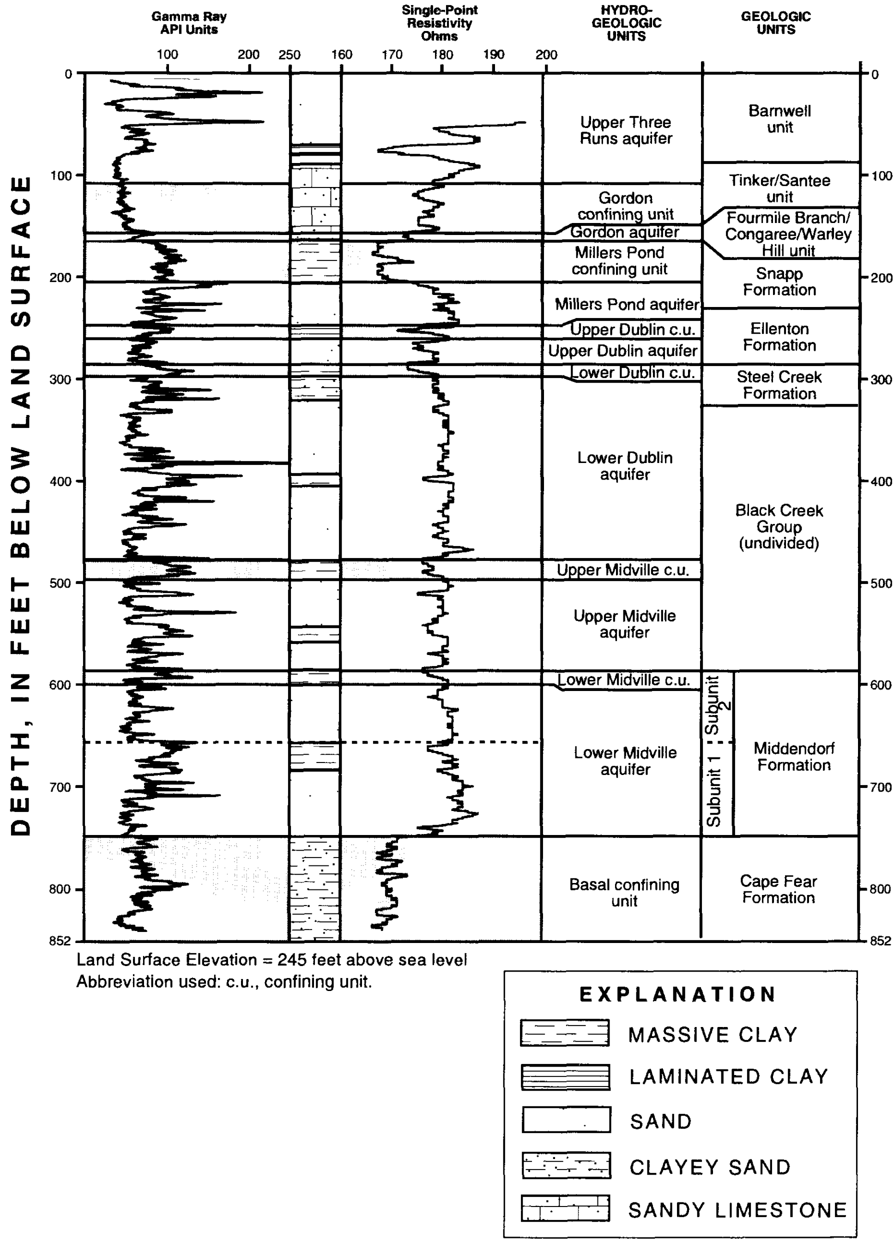


Figure 5. Geologic and hydrogeologic units of Millers Pond testhole in Burke County, Ga.

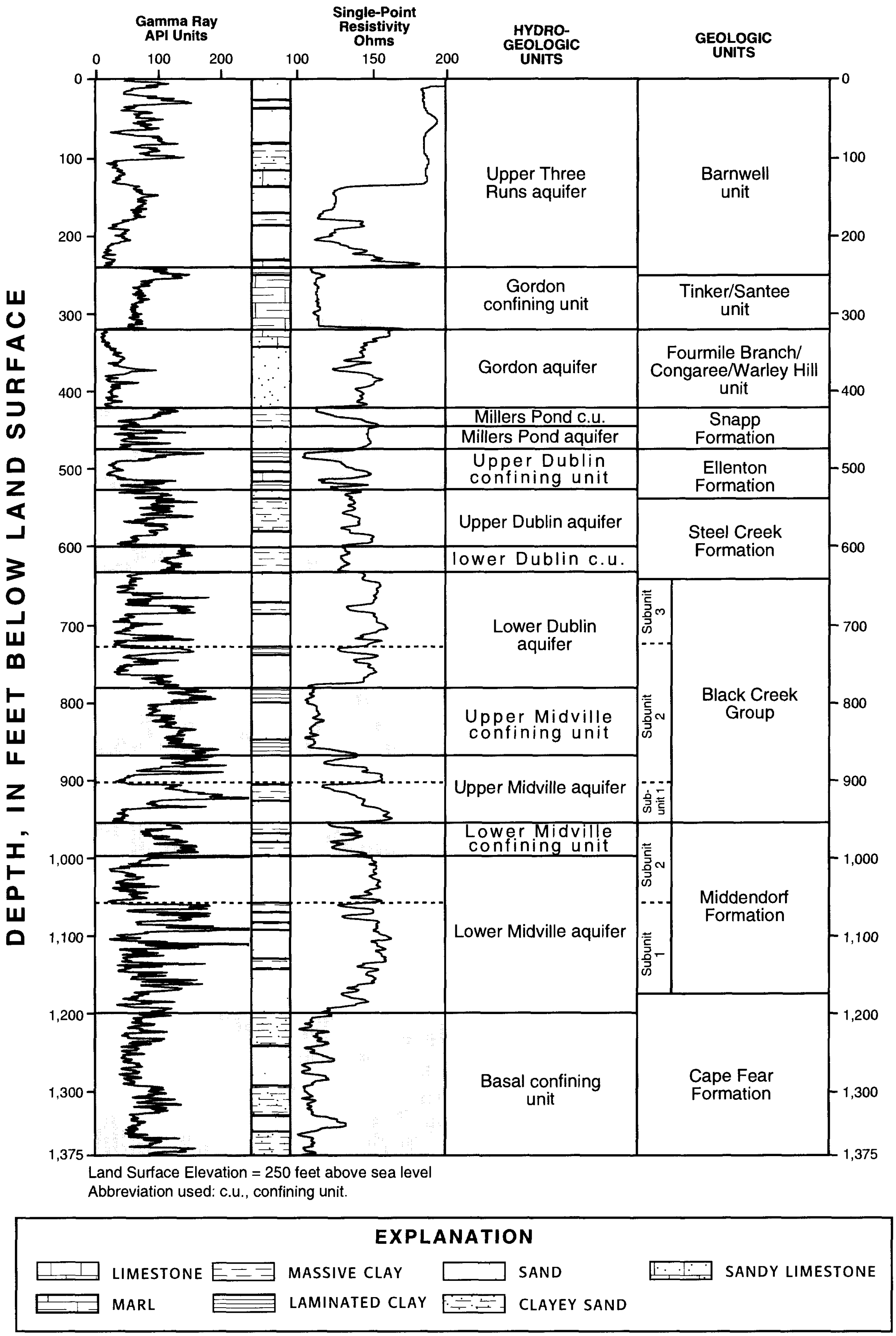
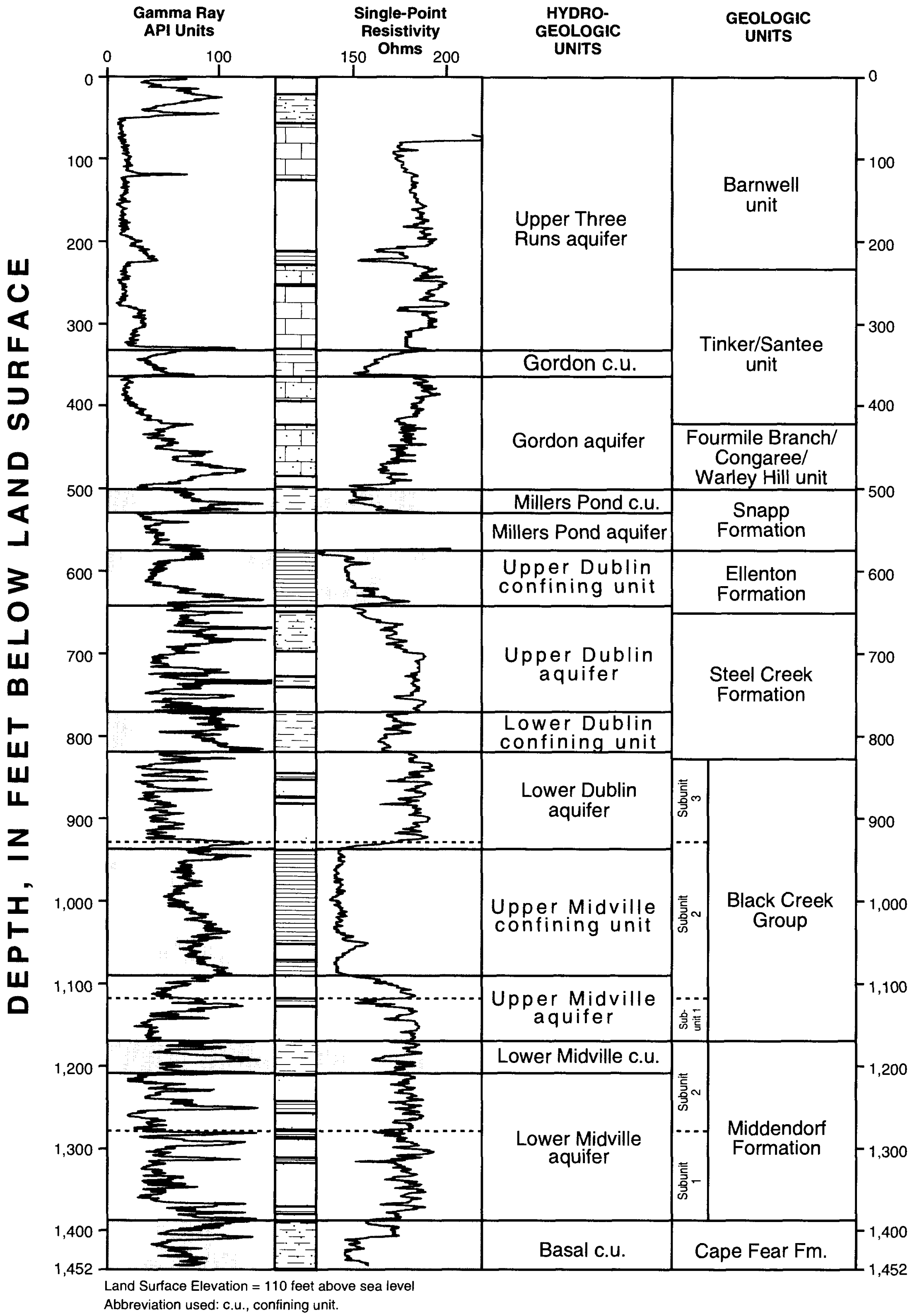


Figure 6. Geologic and hydrogeologic units of Girard testhole in Burke County, Ga.



EXPLANATION

LIMESTONE — MASSIVE CLAY — SAND — SANDY LIMESTONE

MARL — LAMINATED CLAY — CLAYEY SAND

Figure 7. Geologic and hydrogeologic units of the Millhaven testhole in Screven County, Ga.

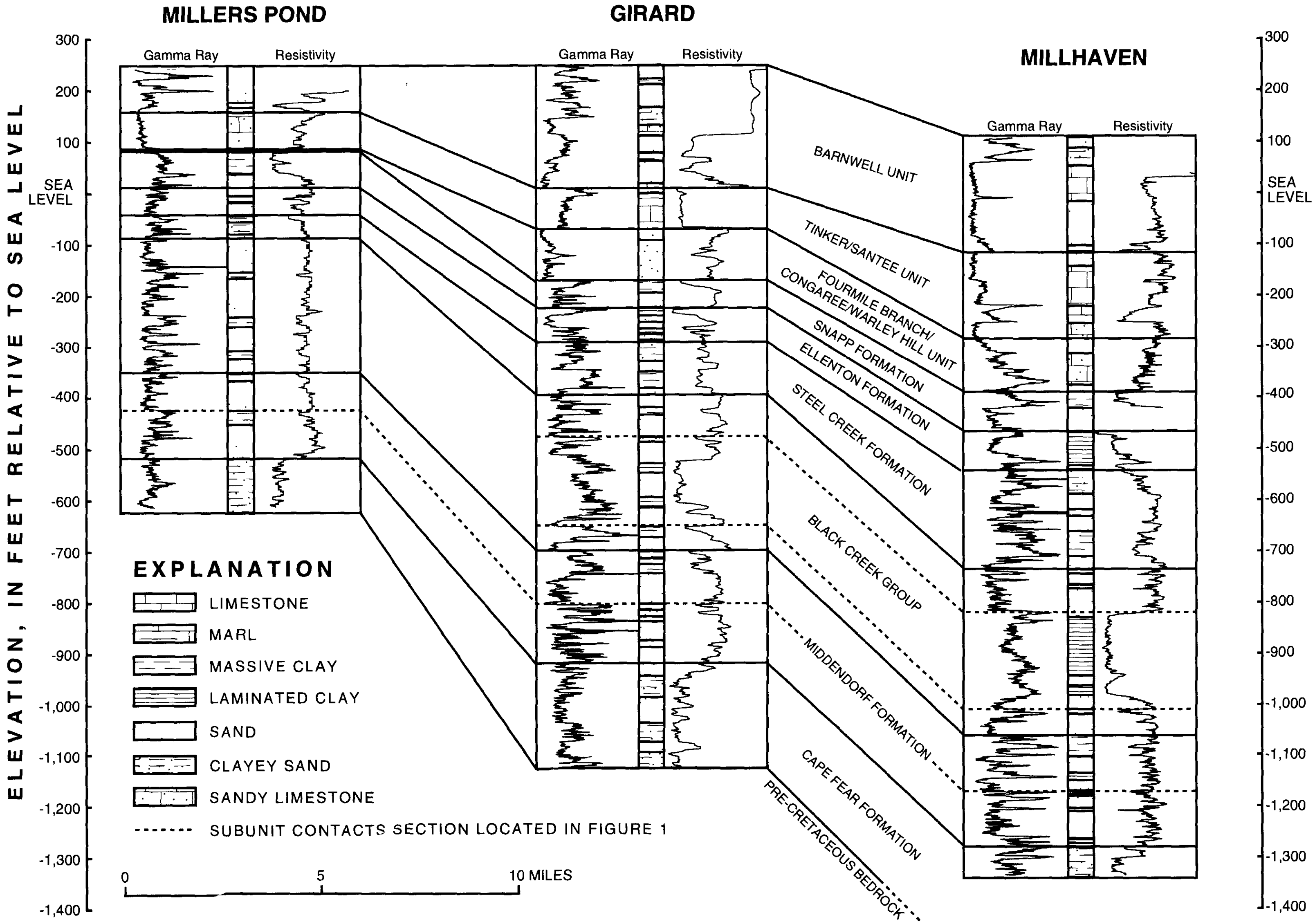


Figure 8. Dip-oriented correlation of geologic units from the Millers Pond testhole to the Millhaven testhole. Faults are not included on section. (Datum is sea level).

The Cape Fear Formation contains multiple fining-upward cycles that range from 3 to 15 ft in thickness. Each cycle grades from a basal coarse pebbly sand upward to clayey sand and clay. The oxidized clay is generally stained with reddish-brown and yellowish-brown patches of iron oxide. A root-trace pattern is present at the top of a few fining-upward cycles and at the top of the Cape Fear unit in the Millhaven core. Sediments directly beneath the upper contact of the Cape Fear in the other Georgia cores also are stained with iron oxides. Basal Cape Fear lag deposits contain clasts of saprolitic gneiss in the Millers Pond core and Triassic/Jurassic siltstone in the Girard core. The mineralogy, texture, and bedding characteristics of the Cape Fear Formation in east-central Georgia are considered typical of the Cape Fear Formation throughout the study area (Prowell and others, 1985; Fallaw and Price, 1995).

Most Cape Fear strata in this unit are barren of fossils, but gray and olive-gray, silty clay from the Millers Pond core yielded low-abundance and low-diversity pollen assemblages. Palynologic analysis of the Millers Pond core samples (Norman O. Frederiksen, U.S. Geological Survey, written commun., 1997) indicates a Coniacian microflora that is consistent with the microflora of the Cape Fear Formation of South Carolina and North Carolina (Christopher and others, 1979; Christopher, 1982; Sohl and Owens, 1991).

Prowell and others (1985) and Fallaw and Price (1995) suggest a Santonian age for the Cape Fear Formation. Huddlestun and Summerour (1996) suggest that the Cape Fear Formation is equivalent to the Cenomanian-Turonian Tuscaloosa Formation of western Georgia. The Cape Fear does not outcrop in the study area and has an approximate updip limit that lies between Town Creek and the northwestern boundary of the SRS in Aiken County (Snipes and others, 1993; Aadland and others, 1995) (fig. 4).

The presence of a terrestrial microflora and the absence of dinoflagellates and other marine fossils indicate the Cape Fear Formation was deposited in a nonmarine environment at Millers Pond, and is consistent with previous interpretations (Prowell and others, 1985; Fallaw and Price, 1995). The multiple fining-upward cycles, the coarse texture of the sands, the iron-oxide staining, and root-trace patterns in the clays suggest that most of this unit was deposited in channel and overbank environments during aggradation of a fluvially dominated, subaerially exposed part of a delta-plain environment.

Middendorf Formation

The Middendorf Formation consists predominantly of unlithified, fine to very coarse or fine to medium sand. The sand includes smoky-quartz granules and pebbles, mica, lignite, and generally very little clay matrix. The Middendorf sands are moderately to poorly sorted and are very porous and permeable in comparison to sands of the underlying Cape Fear Formation. Black clay is present in laminae and thin beds that are less than 2 ft thick in the Millhaven core. Clay beds in the Millers Pond core and most of the Girard core generally are light gray to white and range in thickness from 1 to 10 ft.

The Middendorf Formation contains two distinct subunits in the Millers Pond, Girard, and Millhaven cores (figs. 5, 6, 7). Additional work in the study area may show these subunits to be separate, mappable formations. At present, they are informally referred to in ascending order as subunits 1 and 2 of the Middendorf Formation (table 1). Each subunit contains a basal lag deposit of poorly sorted sand that grades up to interbedded and interlaminated clay and sand. Micaceous and lignitic sand laminae are common in the Middendorf sections, particularly near the top of each subunit. The two subunits could not be identified in the P-21 core (fig. 3).

Clay beds are generally thicker and display more abundant iron-oxide staining near the top of each subunit in the Millers Pond and Girard cores. A root-trace pattern is observed in the clay at the top of subunit 2 in the Girard core. Clays at the top of each subunit in the Millhaven core are not stained with iron oxides.

Fallaw and Price (1995) also recognized oxidized clays at the top and in the middle of the Middendorf Formation on the SRS and in the surrounding counties. Their description of the Middendorf Formation at the SRS is similar to the Middendorf Formation in the three Georgia testhole cores. The top of their middle clay roughly correlates to the top of subunit 1, although this contact has not been mapped. Cores and outcrops descriptions in Aiken County indicate that the updip equivalent of the Middendorf Formation, as defined at the SRS by Fallaw and Price (1995), is slightly coarser grained with distinct cross bedding and channel-fill structures (Nystrom and others, 1986; Gellici and others, 1995).

Lithologic data and characteristic geophysical log patterns were used to correlate the upper contact of the Middendorf Formation with the top of unit UK2 (Prowell and others, 1985) and the top of the Middendorf Formation in the P-21/P5R testhole on the SRS (Fallaw and Price, 1995) (fig.3). Prowell and others (1985) did not report paleontologic results for this unit at the SRS, but they inferred its Santonian age by correlation to a partially cored section in a testhole in Johnson County, Ga., located more than 70 mi (mile) southwest of the Girard site. The Middendorf Formation in the Johnson County testhole contains microfloras of dinoflagellates and pollen that are similar to the microfloras of the Middendorf Formation in South Carolina (Christopher and others, 1979). Gellici and others (1995) and Fallaw and Price (1995) also reported microfloras of dinoflagellates and pollen in samples of the Middendorf Formation in Allendale and Barnwell Counties, South Carolina. Huddlestun and Hetrick (1991) applied the name Pio Nono Formation to this unit in updip areas of east-central Georgia. Samples collected at 1,138; 1,046; and 1,012 ft in the Girard core, and 1,212 ft in subunit 2 in the Millhaven core contain pollen, which suggest a late Santonian to earliest Campanian age (Norman O. Frederiksen, U.S. Geological Survey, written commun., 1997) (figs. 6, 7).

All or part of what has been described as Middendorf Formation in this part of east-central Georgia may actually be correlative to part of the Black Creek Group or an updip lithofacies of the Caddin or Shepherd Grove Formations, identified as late Santonian to early Campanian in age (Gohn, 1992). Evidence of subaerial exposure and a basal erosional lag at the contact between subunits 1 and 2 support the possibility that unit UK2 (Prowell and others, 1985) contains more than one depositional sequence and is in part equivalent to unit UK3. Dinoflagellates and other marine indicators are sparse, suggesting a nonmarine fluvio-deltaic environment for most of the study area and a marginal-marine environment in Screven and Allendale Counties.

Black Creek Group

The Black Creek Group consists of three distinct subunits in the Girard and Millhaven cores (figs. 6, 7; table 1). Lag deposits at the base of the subunits suggest the possibility of unconformities in the Black Creek Group. The Black Creek Group at Millers Pond is coarser and sandier and is not divided into subunits (fig. 5).

Black Creek subunit 1 consists of moderately to poorly sorted, fine to coarse quartz sand with a few thin beds of clay. The sand contains very little clay matrix and abundant laminae of fine lignite and mica. This subunit is lithologically similar to the underlying Middendorf Formation.

Black Creek subunit 2 in the Millhaven core has a basal lag deposit of very poorly sorted sand that grades into an overlying 161-ft section of predominantly silty laminated black clay. Most of subunit 2 is calcareous and is interlaminated with very fine to fine, micaceous sand from 934 to 927 ft. Subunit 2 in the Girard core is sandier and consists of very fine to fine sand with interbedded black clay. The sand at Girard and Millhaven includes mica, lignite, and minor amounts of glauconite. Bioturbation features in subunit 2 at Girard and Millhaven include clay-lined burrows, mottled textures, and discontinuous laminae of clay in the sands. Subunit 2 at Girard and Millhaven yielded the most abundant and diverse marine macro- and microfaunas, and microfloras in the Cretaceous section in the study area, and include shark teeth, pelecypods, ostracodes, benthic and planktonic foraminifers, spicules, dinoflagellates, pollen, and calcareous nannofossils (Lucy E. Edwards and others, U.S. Geological Survey, written commun., 1997).

Black Creek subunit 3 in the Millhaven core is a coarsening-upwards sequence and consists of a very poorly sorted lag deposit overlain by moderately to well-sorted, very fine to medium sand (926 - 880 ft), and moderately sorted, fine to coarse sand (880 - 839 ft). Subunit 3 at Millhaven includes laminae and thin beds of dark gray clay, large and small pieces of lignite, and mica, and is crossbedded from 907 to 900 ft. The basal lag deposit in the Girard core is overlain by beds of moderately to poorly sorted, medium to very coarse sand, and moderately sorted, fine to medium sand, which is crossbedded from 714 to 710 ft and 679 to 660 ft. Clay matrix varies from 5 to 10 percent.

At Millers Pond, the Black Creek Group contains poorly sorted, fine to very coarse sand and beds of oxidized clay (fig. 5). Granules and pebbles are more abundant and form several very poorly sorted lags at the base of the sand beds, which generally include clay clasts. The sand is unlithified and has minor amounts of clay matrix. The tops of clay beds generally are stained with yellow and red iron oxides.

The dip-oriented change in the lithology of the Black Creek Group in east-central Georgia (fig. 8) also is reported in west-central South Carolina (Nystrom and others, 1986; Prowell, 1994; Fallaw and Price, 1995; Gellici and others, 1995). The Black Creek Group is coarser grained and oxidized with interbeds of kaolin in outcrops and cores in Aiken County and becomes progressively finer grained with interbedded, laminated black clay beneath Barnwell and Allendale Counties. Huddlestun and Hetrick (1991) applied the name Gaillard Formation to a fluvial lithofacies in the updip Georgia Coastal Plain that includes the same section of the Black Creek Group described at Millers Pond.

Paleontologic data from the cores in east-central Georgia suggest a Campanian age for the Black Creek Group (Lucy E. Edwards and others, U.S. Geological Survey, written commun., 1997). Units UK4 and UK5 (Prowell and others, 1985) and the Black Creek Group at SRS (Fallaw and Price, 1995) are assigned a Campanian to Maastrichtian age. Paleontologic data suggest that the calcareous lithologies of subunit 2 at Millhaven specifically are equivalent to the Donoho Creek Formation of the Black Creek Group (Owens, 1989; Sohl and Owens, 1991).

Like the Middendorf Formation, the Black Creek Group of east-central Georgia and west-central South Carolina is nonmarine in the updip part of the study area and become progressively more marginal marine to distal deltaic in a downdip, southeasterly direction (Lucy E. Edwards and others, U.S. Geological Survey, written commun., 1997). The composition of the microflora and the absence of other marine indicators suggest that subunit 1 at Millhaven and Girard, and the entire section of the Black Creek Group at Millers Pond, reflect nonmarine deltaic sedimentation. The diversity and abundance of dinoflagellates, the abundance of marine faunas, and the presence of glauconite at Girard and Millhaven suggest a strong marine influence during deposition of subunit 2, probably in the distal part of a deltaic complex, and a marginal-marine depositional environment in subunit 3.

Steel Creek Formation

Most of the Steel Creek Formation in the Georgia cores consists of poorly to very poorly sorted, fine to very coarse sand with granules and pebbles of smoky quartz and 5 to 15 percent clay matrix (figs. 5, 6, 7). The basal lag deposits are overlain by thick intervals of oxidized clay in the Girard and Millhaven testholes. The Steel Creek Formation includes multiple fining-upward sequences of coarse sand that fine into overlying clay beds. Many of the clay beds are stained with iron oxide, and contain as much as 40 percent sand by volume. Crossbedding is common at Millhaven. Root traces typically are present at the top of the thick oxidized clay near the base of the section and in some of the clay beds near the top of this unit. Lignite and mica are common accessory constituents.

Kidd (1996) used subtle differences in grain size and clay content, and geophysical-log patterns to identify a basal unconformity at 397 ft in the Millers Pond core. Huddlestun and Summerour (1996) identified the basal contact at 367 ft in the Millers Pond core and 414 ft in the Thompson Oak core and described the contact between the Black Creek (Gaillard) and Steel Creek Formations as either conformable or paraconformable in updip parts of Burke County. An unconformable contact separates the Black Creek Group and the Steel Creek Formation at the Millhaven and Girard sites. A sharp contact at 322 ft in the Millers Pond core was determined in this study on the basis of correlation from the more downdip Georgia cores. The Steel Creek section decreased in thickness from 197 ft at Millhaven to 38 ft at Millers Pond (fig. 8).

Colquhoun (1991) indicated that the Maastrichtian-age strata thinned beneath a regional unconformity at the top of the Cretaceous section and pinched out at the southeastern border of the SRS. Fallaw and Price (1995) extended the Maastrichtian-age strata (the Steel Creek Formation) across the SRS and indicated that the unit was 60 ft thick at the northwestern border of the SRS in Aiken County. The Steel Creek Formation does not crop out in the study area (Prowell, 1994) and is presumed to be absent in most of Richmond and Aiken Counties, the upper part of Jefferson County, and in the parts of Georgia and South Carolina counties along the inner margin of the Coastal Plain.

Most sediments of the Steel Creek Formation identified in the Georgia cores are barren of fossils. Paleontologic data from thin beds of brownish gray clay near the base of the Steel Creek section at Millhaven indicate a middle Maastrichtian age (Lucy E. Edwards and others, U.S. Geological Survey, written commun., 1997).

The middle-Maastrichtian Steel Creek Formation in the Georgia cores is equivalent to unit UK6 (Prowell and others, 1985) and the Steel Creek Formation (Fallaw and Price, 1995) at P-21/P5R (fig. 3).

Prowell and others (1985) considered unit UK6 to be a biostratigraphic equivalent of the Providence Sand and part of the Ripley Formation in Georgia, and the Peedee Formation in eastern South Carolina (fig. 2). Fallaw and Price (1995) described and named the Steel Creek Formation at the SRS. Huddlestun and Summerour (1996) considered the Steel Creek Formation to be early Maastrichtian.

Marine fossils, carbonate, and glauconite are absent in the Steel Creek sections in the Georgia cores. Fallaw and Price (1995) and Gellici and others (1995) reported sparse dinoflagellates and the absence of other marine indicators in the Steel Creek section beneath the South Carolina part of the study area. The coarse sediments, fining-upward sequences, indications of rooting, and iron-oxide staining suggest channel and overbank deposits in subaerially exposed, fluvial and delta-plain environments.

Tertiary Stratigraphy

The Tertiary section in this report is divided into the Paleocene-age Ellenton and Snapp Formations, and the Fourmile Branch/Congaree/Warley Hill unit, the Tinker/Santee unit, and the Barnwell unit of Eocene and younger age (fig. 2). Each Eocene-age unit identified in the Georgia testholes can be lithologically, geophysically, or biostratigraphically correlated to more than one of the formally named stratigraphic units in the study area. Therefore, informal stratigraphic names are used in this report.

The Tertiary stratigraphy proposed by Prowell and others (1985) at P-21/P5R included two Paleocene units designated as units P1 and P2, six Eocene units designated as units E1, E3, E4, E5, E7, and E8, and an Oligocene unit designated as unit O1 (fig. 3). Units E2, E6, and M1 were recognized and correlated in Georgia but were not correlated to the P-21/P5R site at the SRS (Prowell and others, 1985).

Ellenton Formation

The Ellenton Formation is coarser grained and noncalcareous in the updip Millers Pond core, and finer grained, calcareous, and very glauconitic in the downdip Girard and Millhaven cores (figs. 5, 6, 7). Lag deposits and sharp bedding contacts help identify basal unconformities and other possible unconformities within the Ellenton Formation.

In ascending order, the Ellenton Formation at Millhaven consists of glauconitic, calcareous, fine to coarse sand and laminated black clay (642 - 622 ft), well laminated, slightly calcareous, silty black clay (622 - 595 ft), and calcareous to noncalcareous clay with irregularly bedded to nodular limestone (595 - 570 ft) (fig. 7). The Ellenton section in the Girard core consists of noncalcareous sand and black clay (542 - 518 ft); sandy carbonate and limestone, and calcareous sand with abundant glauconite (518 to 491 ft); and well-laminated, noncalcareous silty clay (491 - 481 ft) (fig. 6). The section generally contains well-sorted, fine to medium quartz sand. Lag deposits at 638; 625; and 595 ft in the Millhaven core, and 518 ft in the Girard core contain 10 to 20 percent glauconite, several rounded phosphatic clasts, and shark teeth. A high-angle surface, possibly a fault plane, defines a sharp contact at 491 ft in the Girard core.

The Ellenton Formation in the updip Millers Pond core consists of fine to very coarse sand with interbedded sandy clay (284 - 263 ft), interlaminated black lignitic clay and very fine to medium sand (263 - 247 ft), and fine to medium clayey sand (247 - 232 ft) (fig. 5). Poorly sorted pebble lag deposits at 284 and 271 ft, and clay clasts at 263 and 244 ft suggest possible unconformities and reworking of Ellenton section in the Millers Pond core.

Paleontologic data suggest that the Ellenton Formation in east-central Georgia is equivalent to unit P1 at P-21/P5R (Prowell and others, 1985), the Ellenton Formation in South Carolina (Prowell, Edwards, and Frederiksen, 1985), and the Sawdust Landing and Lang Syne Formations located at SRS (Fallaw and Price, 1995). The noncalcareous, non-glauconitic sand and clay at Girard (542 - 518 ft) and Millers Pond (284 - 263 ft) are lithologically similar to the Sawdust Landing Formation; however, a similar lithologic unit is not recognized at Millhaven. The rest of the Ellenton Formation at Millhaven and Girard was similar to the very glauconitic and silty lithology of the Lang Syne Formation. The carbonate component described in the Millhaven and Girard cores (Clarke and others, 1996; Leeth and others, 1996) was not described in the Lang Syne Formation at the SRS, but was described as part of this unit beneath Allendale County, South Carolina (Fallaw and Price, 1995; Gellici and others, 1995).

Huddlestun and Summerour (1996) described an equivalent unit in Georgia that they identified as the undifferentiated Black Mingo Formation. They recognized lithologies that are similar to the Rhems, Williamsburg, and Lang Syne Formations of the Black Mingo Group in South Carolina (Van Nieuwenhuise and Colquhoun, 1982), but did not separate the strata into units.

The Ellenton Formation is reported to contain diverse microfloras of dinoflagellates, pollen, and calcareous nannofossils, and faunal components of ostacodes, planktonic foraminifers, pelecypods, and gastropods in the downdip sections (Lucy E. Edwards and others, U.S. Geological Survey, written commun., 1997). The updip Ellenton Formation at Millers Pond contains low-diversity microfloras of dinoflagellates and pollen (Clarke and others, 1994). The marine fossils, glauconite, and carbonate indicate an open-marine environment in downdip sediments, possibly distal prodelta. The low diversity and the low abundance of dinoflagellates, and the absence of other marine components at Millers Pond, indicate a change to a more restricted marginal-marine environment. Similar dip-oriented changes in lithology and depositional environment as seen in the east-central Georgia cores also were reported in the west-central South Carolina (Nystrom and others, 1986; Prowell, 1994; Fallaw and Price, 1995; Gellici and others, 1995).

Snapp Formation

The Snapp Formation in east-central Georgia consists of moderately to poorly sorted, fine to very coarse sand overlain by iron-stained, oxidized kaolin (figs. 5, 6, 7) The lower part of the unit is unlithified sand and generally contains granules, pebbles, and less than 10 percent clay matrix. The sand typically is coarse to very coarse in the lower part of the section, and fine to medium in the middle part of the section, and grade into white to very light gray kaolin at the top of the section. The clay is stained with red and yellow iron oxides. Pedogenic structures in the otherwise massive clay include root traces and desiccation cracks. Pyrite is disseminated in the clay and along desiccation cracks found near the top of the Snapp Formation in the Millers Pond and Girard cores.

The Snapp Formation in the east-central Georgia cores is equivalent to unit P2 (Prowell and others, 1985) and the Snapp Formation at SRS (Fallaw and Price, 1992, 1995). McClelland (1987) applied the name Rhems Formation (lower Paleocene part of the Black Mingo Group) to a combined section of the Snapp and Ellenton Formations in upper Burke County. The Snapp Formation holds the same upper Paleocene stratigraphic position as the Chicora Member of the Williamsburg Formation of the Black Mingo Group (Van Nieuwenhuise and Colquhoun, 1982). However, the Snapp Formation as seen in the east-central Georgia cores and at the SRS (Fallaw and Price, 1995) is lithologically different from the marine Chicora Member.

The Snapp Formation is absent at Thompson Oak (fig. 1; table 1). Fallaw and Price (1995) indicated that the updip limit of the Snapp Formation was near Upper Three Runs Creek in Aiken County, S.C. Extension of this boundary into Georgia would place the Thompson Oak core near the updip limit of the Snapp Formation. The presence of Snapp Formation sediments in the McBean core suggests that the updip limit of the formation extends northwest from Thompson Oak across the northern part of Burke County, Georgia (fig. 1).

Paleontologic samples were not collected from this formation in the Girard and Millers Pond cores because of the extensive oxidation of the sediments. A sample collected from the base of this formation in the Millhaven core yielded sparse dinoflagellates that were not age diagnostic (Lucy E. Edwards, U.S. Geological Survey, written commun., 1997). The stratigraphic position of this unit between the Ellenton Formation and the Fourmile Branch/Congaree/Warley Hill unit suggested that the strata are either late Paleocene (Prowell and others, 1985; Fallaw and Price, 1992, 1995) or early Eocene (Harris and Zullo, 1992) in age. Paleontologic data from a sample at 264 ft in the McBean core indicated a Paleocene age (Norman O. Frederiksen, U.S. Geological Survey, written commun., 1997).

Sedimentary characteristics suggest a fluvial depositional environment either in an upper delta plain or an incised alluvial valley. The presence of dinoflagellates in the Millhaven core suggests that the formation grades to a marginal-marine environment in the downdip part of the study area. The Snapp Formation at Girard is 58-ft thick, which is roughly 20-ft thicker than the Snapp Formation at P-21/P5R (fig. 9). Conversely, the Ellenton Formation at Girard is 20-ft thinner than the equivalent section at P-21/P5R. Structural-contour and isopach maps also indicate thick sections of the Snapp Formation overlie comparatively thin sections of the Ellenton (Black Mingo) Formation in eastern Burke County and southern Barnwell County (Huddlestun and Summerour, 1996).

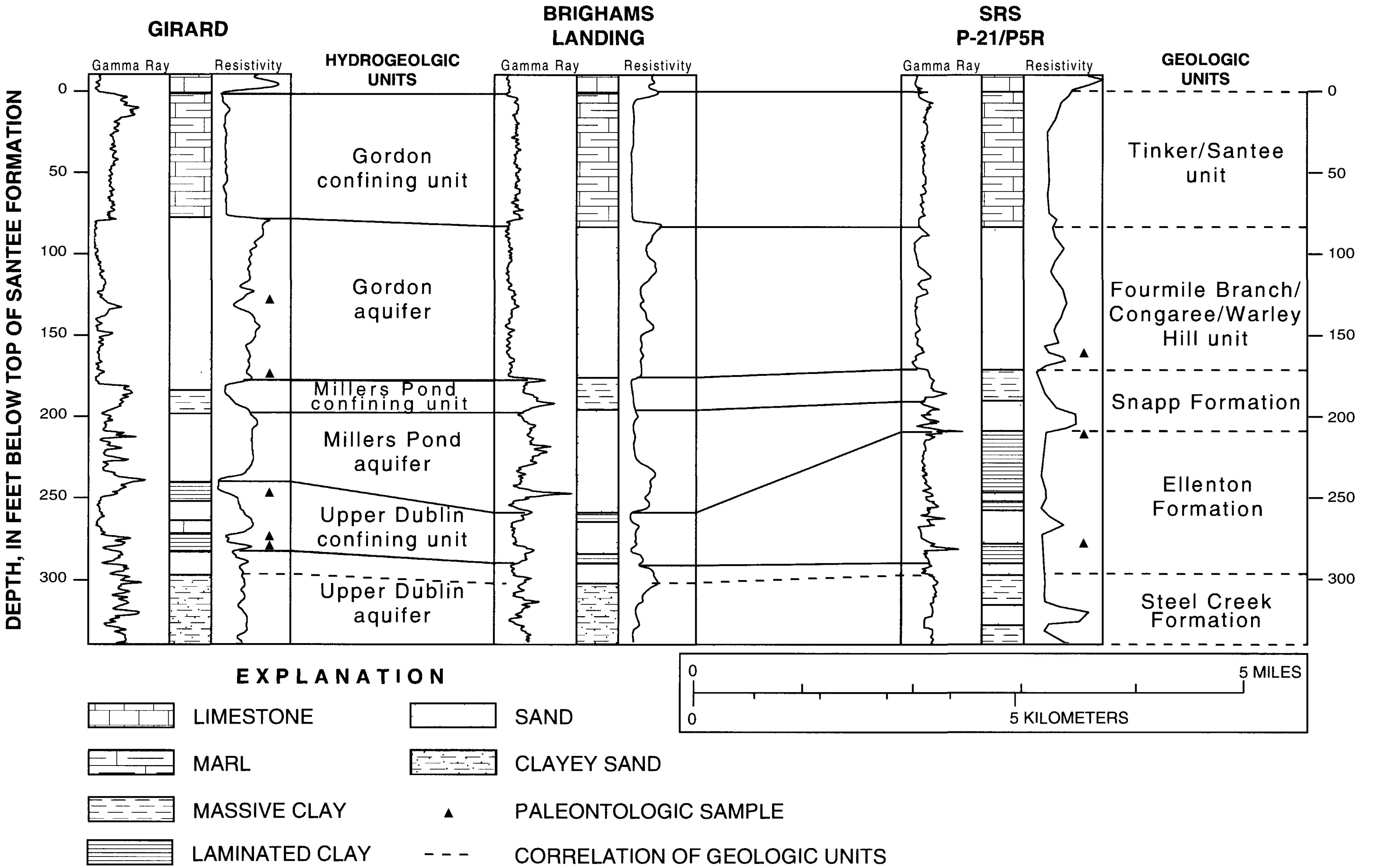


Figure 9. Strike-oriented correlation of hydrogeologic units from the Steel Creek, Ellenton, and Snapp Formations, and the Fourmile Branch/Congaree/Warley Hill and Tinker/Santee units in the Girard, Brighams Landing, and P-21/P5R testholes. (The top of the Tinker/Santee unit is the stratigraphic datum).

Differences in the thickness of these formations suggest that the channel sands of the Snapp Formation are incised into the laminated black clay of the Ellenton Formation.

Fourmile Branch/Congaree/Warley Hill Unit

The lithologies of the Fourmile Branch/Congaree/Warley Hill unit vary from siliciclastic sections in the updip cores to mixed-siliciclastic-carbonate sections in the central and downdip Georgia cores (figs. 2, 5, 6, 7). Paleontologic data suggest that this unit is correlative to three formally named formations at the SRS. However, the three formations are not present in all of the Georgia testhole sites (table 1).

In the downdip Millhaven core, the Fourmile Branch/Congaree/Warley Hill unit consists of interbedded quartz sand and limestone (fig. 7). The sand is very fine to fine below a depth of 415 ft and fine to medium above a depth of 415 ft, and is moderately to well sorted with 5 to 20 percent clay and carbonate matrix. Glauconite, a common accessory mineral, is abundant at 462 ft. The carbonate beds vary from lithified to unlithified and include glauconite, clay matrix, and fossils. Extensive burrowing is recognized within the sandy carbonate matrix.

In the Girard core, the Fourmile Branch/Congaree/Warley Hill unit consists of medium to coarse sand (423 - 390 ft); fine to medium sand (366 - 350 ft); and medium to coarse sand, sandy carbonate, and limestone (342 - 325 ft) (fig. 6). A large part of the unit from 390 to 366 ft and several other parts of the section were not recovered during coring. The section below 390 ft is predominantly noncalcareous with clay laminae, clay-lined burrows, less than 5 percent clay matrix, and trace amounts of glauconite. Sandy carbonate and calcareous sand are abundant above 342 ft.

The Fourmile Branch/Congaree/Warley Hill unit in the Millers Pond core consists of a 9-ft section of well-sorted, very fine to fine sand (fig. 5). The sand contains less than 5 percent clay matrix and clay-lined burrows. One mile west of the Millers Pond site, McClelland (1987) described a 40-ft section of the Huber Formation, a deltaic lithofacies equivalent in age to the Congaree Formation. The Huber Formation consists of burrowed, fine sand that is overlain by a crossbedded, fine to coarse quartz sand, and lenticular beds of massive, lignitic kaolin. Only the lower fine sand interval of the Huber Formation (described here as Congaree) is present at Millers Pond and has a mineralogy and texture comparable to Huber sections in Aiken County (Nystrom and Willoughby, 1982; Nystrom and others, 1986; Prowell, 1994).

Marine fossils in this unit include bryozoans, pelecypods, and foraminifers below a depth of 462 ft, and pelecypods and foraminifers above 462 ft at Millhaven. Pelecypods, bryozoans, and shark teeth are present above a depth of 342 ft at Girard. Biomoldic pores indicate that gastropods were present in both sections. Samples of the Georgia cores contained dinoflagellates, pollen, and calcareous nannofossils at Girard and Millhaven, and dinoflagellates and pollen at Millers Pond and Thompson Oak. The microfossils indicate that this unit is early Eocene to early middle Eocene in age (Laurel M. Bybell, Norman O. Frederiksen, and Lucy E. Edwards, U.S. Geological Survey, written commun., 1997).

The Fourmile Branch/Congaree/Warley Hill unit from 423 to 390 ft in the Girard core is lithologically and geophysically correlative to the Fourmile Branch Formation at the SRS (Fallaw and Price, 1995). The age of this part of the Girard core could not be determined from the fossil evidence. In a lithologically similar section in the Thompson Oak core (274 to 251 ft), dinoflagellates suggest an age of early Eocene (Lucy E. Edwards, U.S. Geological Survey, written commun., 1997). These sections in the Thompson Oak and Girard cores are equivalent to unit E2 of Prowell and others (1985). However, an age-equivalent section was not identified at Millers Pond or Millhaven.

The section from 390 to 325 ft in the Girard core is biostratigraphically correlative to the sections from 504 to 462 ft in the Millhaven core and 165 to 156 ft in the Millers Pond core, and to samples collected from depths of 210, 194, 192, and 183 ft in the Thompson Oak core. This part of the Fourmile Branch/Congaree/Warley Hill unit is equivalent to unit E3 (Prowell and others, 1985) and the Congaree Formation in South Carolina and Georgia (Fallaw and Price, 1995; Huddlestun and Summerour, 1996).

The section from 462 to 401 ft in the Millhaven core is lithologically equivalent and geophysically correlative to part of the Congaree Formation as identified in AL-348 (SCDNR C-10) of Allendale County, South Carolina (Gellici and others, 1995) (fig. 4). This section is biostratigraphically equivalent to the lower part of unit E4 by Prowell and others (1985) and the Warley Hill Formation at SRS (Fallaw and Price, 1995). Equivalent strata have not been identified at Girard and Millers Pond.

Sedimentary characteristics of the Fourmile Branch Formation in the Thompson Oak and Girard cores suggest a nearshore-marine environment. Sedimentary characteristics of the overlying Congaree beds suggest a fluvially dominated to marginal-marine environment in the updip Millers Pond core and an open-marine shelf environment in the downdip cores. The sections in Aiken, Burke, Richmond, and Jefferson Counties is an updip deltaic facies. The Warley Hill Formation at Millhaven is an open-marine shelf environment.

Tinker/Santee Unit

The Tinker/Santee unit derives its name from the Santee Limestone (Sloan, 1908) and the Tinker Formation (Fallaw and Price, 1992, 1995), which are age-equivalent lithofacies in the study area. The sections at Millers Pond, Girard, and Millhaven are predominantly carbonate lithologies that are typical of the Santee Limestone. The lithologies of the Tinker Formation are present in the updip part of SRS and typically include a very fine to fine sand with laminae and thin beds of green clay near the base of the formation (Fallaw and Price, 1995).

The Tinker/Santee unit in the Millhaven core consists of sand and sandy limestone (401 - 365 ft), marl and limestone (365 - 245 ft), and sandy carbonate (245 - 228 ft) (fig. 7). The section is glauconitic and includes a basal medium to coarse sand grading upward to fine to medium sand. Limestone from 365 to 268 ft has biomoldic porosity. Bedding contacts at 365 and 322 ft are phosphatized and pyritized, and underlain by limestone with biomoldic porosity. Fossils in the limestone are more abundant and more diverse than fossils in the marl and include pelecypods, gastropods, bryozoans, echinoids, foraminifers, brachiopods, and shark teeth.

The Tinker/Santee unit in the Girard core includes sandy limestone, marl, and clayey sand (fig. 6). The sandy limestone (325 - 322 ft) has glauconite and abundant pelecypod-moldic porosity and is pyritic along its upper contact with the overlying marl. The marl (322 - 250 ft) has as much as 30 percent clay matrix and varies in the amount of very fine to fine quartz sand from 2 percent near the base of the section to 25 percent near the top of the section. The marl and calcareous sand are burrow mottled and contain minor amounts of lignite and glauconite. Macrofossils are sparse and include pelecypods.

The Tinker/Santee unit in the Millers Pond core (156 - 82 ft) consists of sandy limestone and calcareous sand (fig. 5). A thin basal lag of very poorly sorted sand (156 - 154 ft) includes quartz pebbles and granules, glauconite, and pelecypods. The quartz sand above the basal lag deposit is fine to very coarse in the calcareous sand beds and fine to medium in the sandy limestone beds. The limestone below a depth of 121 ft is finely crystalline and contains glauconite and marine fossils, including pelecypods, spicules, foraminifers, and shark teeth. Marine fossils in the limestone above a depth of 100 ft include oysters and other pelecypods, foraminifers, and echinoid fragments. Biomoldic porosity also is present above a depth of 100 ft and indicates dissolution of aragonitic pelecypods and gastropods.

The updip section at Millers Pond is thicker than that reported in other nearby wells (Nystrom and Willoughby, 1982; Nystrom and others, 1986; McClelland, 1987; Prowell, 1994). McClelland (1987) described a 40-ft thick unit in a drill hole located west of the Millers Pond site. This local variation in thickness and missing section in the underlying Fourmile Branch/Congaree/Warley Hill unit collectively suggest that the Santee Formation has incised the underlying unit, possibly the result of localized channeling. Similar channels are reported in nearby strip mines (Nystrom and others, 1986).

The lower part of the Tinker/Santee unit at the McBean (sample depth 181 ft), Millers Pond (154 - 139 ft), Thompson Oak (sample depths of 181.5, 174, 172, 164, and 154 ft), Girard (325 - 322 ft), and Millhaven (401 - 365 ft) sites is biostratigraphically equivalent to the upper part of unit E4 (Lucy E. Edwards, Laurel M. Bybell, and Norman O. Frederiksen, U.S. Geological Survey, written commun., 1997). Prowell and others (1985) identified the upper part of unit E4 as correlative to part of the Warley Hill Formation on the southeastern part of the SRS. Gellici and others (1995) have described a similar lithologic unit with the same stratigraphic position at AL-348 (SCDNR C-10) in Allendale County and designated it as the Warley Hill Formation. Fallaw and Price (1995) also described a calcareous lithofacies of the Warley Hill Formation in parts of Barnwell and Allendale County and correlated the downdip lithofacies of the Warley Hill Formation to a updip sporadic sand lithofacies between the Congaree and Tinker Formations at the SRS. The updip sand facies typically is clayey and can include laminae or thin beds of green to tan clay.

The upper part of the Tinker/Santee unit above 139 ft at Millers Pond, 322 ft at Girard, and 365 ft at Millhaven is biostratigraphically equivalent to unit E5 (Prowell and others, 1985). This part of the unit is lithologically similar to the Blue Bluff Marl of the Lisbon Formation (Huddlestun and Hetrick, 1986), the Santee Limestone (Sloan, 1908), and the McBean Formation (Veatch and Stephenson, 1911). The east-central Georgia sections are age equivalent to the siliciclastic lithology of the Tinker Formation that occurs in the updip part of the SRS (Fallaw and Price, 1995).

Calcareous nannofossils, planktonic foraminifers, dinoflagellates, and pollen from the Georgia cores indicate a late middle Eocene (late Claibornian) age for the Tinker/Santee unit (Lucy E. Edwards, Laurel M. Bybell, Norman O. Frederiksen, and Thomas G. Gibson, U.S. Geological Survey, written commun., 1997). Marine fossils indicate an open-marine, shallow-shelf environment. The distribution of siliciclastic sediments and the diversity of marine fossils in the carbonate facies suggest that the updip Millers Pond site is more proximal to a source of siliciclastic sediments, relative to the downdip Millhaven site. Marine fossils and glauconite also suggest that the Tinker Formation was deposited in a nearshore, clastic shoreface environment (Fallaw and Price, 1995).

Barnwell Unit

The Barnwell unit derives its name from the Barnwell Group (Huddlestun and Hetrick, 1979, 1986). The Barnwell Group of late-Eocene age consists of the Clinchfield, Dry Branch, and Tobacco Road Formations that have been described and mapped on both sides of the Savannah River in the vicinity of the SRS (Huddlestun, 1982; Huddlestun and Hetrick, 1978, 1979, 1986; Prowell, 1994; Fallaw and Price, 1995). The Barnwell Group includes an updip siliciclastic lithofacies, and interbedded siliciclastics and carbonates in downdip parts of the study area (Nystrom and others, 1986; Hetrick, 1992; Prowell, 1994; Fallaw and Price, 1995; Gellici and others, 1995; Huddlestun and Summerour, 1996). The informally named Barnwell unit in this report includes the Barnwell Group strata as well as post-Eocene strata that occur in the study area.

The Barnwell unit at Millhaven includes a basal calcareous clay (228 - 223 ft), and moderately to well-sorted, calcareous quartz sand and partially lithified sandy limestone (223 - 123 ft) (fig. 7). The section from 123 to 54 ft consists of partially lithified carbonate and contains generally less than 10 percent quartz sand and 1 percent glauconite. Irregularly shaped, phosphatized limestone clasts at the base of this part of the section produce a sharp spike on the gamma-ray log at 123 ft. The upper part of the Barnwell unit from 54 ft to land surface consists of a coarsening-upwards sequence of clayey sand and sandy clay. Fossils include pelecypods, bryozoans, echinoids, and foraminifers from 223 to 54 ft. Biomoldic pores are present from 67 to 34 ft and reflect dissolution of aragonitic pelecypods and gastropods.

The Barnwell unit in the Girard core consists of sand, clay, and carbonate lithologies in the lower part of the section (250 - 104 ft), and sand and clay in the upper part of the section (104 ft to land surface) (fig. 6). A basal calcareous clay (250 - 244 ft) is overlain by partially silicified, phosphatized, glauconitic limestone (244 - 234 ft); calcareous quartz sand (234 - 193 ft); sandy limestone (193 - 183 ft); marl (183 - 136 ft); and sandy limestone that grades upward to calcareous quartz sand (136 - 104 ft). Fossils include pelecypods and bryozoans. Biomoldic porosity varies from 5 to 20 percent in the limestone. Sand is fine to coarse near the base of the Barnwell unit and very fine to fine in the part of the section from 250 to 104 ft. Clay matrix varies from 20 to 40 percent. Clay laminae are abundant below 172 ft. The uppermost part of the Barnwell unit (104 ft to land surface) is noncalcareous and contains clayey sand, sandy clay, and clay. The sand varies from fine to coarse and contains several flattened, ovoid pebbles at 88 ft. The section from 80 ft to land surface is lithologically variable and difficult to describe because of sample loss during coring.

The Barnwell unit at Millers Pond is 82 ft thick and consists of siliciclastic sediments (fig. 5). The contact with the Santee Formation was not recovered during coring. Below a depth of 67 ft, the Barnwell unit includes thin beds of fine to medium and fine to very coarse sand, and contains thin beds of well-laminated clay, lignite, clay clasts, and 10 to 20 percent clay matrix. The section from 67 ft to land surface varies from fine to medium sand up to fine to very coarse sand, includes 5 to 25 percent clay matrix, and contains granules and pebbles from 49 to 42 ft. Sedimentary structures include wispy clay laminae (66 - 62 ft, 48 - 47 ft, and 38 - 27 ft).

Paleontologic data for the Girard and Millhaven cores suggest a late Eocene to questionably early Oligocene age for the Barnwell unit (Lucy E. Edwards, Laurel M. Bybell, Norman O. Frederiksen, Thomas G. Gibson, U.S. Geological Survey, written commun., 1997). The unit is equivalent to units E6, E7, and E8 (Prowell and others, 1985), and the Clinchfield, Dry Branch, and Tobacco Road Formations of the Barnwell Group at the SRS (Fallaw and Price, 1995).

The potential for post-Eocene units is acknowledged on the basis of previous studies, but all post-Eocene strata, excluding Quaternary alluvium, are included as part of the Barnwell unit. A thin unit of presumed Miocene-age strata has been mapped as the uppermost stratigraphic unit at the Girard site (Prowell, 1994). This unit was described and designated as map unit Tu (Prowell, 1994) and is roughly equivalent to units O1 and M1 (Prowell and others, 1985). The contact between the Barnwell Group and the post-Eocene unit, as mapped in the area of the Girard site (Prowell, 1994), could not be identified in the Girard core because of poor core recovery. Fallaw and Price (1995) recognized the Miocene Altamaha Formation at the SRS, deriving the name from the Altamaha Formation of eastern and central Georgia (Huddlestun, 1988). The strata of the Altamaha Formation at the SRS are quite distinct from the sections in the three Georgia core and include poorly sorted sands and gravels. Other post-Eocene units include discontinuous Pliocene dune deposits (Prowell and others, 1985; Nystrom and others, 1986; Hetrick, 1992; and Prowell, 1994) and a marine unit of upper Pliocene age that extends across the eastern half of Allendale and Screven Counties (Prowell, 1994).

Throughout the study area, carbonate, glauconite, and abundant marine macrofossils and microfossils in the calcareous part of the section indicate that the Barnwell strata were deposited in open-marine environments. The calcareous sand probably was deposited in a shallow-shelf environment, and the fossil bed at the base of the Barnwell unit is a lag deposit produced by a late Eocene marine transgression. The noncalcareous sand and clay, the ovoid flattened pebbles, and the clay wisps in the upper part of the Barnwell unit suggest that these strata were deposited in nearshore-marine environments.

HYDROGEOLOGY

Several different hydrogeologic nomenclatural schemes have been applied in east-central Georgia (fig. 3). Miller (1986) mapped late Eocene- and Oligocene-age carbonate strata of the Floridan aquifer system in the eastern half of Allendale County, the southern halves of Burke and Jefferson Counties, and all of Jenkins and Screven Counties. The siliciclastic and mixed-siliciclastic-carbonate strata of Eocene age north of the Floridan aquifer system were divided into the Jacksonian aquifer (Vincent, 1982) and the Gordon aquifer system (Brooks and other, 1985). Krause and Randolph (1989) recognized and described the hydraulic interconnection of the updip siliciclastic Jacksonian and Gordon aquifers with the downdip carbonate strata of the Floridan aquifer system. Clarke and others (1985) correlated the Dublin and Midville aquifer systems to the Cretaceous and Paleocene strata and described each as a separate, confined system in the middle and downdip parts of the study area. Clarke and others (1985) described a local confining unit of the Dublin aquifer system near the Savannah River that separates an upper aquifer of Paleocene age from a lower aquifer of Late Cretaceous age.

Aadland and others (1995) developed a hydrogeologic nomenclature for the aquifers and confining units that lie beneath the SRS and adopted the names of several of the aquifers and aquifer systems defined in Georgia (fig. 3). The hydrogeologic section at the SRS was divided into the Floridan, Dublin, and Midville aquifer systems, and the Meyers Branch, Allendale, and Appleton confining systems.

At the SRS, the downdip carbonate strata of Eocene and post-Eocene age comprise the Floridan aquifer system (Aadland and others, 1995). Updip clastic equivalents of the Floridan aquifer system include the Upper Three Runs (Aadland and others, 1995) and Gordon aquifers and the intervening Gordon confining unit. Where the Gordon confining unit is absent in updip localities, the combined Upper Three Runs and Gordon aquifers are known as the Steed Pond aquifer (Aadland and others, 1995).

The Meyers Branch confining system of South Carolina includes the Paleocene strata and most of the Steel Creek Formation and separates the Floridan and Dublin aquifer system in the downdip part of the study area (Aadland and others, 1995). With increasing leakage across the Meyers Branch confining system in updip areas, the hydrogeologic equivalents of the Meyers Branch confining system and Dublin aquifer system are named the Crouch Branch confining unit and aquifer (Aadland and others, 1995). In downdip parts of South Carolina, the Dublin and Midville aquifer systems are separated by the Allendale confining system. With increasing leakage across the Allendale confining system in updip areas, the hydrogeologic equivalents of the Allendale confining system and Midville aquifer system are known as the McQueen Branch confining unit and aquifer (Aadland and others, 1995). The Appleton confining system (Aadland and others, 1995) is correlated to most of the Cape Fear Formation and the saprolite at the top of pre-Cretaceous bedrock. The base of the Midville aquifer system is delineated by the Appleton confining unit.

For the purpose of this study, the Eocene and post-Eocene strata of the Tertiary are assigned to the Upper Three Runs aquifer, Gordon confining unit, and Gordon aquifer, regardless of the amount of carbonate (fig. 3). These hydrogeologic units is partially to fully incised by the Savannah River and its tributaries in the vicinity of the SRS. As a result of incision by the Savannah River alluvial valley through the sediments of the Gordon confining unit, the Gordon aquifer beneath the SRS Savannah River border varies from unconfined conditions in the upstream area to confined conditions in the downstream areas. The sediments of the Dublin and Midville aquifer systems, as defined by Clarke and others (1985), are divided in this report into five aquifers and five intervening confining units and are underlain by the basal confining unit. The hydrogeologic units as recognized in the P-21/P5R testhole in South Carolina and each of the three cored testholes in Georgia are shown in figures 3, 5, 6, and 7. The Dublin aquifer system is divided into the Millers Pond, upper Dublin, and lower Dublin confining units and aquifers. The Midville aquifer system is divided into the upper and lower Midville confining units and aquifers.

The correlation of all seven aquifers and seven confining units is shown in a dip-oriented section from Millers Pond to Millhaven (fig. 10). Contour maps showing the configuration of the top and thickness are presented for each unit. Geophysical logs, descriptions of cores, drillers logs, and paleontologic data from as many as 109 sites (fig. 4; table 2) were used to map the units. The altitude and thickness of each aquifer and confining unit at each site are shown in tables 3 and 4.

Each confining unit consists largely of a fine-grained lithofacies and generally includes part or most of a specific geologic unit defined previously. The lower Dublin and basal confining units are correlated to more than one geologic unit.The clay and clayey sand lithologies in confining units are geophysically characterized by high natural-gamma counts and low resistivity, relative to overlying and underlying aquifers. Paleontologic results are used to biostratigraphically confirm the correlation of the fine-grained lithologies in the Gordon, upper Dublin, and upper Midville confining units. For purposes of this report, confining units are assigned the name of the underlying aquifer: for example, the lower Dublin confining unit overlies the lower Dublin aquifer.

Each aquifer is correlated to one or more relatively coarse-grained geologic units or coarse-grained lithofacies and generally have a high porosity and permeability, relative to the confining units. The hydraulic properties of different aquifers that underlie the study area are included in a subsequent discussion of each hydrogeologic unit and are summarized in table 5.

The hydrogeologic framework described in this report was developed as a modeling framework for the USGS trans-river flow study. Each hydrogeologic unit is described as recognized in the three Georgia testholes and as correlated to previously described hydrogeologic units in the study area.

Upper Three Runs Aquifer

The Upper Three Runs aquifer in this study derives its name from the Upper Three Runs aquifer at the SRS (Aadland and others, 1995) and is hydrogeologically equivalent to the Jacksonian aquifer in east-central Georgia (Vincent, 1982) and the Floridan aquifer system (Miller, 1986). The unit consists of all Coastal Plain sediments, with the exception of Quaternary river- and creek-valley alluvium, that overlie the top of the Gordon confining unit in the part of the study area to the southeast of the updip limit of the Gordon confining unit (fig. 11 at end of report). Where the Gordon confining unit is absent in updip part of the study area, the Upper Three Runs aquifer directly overlies the Gordon aquifer. This Upper Three Runs aquifer includes sediments of the Tinker/Santee and Barnwell units at Millers Pond and Millhaven, and the Barnwell unit at Girard (figs. 5, 6, 7). In the central and updip parts of the SRS, the aquifer consists of the mostly siliciclastic sections of the Barnwell unit and the transmissive upper part of the Tinker Formation.

The dominant porosity type is intergranular in the sands, and intergranular and moldic in the sandy carbonates and limestones. The Upper Three Runs aquifer has a reported transmissivity of 840 ft^2/d (square feet per day) and hydraulic conductivity of 8 ft/d (feet per day) (Snipes and others, 1995; Kidd, 1996).

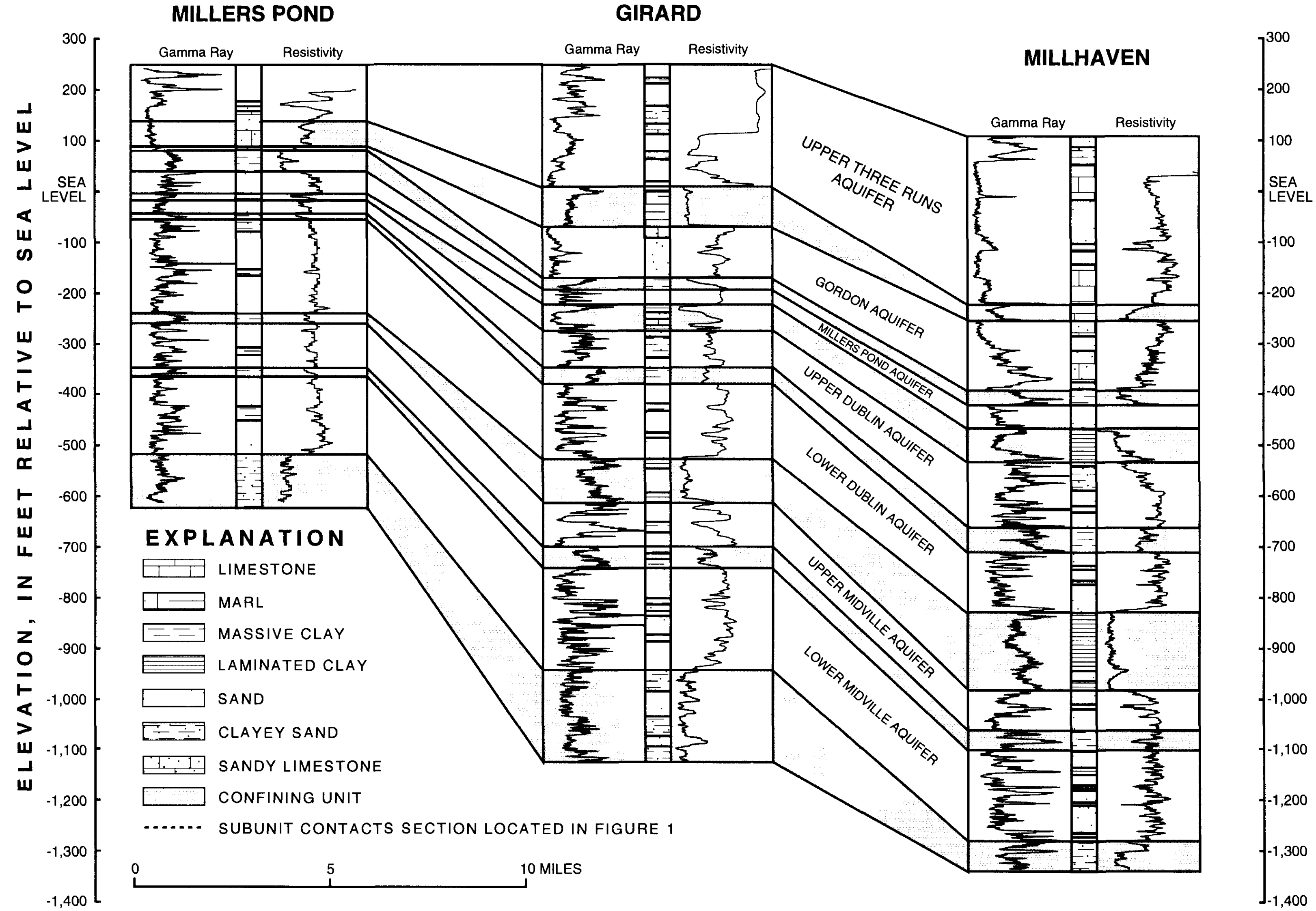


Figure 10. Dip-oriented correlation of hydrogeologic units from the Millers Pond testhole to the Millhaven testhole. Faults are not included on section. (Datum is sea level).

Gordon Confining Unit

The Gordon confining unit in this study derives its name from the Gordon aquifer system (Brooks and others, 1985). This unit is correlated to a fine-grained limestone lithology of the Tinker/Santee unit in Georgia and the middle and downdip parts of South Carolina. The lithologies include a sandy, fine-grained limestone at Millers Pond, a thick unit of sandy marl at Girard, and a thinner unit of marl at Millhaven (figs. 5, 6, 7). This unit is equivalent to the "green" clay confining unit in the updip and central parts of the SRS (Fallaw and Price, 1995).

Outcrops of the Tinker/Santee unit (Lisbon and McBean Formations) are mapped in parts of Aiken, Richmond, and Burke Counties (Hetrick, 1992; Prowell, 1994) and are used to map the updip limit of the Gordon confining unit to the southeast of Hollow Creek in South Carolina and the mouth of Spirit Creek in Georgia (figs. 4, 11). The confining unit is absent beneath parts of the Upper Three Runs Creek (figs. 4, 11). The top of the Gordon confining unit as mapped in this study is roughly the same surface mapped by Brook and others (1985) and Aadland and others (1995), except in Allendale and Screven Counties (fig. 11). Aadland and others (1995) include some of the shelly limestone above the marl as part of the Gordon confining unit at AL-348 (SCDNR C-10), AL-27 (Sandoz Chemical, Incorporated) and 33X048 (USGS Millhaven). Outcrops (Prowell, 1994) and subsurface data collected in the Savannah River Valley (Leeth and Nagle, 1996) indicate that incision of the Savannah River alluvial valley has removed the Gordon confining unit as far south as BW-893 (SRS PBF-6) (figs. 4, 11). The unit has a maximum thickness that exceeds 75 ft near 33Y030 (USGS Brighams Landing) and AL-27 (Sandoz Chemical, Incorporated) (figs. 4, 12 at end of report).

A vertical hydraulic conductivity of 10^{-4} ft/d is reported from laboratory analysis of one sample at Girard (Leeth and others, 1996). Leakance at Girard is estimated to be 10^{-6}/d. Aadland and others (1995) reported leakance to range from 10^{-3} to 10^{-6}/d.

Gordon Aquifer

The Gordon aquifer derives its name from the Gordon aquifer system (Brooks and others, 1985), includes strata of the Fourmile Branch/Congaree/Warley Hill unit, and can include a transmissive bed in the lower part of the Tinker/Santee unit (figs. 5, 6, 7). The top of the Gordon aquifer, as mapped in this study, is roughly the same surface mapped in previous studies (Brooks and others, 1985; Aadland and others, 1995) (fig. 13 at end of report). The Gordon aquifer of this study has been extended farther updip than that mapped by Aadland and others (1995). Because the sediments of the Gordon aquifer are correlated farther updip than the Gordon confining unit (fig. 11), the top of the Gordon aquifer in most of Aiken, Richmond, and the upper part of Jefferson Counties is the top of the Congaree (Huber) Formation (Nystrom and others, 1986; Hetrick, 1992; Prowell, 1994). The aquifer thickens from the northwest to the southeast, with notable exception at 30Z017 (Millers Pond), 33X037 (Millhaven Buena Vista #1), AL-47 (Groton Plantation), and BW-417 (SRS P-24) (figs. 4, 14 at end of report).

Intergranular porosity in the sand and calcareous sand is estimated to be 25 to 35 percent. However, calcareous clay matrix in the Girard and Millhaven sections, and clay matrix in the updip Millers Pond section, occludes 5 to 10 percent of the porosity in a few sand beds. Pelecypod moldic porosity in the sandy limestone beds at Girard and Millhaven varies from 5 to 40 percent. Transmissivities are reported to be 180 and 3,500 ft^2/d at the Thompson Oak and Brighams Landing sites, respectively (Peter G. Luetkehans and Rex A. Hodges, Clemson University, written commun., 1995, 1996). The hydraulic conductivity of the Gordon aquifer for these two sites is estimated to be 2 and 36 ft/d, respectively. Transmissivity and hydraulic conductivity at two SRS production wells in Barnwell County are 180 and 1,600 ft^2/d, and 2 to 18 ft/d (table 5). Wells were not completed in the Gordon aquifer at Millers Pond, Girard, and Millhaven.

Millers Pond Confining Unit

The Millers Pond confining unit is named herein for its occurrence at the Millers Pond testhole locality in Burke County, Georgia. The Millers Pond confining unit is equivalent to the unnamed confining unit at the top of the original Dublin aquifer system (Clarke and others, 1985) and a clay in the uppermost part of the Crouch Branch confining unit of the Meyers Branch confining system (Aadland and others, 1995) (figs. 3, 15 at end of report). The Millers Pond confining unit separates the finer sand of the Gordon aquifer from the coarser sand of the Millers Pond aquifer (figs. 5, 6, 7) and consists of the clay and sandy clay at the top of the Snapp Formation (fig. 3). The unit does not crop out in the study area and is absent in most of Richmond, Jefferson, and Aiken Counties. An updip limit for the confining unit was chosen near the Pen Branch Fault in South Carolina because the unit can be recognized in most of the testholes that are located downdip of the Pen Branch Fault on the SRS. The Snapp Formation has been described in a few wells as far updip as Upper Three Runs Creek in Aiken County (Fallaw and Price, 1995), but is inconsistently recognized in this area. The white clay of the Millers Pond confining unit is absent in eastern Barnwell and Allendale Counties and at the down dip end of Screven County. The Miller Pond confining unit generally is less than 25 ft thick, except near 33Y011 (Georgia Power VG-8) and AL-41 (Town of Millet) (figs. 4, 16 at end of report). The vertical hydraulic conductivity of the Millers Pond confining unit is not known.

Millers Pond Aquifer

The Millers Pond aquifer is named herein for its occurrence at the Millers Pond testhole locality in Burke County, Georgia. The Millers Pond aquifer is equivalent to the aquifer in the Paleocene sediment of the Dublin aquifer system (Clarke and others, 1985) and an aquifer zone in the Crouch Branch confining unit (Aadland and others, 1995). However, an equivalent hydrogeologic unit has not been mapped in previous studies. The aquifer includes the sands of the Snapp Formation and the upper part of the Ellenton Formation at Millers Pond (fig. 5) and consists of the sand in the Snapp Formation at Girard and Millhaven (figs. 6, 7).

The Millers Pond aquifer does not crop out in the study area. Its northern, updip extent is roughly equivalent to the Millers Pond confining unit (fig. 17 at end of report). Core descriptions and geophysical log data indicate that the Snapp Formation is absent in much of eastern Barnwell and Allendale Counties. Fallaw and Price (1995) and Gellici and others (1995) identified the Snapp Formation in cored sections from BW-349 (SCDNR C-6) and BW-357 (SCDNR C-5) in eastern Barnwell County. The Snapp Formation in these two testholes is glauconitic and considered to be a transitional lithofacies to the Williamsburg Formation (Fallaw and Price, 1995; Gellici and others, 1995). In this study, however, the Millers Pond aquifer is correlated to only the non-glauconitic lithology of the Snapp Formation in BW-357 (295 to 285 ft below land surface) and is not recognized in BW-349. The glauconitic lithologies at these two sites are interpreted to be part of the overlying Fourmile Branch/Congaree/Warley Hill unit and included in the Gordon aquifer in this report. The maximum thickness of the Millers Pond aquifer is 82 ft at 33Y007 (Georgia Power VG-6) in eastern Burke County (figs. 4, 18 at end of report). In most of the study area, the unit is less than 50 ft thick.

Intergranular porosity is estimated to be 25 to 35 percent. The white clay matrix forms a thin coating on individual sand grains and occludes intergranular pores in a few thin clayey sand beds. Transmissivity of 270 ft^2/d and hydraulic conductivity of 7 ft/d were determined from an aquifer test at the Millers Pond site (Snipes and others, 1995; Kidd, 1996).

Upper Dublin Confining Unit

The black laminated clay of the Ellenton Formation is informally named the upper Dublin confining unit in this study (figs. 5, 6, 7). The Ellenton clay was identified by Clarke and others (1985) as a localized confining unit within the Dublin aquifer system in eastern Georgia near the Savannah River. Aadland and others (1992, 1995) included this clay interval as part of the Crouch Branch confining unit of the Meyers Branch confining system. The altitude of the top of the upper Dublin confining unit is roughly equivalent to the top of the Crouch Branch confining unit in updip areas where the Millers Pond confining unit and aquifer are absent. Outcrops of the Ellenton Formation (Prowell, 1994) are used to map an approximate updip limit for the confining unit in Aiken and Richmond Counties (fig. 19 at end of report). The unit generally thickens from the northwest to the southeast and has a maximum thickness in the study area of 250 ft in 34U001 (McCain-Pryor Corporation) in southeastern Screven County (figs. 4, 20 at end of report). The confining unit is absent beneath part of Hollow Creek in South Carolina.

The vertical hydraulic conductivity of the upper Dublin confining unit at the Girard and Millhaven ranges from 10^{-2} to 10^{-5} ft/d (Leeth and others, 1996; Clarke and others, 1996). Leakance ranges from 10^{-4} to 10^{-7}/d at Girard and Millhaven. Aadland and others (1995) reported leakance to range from 10^{-5} to 10^{-6}/d in the Crouch Branch confining unit.

Upper Dublin Aquifer

Sand and interbedded clay that underlie the black laminated clay of the Ellenton Formation and the sand and clay of the Steel Creek Formations are informally named the upper Dublin aquifer (figs. 5, 6, 7). The upper Dublin aquifer contains more clay matrix than the overlying Millers Pond and underlying lower Dublin aquifers, and the sand is more poorly sorted compared to the sand of the lower Dublin aquifer. The upper Dublin aquifer is hydrogeologically equivalent to the upper part of the Cretaceous aquifer of the Dublin aquifer system (Clarke and others, 1985) and part of the Crouch Branch confining unit (Aadland and others, 1995) (fig. 3). Although most of the Steel Creek Formation at P-21/P5R is clay, the kaolin beds are discontinuous across the study area and commonly are correlated to sections of sand and clayey sand in the Georgia testholes and other parts of the study area (fig. 9). The approximate updip limit of the upper Dublin aquifer is in the same general position as the updip limit of the upper Dublin confining unit (figs. 20, 21 at end of report). The unit is thickest across lower Burke County, upper Screven County, and central Allendale County, where the total thickness of the unit exceeds 100 ft (fig. 22 at end of report).

Intergranular porosity ranges from 10 to 20 percent. The aquifer has an estimated transmissivity of 50 ft^2/d (Snipes and others, 1995; Kidd, 1996) and hydraulic conductivity of 0.7 ft/d at Millers Pond.

Lower Dublin Confining Unit

Where the Steel Creek Formation is known to be present in the subsurface, a thick-white clay is commonly observed near the base of the Steel Creek Formation and is informally named the lower Dublin confining unit (figs. 5, 6, 7). The Steel Creek Formation pinches out at roughly the 50-ft contour of the top of the lower Dublin confining unit (fig. 23 at end of report). North and west of the updip limit of the Steel Creek Formation, beds of kaolin at the top of the Black Creek Group in Aiken, Richmond, and most of Jefferson Counties (Prowell, 1994) form the lower Dublin confining unit. The approximate updip limit of the lower Dublin confining unit is east of Horse Creek in Aiken County and south of Butler Creek in Richmond County (figs. 4, 23). The confining unit separates the sands of the upper and lower Dublin aquifers. The clay in the confining unit was originally included in the Dublin aquifer in Georgia (Clarke and others, 1985) and the Crouch Branch aquifer in South Carolina (Aadland and others, 1995). The lower Dublin confining unit is generally less than 50 ft thick, with notable exception in the center of Burke County and western-most Allendale County, where the thickness exceeds 50 ft (fig. 24 at end of report).

A vertical hydraulic conductivity of 10^{-5} ft/d was determined from laboratory analysis of a sample from the Girard core (Leeth and others, 1996). Leakance is estimated to be 10^{-6}/d.

Lower Dublin Aquifer

A thin unit of sand in the lower part of the Steel Creek Formation beneath the lower Dublin confining unit and sand in the upper part of the Black Creek Group are informally named the lower Dublin aquifer. The sand of the lower Dublin aquifer in the Black Creek Group at Girard and Millhaven is in subunit 3 and the upper part of subunit 2 and is moderately to well-sorted with very minor amounts of clay matrix (figs. 6, 7). The aquifer at Millers Pond is coarser and consists of poorly sorted, fine to very coarse sand and interbedded clay (fig. 5). The lower Dublin aquifer is hydrogeologically equivalent to the lower part of the Cretaceous aquifer of the Dublin aquifer system (Clarke and others, 1985), and most of the Crouch Branch aquifer (Aadland and others, 1995). The updip limit of the lower Dublin aquifer (fig. 25 at end of report) is roughly equivalent to that of the lower Dublin confining unit. The unit generally ranges in thickness from 75 to 175 ft and has a maximum thickness of 205 ft at BW-430 (SRS P-27) in Barnwell County (figs. 4, 26 at end of report).

Intergranular porosity is estimated to be 20 to 35 percent at Girard and Millhaven. Clay matrix at Millers Pond varies from 5 to 20 percent by volume and occludes intergranular pores in a few beds. Transmissivity ranges from 57 ft^2/d at Millers Pond to 8,900 ft^2/d at Brighams Landing (Snipes and others, 1995, 1996; Kidd, 1996) (table 5). Hydraulic conductivity ranges from 0.4 ft/d at Millers Pond to 56 ft/d at Brighams Landing. Aadland and others (1995) reported transmissivity for the Crouch Branch aquifer ranged from 4,500 to 19,000 ft^2/d.

Upper Midville Confining Unit

The laminated black clay in subunit 2 of the Black Creek Group and a correlative clay in updip strata of the Black Creek Group (undivided) are informally named the upper Midville confining unit. The upper Midville confining unit separates the lower Dublin and upper Midville aquifers and consists of a 161-ft laminated black clay at Millhaven (fig. 7), a section of interbedded clay and sand at Girard (fig. 6), and thickly bedded, oxidized clay in the Millers Pond core (fig. 5). The upper Midville confining unit is hydrogeologically equivalent to the confining unit between the original Dublin and Midville aquifer systems (Clarke and others, 1985) and is equivalent in most places to the McQueen Branch confining unit of the Allendale confining system (Aadland and others, 1995). The top of the upper Midville confining unit corresponds to the top of the McQueen Branch confining unit, except in several of the SRS testholes in the Upper Three Runs Creek and Pen Branch Fault areas (Aadland and others, 1995); the top of the upper Midville confining unit in this area of the SRS is higher than the top of the McQueen Branch confining unit to include more of the black clays and silts of the Black Creek Group in the upper Midville confining unit. The confining unit is absent beneath the alluvium of Horse and Little Horse Creeks, and along parts of Shaw Creek and the Edisto River (Nystrom and others, 1986; Prowell, 1994;) (figs. 4, 27 at end of report).

The upper Midville confining unit is also absent beneath the Savannah River valley between Butler Creek and the Savannah River. The unit thickens from the northwest to the southeast with a maximum thickness of 173 ft at AL-348 (SCDNR C-10) in Allendale County (figs. 4, 28 at end of report).

Laboratory results for vertical hydraulic conductivity range from 10^{-3} to 10^{-6} ft/d at Girard and Millhaven (Leeth and others, 1996; Clarke and others, 1996). Leakance ranges from 10^{-4} to 10^{-7}/d. Aadland and others (1995) reported a range of leakance from 10^{-5} to 10^{-6}/d for the McQueen Branch confining unit.

Upper Midville Aquifer

The sand in the lower part of the Black Creek Group (undivided) at Millers Pond (fig. 5), and the sand of subunit 1 and the lower part of subunit 2 of the Black Creek Group at Girard and Millhaven (figs. 6, 7) are informally named the upper Midville aquifer. The upper Midville aquifer of this report is hydrogeologically equivalent to the upper part of the Midville aquifer system in Georgia (Clarke and others, 1985) and the McQueen Branch aquifer in South Carolina (Aadland and others, 1992, 1995). The upper Midville aquifer extends across the entire study area, with the exception of a few creek and stream valleys in Aiken and Richmond Counties. Its approximate updip limit is the Fall Line (fig. 29 at end of report). The top of the upper Midville aquifer is roughly equivalent to the top of the McQueen Branch aquifer (Aadland and others, 1995). The top of the upper Midville aquifer is chosen at a higher altitude at Millers Pond and a lower altitude at Thompson Oak, as compared to the McQueen Branch aquifer. A few Georgia wells penetrate the upper Midville aquifer and indicate that the unit in most of the Georgia study area thickens from the Fall Line to 102 ft in eastern Screven County. In South Carolina, the upper Midville aquifer thickens from the Fall Line to more than 75 ft in eastern Aiken County and varies considerably in thickness on the SRS. The unit has a maximum thickness of 110 ft in northeastern Barnwell County and at BW-243 (SRS P-13) on the SRS (figs. 4, 30 at end of report).

Intergranular porosity is estimated at 20 to 35 percent. The sand is very fine to coarse and contains 5 to 10 percent clay matrix. The upper Midville aquifer at the Millers Pond site has a reported transmissivity of 1,570 ft^2/d (Snipes and others, 1995; Kidd, 1996) and a hydraulic conductivity of 30 ft/d (table 5). Wells are not screened in this unit at the other Georgia sites.

Lower Midville Confining Unit

Interbedded clay and clayey sand that form the upper part of the Middendorf Formation are informally named the lower Midville confining unit. The lower Midville confining unit separates the upper and lower aquifers in the Midville aquifer system (figs. 5, 6, 7). The Black Creek Group-Middendorf Formation contact is a mappable horizon across the entire study area and a convenient stratigraphic marker to split both the Midville aquifer system of Georgia (Clarke and others, 1985) and the McQueen Branch aquifer of South Carolina (Aadland and others, 1995) into upper and lower parts. The lower Midville confining unit extends to the Fall Line (fig. 31 at end of report), but is absent due to erosion in a few creek and river valleys in Aiken and Richmond Counties. Regionally, the confining unit is generally less than 50 ft thick and highly variable in thickness locally (fig. 32 at end of report). The vertical hydraulic conductivity of the lower Midville confining unit is not known.

Lower Midville Aquifer

The sand in the Middendorf Formation and a porous, permeable sand interval that locally occurs in the upper 10 to 20 ft of the Cape Fear Formation, as observed at P-21/P5R and Girard, are herein named the lower Midville aquifer (figs. 3, 5, 6, 7). The lower Midville aquifer consists of beds of fine to very coarse and fine to medium sand with generally less than 5 percent clay matrix. The lower Midville aquifer is equivalent to the lower part of the Midville aquifer system of Georgia (Clarke and others, 1985) and the lower part of the McQueen Branch aquifer of South Carolina (Aadland and others, 1992, 1995). This aquifer extends across the entire study area, but locally is absent beneath a few creek and stream valleys (fig. 33 at end of report). The lower Midville aquifer generally thickens southeastward from the Fall Line and has a maximum thickness of 228 ft in 34U001 (McCain-Pryor Corporation) in eastern Screven County (figs. 4, 34 at end of report).

The lower Midville aquifer is texturally similar to the upper Midville aquifer. Intergranular porosity is estimated to be 30 to 35 percent. Reported transmissivity in Burke and Screven Counties ranges from 1,100 ft^2/d at Girard to 15,000 ft^2/d at Brighams Landing (Snipes and others, 1995, 1996; Kidd, 1996) (table 5). Hydraulic conductivity ranges from 6 ft/d at Girard to 80 ft/d at Brighams Landing. Transmissivities of 7,400 and 16,100 ft^2/d, and hydraulic conductivities of 74 and 145 ft/d, were calculated from aquifer-test data for two production wells in western Aiken County (table 5). Long-term aquifer tests at three SRS production wells yield transmissivities of 9,300; 17,000; and 19,000 ft^2/d and hydraulic conductivities of 65; 120; and 140 ft/d (Snipes and others, 1996).

Basal Confining Unit

The low-porosity, low-permeability sediments that characterize most of the Cape Fear Formation and the saprolite at the top of the crystalline bedrock that underlies the Coastal Plain strata are informally named the basal confining unit. The basal confining unit separates the lower Midville aquifer from fractured bedrock and is equivalent to the Appleton confining system (Aadland and others, 1995) and the unnamed confining unit that underlies the Midville aquifer system (Clarke and others, 1985) (fig. 35 at end of report). The upper contact for the basal confining unit is recognized on geophysical logs as a sharp change from the low resistivity of the basal confining unit to the high resistivity of the lower Midville aquifer. Maps showing the altitude of the pre-Cretaceous unconformity (Wait and Davis, 1986; Snipes and others, 1993; Aadland and others, 1995), top of the confining unit beneath the Midville aquifer system (Clarke and others, 1985), top of the Appleton confining system (Aadland and others, 1995), and top of the basal confining unit were used to locate the approximate updip limit of the Cape Fear Formation at the 300-ft contour line of the basal confining unit (fig. 35). Northwest of the 300-ft contour line, the basal confining unit consists of only the saprolite at the top of crystalline bedrock. The Fall Line represents the updip limit of the basal confining unit.

Cristobalitic clay matrix occludes most intergranular porosity in the Cape Fear sand beds and contributes to the hard, dense lithologies in the basal confining unit. Intergranular porosity of generally less than 10 percent is observed in only a few sand beds. Although intergranular porosity is low and the vertical hydraulic conductivity of the basal confining unit lithologies is assumed to be low, extension of basement faults into the overlying Coastal Plain strata has been documented in the study area (Prowell and O'Connor, 1978; Faye and Prowell, 1982; Snipes and others, 1993; Stieve and Stephenson, 1995) and could induce fracturing of the partially lithified Coastal Plain strata in the basal confining unit. Fractures in the basal confining unit could enhance the vertical hydraulic connection between the underlying fractured-bedrock aquifer and the overlying lower Midville aquifer.

Depositional Control on Confining Units

Assumptions about the lateral continuity of a fine-grained lithologic unit, and the potential for the fine-grained lithology to function as a confining unit, were initially made on the basis of stratigraphy and depositional environment. As discussed in the previous unit descriptions, paleontologic, lithologic, and geophysical data were used to stratigraphically constrain the correlation a fine-grained lithology across the study area. The paleontologic and lithologic data were also used to classify each fine-grained lithologic unit as nonmarine and marine deposits.

The fine-grained sediments of the Millers Pond, lower Dublin, and lower Midville confining units accumulated in nonmarine environments at the top of the Snapp Formation, the bottom of the Steel Creek Formation, and the top of the Middendorf Formation. In an alluvial valley or upper delta plain environment, suspended sediment is commonly dispersed during flooding and settles on flood plains as fine-grained deposits. However, reworking of flood-plain deposits by channels in a fluvially dominated environment typically form lenticular deposits of fine- and coarse-grained sediments that are laterally discontinuous. Although the clay in these units has very low vertical hydraulic conductivity and can be correlated across most of the study area on the basis of stratigraphic position, these units are assumed to be laterally discontinuous confining units that are only capable of locally impeding leakage.

The fine-grained sediments of the Gordon and upper Dublin confining units were deposited in the open marine environment of the Tinker/Santee unit and the marine-influenced part of the Ellenton delta. Settling of suspended sediments in lower delta plains and open marine environments can produce areally extensive deposits of fine sediment. In addition to well-developed clay laminae, mica and lignite are commonly oriented with bedding and contribute to the low vertical conductance of the sand and clay parts of the upper Dublin confining unit. The marl and clay of the Gordon and upper Dublin confining units are laterally more continuous and are more effective at impeding leakage when compared to the Millers Pond, lower Dublin, and lower Midville confining units. Incision by overlying alluvial sediments of the Snapp Formation has reduced the thickness of the Ellenton clay in eastern Burke and western Allendale Counties (fig. 9) and could locally reduce this effectiveness of the upper Dublin confining unit.

The fine-grained sediments of the upper Midville confining unit were deposited in the marine environments of the Black Creek Group in the intermediate and downdip sections, and a fluvially dominated, nonmarine part of the delta in the updip sections. The nonmarine depositional environment of the updip sediments is similar to that of the discontinuous fine-grained sediments of the Millers Pond, lower Dublin, and lower Midville confining units and results in a confining unit that is capable of locally impeding leakage. The marine deposition of the intermediate and downdip sections is similar to that of the upper Dublin confining unit and results in a laterally continuous confining unit that is capable of impeding leakage across the study area.

HYDRAULIC ASSESSMENT OF HYDROGEOLOGIC FRAMEWORK

So far, the correlation and lateral continuity of the intervening confining units have been geologically defined. In this section, static water-level data collected at six South Carolina cluster sites (Bledsoe, 1987, 1988) and aquifer-test drawdown response at the Miller Pond site (Clarke and others, 1994; Snipes and others, 1995) are used to qualitatively evaluate leakage across the Gordon confining unit and the five intervening confining units of the Dublin and Midville aquifer systems.

Monitoring wells were installed at the Georgia testhole sites for the purpose of collecting hydraulic data; however, none of the Georgia sites were designed to provide data for all of the different aquifers and confining units described in this report (table 6). Several SRS monitoring-well clusters discretely monitor each aquifer and were selected to evaluate the degree of confinement between aquifers (fig. 1).

Static Water-Level Data

Six South Carolina sites are located in close proximity to areas of local and regional ground-water recharge (P-19 and P-30) and ground-water discharge (P-21, P-22, P-23, and P-26) (fig. 1). At least one monitoring well is screened in each of the seven aquifers at P-21, P-22, and P-23, and in each of the six aquifers at the P-19, P-26, and P-30 sites. Recharge and discharge in the vicinity of these sites create a vertical flow component in the ground-water-flow system. A large difference in static water-level altitudes between adjacent aquifers, defined as greater than 3 ft in this report, indicates that the vertical flow component is significantly impeded by the intervening confining unit (table 6).

Static water levels for the SRS monitoring well sites were measured as part of a synoptic water-level survey of the study area in May 1992, but several water wells used for industrial supply are located in the study area and may directly influence water levels at the six SRS monitoring well sites. Production wells are located within a 1- mi radius of the P-26 and P-30 sites. The P-19 monitoring well cluster is located in the center of the SRS and is less than 2 mi from several major industrial facilities with production wells. P-21, P-22, and P-23 are located more than 2 mi from the nearest production well.

Water-level data indicate that strong vertical hydraulic gradients are associated with the Gordon, upper Dublin, and upper Midville confining units at most of the specified SRS sites and support the geologic assumption that the marine sediments of these three confining units are laterally continuous and regionally capable of impeding vertical flow, particularly beneath the Savannah River near the SRS (table 6). A large difference in the water-level altitudes of the Upper Three Runs and Gordon aquifers indicates strong downward head gradients across the Gordon confining unit at P-21, P-22, P-23, and P-30 and a recharge potential from the Upper Three Runs aquifer to the Gordon aquifer. The Gordon confining unit is absent at P-26 and is breached by faulting at P-19, where the difference in hydraulic head between the Upper Three Runs and Gordon aquifers is very small. At P-21, P-22, and P-23, a large difference in static water-level altitudes between the Millers Pond and upper Dublin aquifers indicate strong upward head gradients across the upper Dublin confining unit. Water-level altitudes indicate a strong upward head gradient at P-26 and a strong downward head gradient at P-19, where the upper Dublin confining unit separates the Gordon and upper Dublin aquifers. Water-level altitudes also indicate strong upward head gradients at P-21, P-22, P-23, and P-26, and a strong downward head gradient at P-30 where the upper Midville confining unit separates the lower Dublin and upper Midville aquifers.

Conversely, water-level data indicate that weak vertical hydraulic gradients are associated with the Millers Pond, lower Dublin, and lower Midville confining units at most of the specified South Carolina sites and support the geologic assumption that the non-marine sediments of these confining units are laterally discontinuous and leaky across most of the study area (table 6). Strong vertical hydraulic gradients are only associated with the Millers Pond confining unit at P-23, the lower Dublin confining unit at P-26, and the lower Midville confining unit at P-26 and P-30.

Drawdown Response

Seven 72-hour aquifer tests were conducted at the Millers Pond site in Georgia in which drawdown responses were monitored in the pumping and observation wells (Clarke and others, 1994; Snipes and others, 1995; Kidd, 1996) (table 7). Each well at the Millers Pond site is screened in a different part of the hydrogeologic section, including the Upper Three Runs (TW-4 well), Millers Pond (TW-5a well), upper Dublin (TW-6 well), lower Dublin (TW-7 well), upper Midville (TW-3), and lower Midville (TW-2 and TW-1 wells) aquifers. A well was not screened in the thin sand interval of the Gordon aquifer. For this discussion, the drawdown responses in observation wells are used to qualitatively interpret the potential for leakage across the upper and lower Dublin confining unit, and the upper and lower Midville confining units.

Aquifer tests of wells screened in the Dublin and Midville aquifers induced drawdown responses in observation wells screened in adjacent parts of the Dublin and Midville aquifers, but induced no measurable drawdown (less than 0.01 ft) in the Millers Pond aquifer. The aquifer test of the Millers Pond aquifer induced no measurable drawdown in the wells screened in the underlying Dublin and Midville aquifers. The drawdown response of observation wells in these tests suggests that leakage is more easily induced across the lower Dublin, upper Midville, and lower Midville confining units, when compared to the upper Dublin confining unit at the Millers Pond site.

Hydrogeologic Implications of Hydraulic Data

The static water-level data from the selected South Carolina sites and the drawdown response data from the Millers Pond site indicate that the Millers Pond, lower Dublin, and lower Midville confining units are leaky in the trans-river flow study area, when compared to the Gordon, upper Dublin and upper Midville confining units. This means that the upper and lower Dublin aquifers tend to respond to hydraulic stress as one unit. The same is true of the upper and lower Midville aquifers. Although part of the original Dublin aquifer system (Clarke and others, 1985), the hydraulic connection between the Millers Pond aquifer and the upper and lower Dublin aquifers is restricted by the upper Dublin confining unit in the study area.

The few water-level data available for the Millers Pond aquifer indicate that the potentiometric surface for the Millers Pond aquifer at the SRS (not mapped due to limited data) would have greater similarity to the potentiometric surface of the Gordon aquifer and be considerably different from the potentiometric surfaces for the upper and lower Dublin aquifers. This suggests that the Millers Pond aquifer should hydraulically be included as a part of the Gordon aquifer system (Brooks and others, 1985), not as a part of the Dublin aquifer system and not as an isolated aquifer zone in the Crouch Branch confining unit of the Meyers Branch confining system. If so, the upper Dublin confining unit hydraulically defines the base of the Gordon aquifer system beneath the SRS. Because the strata of the Millers Pond confining unit and aquifer are not present west of the Pen Branch Fault, the tops of the Crouch Branch (Aadland and others, 1995) and upper Dublin confining units are the same in this area. However, to the east of the Pen Branch Fault, the tops of the Crouch Branch and upper Dublin confining units are not the same; if contaminants, particularly dense non-aqueous phase liquids, were to enter the Gordon aquifer system in this part of the SRS, the upper Dublin confining unit, not the leaky Millers Pond confining unit, probably represents a better barrier to the downward movement of contaminants.

SUMMARY AND CONCLUSIONS

Geologic and hydrogeologic frameworks were developed for east-central Georgia and west-central South Carolina to aid an investigation designed to evaluate the potential for ground water that enters or flows beneath the U.S. Department of Energy Savannah River Site in South Carolina to discharge on the Georgia side of the Savannah River, referred to as trans-river flow. Principle geologic and hydrogeologic units in testholes located in Burke and Screven Counties, Georgia, were correlated across five primary counties in Georgia and three primary counties in South Carolina.

Nine geologic units in east-central Georgia are identified as the Cape Fear Formation, the Middendorf Formation, the Black Creek Group, and the Steel Creek Formation of Late Cretaceous age, and the Ellenton Formation, the Snapp Formation, the Fourmile Branch/Congaree/Warley Hill unit, the Tinker/Santee unit, and the Barnwell unit of Tertiary age. The Middendorf Formation and the Black Creek Group are divided into subunits. The geologic units provide a spatial framework for the identification and correlation of the Upper Three Runs aquifer, the Gordon confining unit, the Gordon aquifer, five aquifers and five confining units in the Dublin and Midville aquifer systems, and a basal confining unit.

The clastic and mixed-clastic-carbonate Coastal Plain sections of the Upper Three Runs and Gordon aquifers and the Gordon confining unit consist of sediments of Eocene and younger age in the updip and central part of the study area. Fine grained lithofacies in the Tinker/Santee unit comprise the Gordon confining unit; these facies grade southeastward from an updip clastic to a downdip carbonate section. Collectively, these strata delineate the base of the Upper Three Runs aquifer and the top of the Gordon aquifer.

The hydrogeology of east-central Georgia is revised to include the Millers Pond, upper Dublin, and lower Dublin aquifers and confining units in the original Dublin aquifer system, and the upper and lower Midville aquifers and confining units in the original Midville aquifer system. The Millers Pond confining unit and aquifer are formally recognized in this report at the type locality of the Millers Pond testhole in Burke County, Georgia. The upper and lower Dublin, and upper and lower Midville units are informally defined. These revisions provide greater hydrogeologic resolution for the confined aquifer systems in the vicinity of the SRS for the investigation of trans-river flow. Each of the aquifers in the Dublin aquifer system can be differentiated from adjacent aquifers on the basis of grain size, sorting, the amount and distribution of clay matrix, and porosity. The sediments of the two aquifers in the Midville aquifer system are texturally similar and are correlated on the basis of stratigraphic position relative to the top of the Middendorf Formation.

The fine-grained sediments of the Millers Pond, lower Dublin, and lower Midville confining units were deposited in nonmarine environments and tend to be lenticular rather than widespread units of low permeability. These three confining units are leaky but locally impede vertical flow between adjacent aquifers. The fine-grained sediments of the Gordon confining unit were deposited in shallow nearshore and offshore marine environments and form a laterally continuous unit of low vertical permeability. The fine-grained sediments of the upper Dublin and upper Midville confining units were deposited in marine-influenced parts of deltaic environments. The Gordon and upper Dublin confining units are interpreted as regional confining units in the parts of the study area where they are mapped. The upper Midville confining unit is interpreted as a confining unit in middle and downdip sections, and as a leaky confining unit in the updip sections.

The upper Dublin confining unit hydraulically restricts the Millers Pond aquifer from the upper and lower Dublin aquifers. The Millers Pond confining unit is leaky. Therefore, the upper Dublin confining unit hydraulically defines the base of a revised Gordon aquifer system that includes the Gordon and Millers Pond aquifers. Because the strata of the Millers Pond confining unit and aquifer are not present west of the Pen Branch Fault, the tops of the Crouch Branch confining unit and upper Dublin confining unit are the same in this area. However, to the east of the Pen Branch Fault, the tops of the Crouch Branch and upper Dublin confining units are not the same; if contaminants, particularly dense non-aqueous phase liquids, were to enter the Gordon aquifer in this part of the SRS, the upper Dublin confining unit, not the Millers Pond confining unit, would act as a better barrier to the downward movement of contaminants.

The strata of the upper Dublin aquifer are texturally different from the lower Dublin aquifer across most of the study area; however, the two aquifers generally respond as one to hydraulic stress. The strata of the upper and lower Midville aquifers are texturally similar; the two aquifers also respond as one to hydraulic stress.

Additional long-term aquifer tests at the P-21, P-22, and P-23 sites are needed to evaluate leakage across the Millers Pond, lower Dublin, and lower Midville confining units. At present, these three sites are the only localities in the study area where all of seven aquifers are present and monitored by observation wells.

REFERENCES

Aadland, R.K., Thayer, P.A., and Smits, A.D., 1992, Hydrostratigraphy of the Savannah River Site region, South Carolina and Georgia: *in* Price, Van, and Fallaw, W.C. eds., 1992, Geological Investigations of the central Savannah River area, South Carolina and Georgia: Carolina Geological Society field trip guidebook, November 13-15, 1992, 105 p.

Aadland, R.K., Gellici, J.A., and Thayer, P.A., 1995, Hydrogeologic framework of west-central South Carolina: South Carolina Department of Natural Resources, Water Resources Division Report 5, 200 p., 47 plates.

American Society for Testing and Materials, 1990, Standard test method for measurement of hydraulic conductivity of saturated porous materials using a flexible wall permeameter (ASTM-D-5084-90): Philadelphia, Pa., 8 p.

Bechtel Corporation, 1972, Applicants environmental report, volumes I and II - Alvin W. Vogtle Nuclear Plant: Unpublished report for Georgia Power Company, Atlanta, Ga.: Report on file at U. S. Geological Survey, Atlanta, Ga.

———1973, Preliminary safety analysis report, volumes II and III - Alvin W. Vogtle Nuclear Plant: Unpublished report for Georgia Power Company, Atlanta, Georgia: Report on file at U. S. Geological Survey, Atlanta, Ga.

———1982, Studies of postulated Millett fault, Georgia Power Company Vogtle Nuclear Plant: Unpublished report, v. 1 and v. 2: Report on file at the U. S. Geological Survey, Atlanta, Ga.

Bledsoe, H.W., 1984, SRP baseline hydrogeologic investigation--Phase I: E.I. duPont de Nemours & Co., Savannah River Laboratory, Aiken, S.C., DPST-84-833, 102 p.

———1987, SRP baseline hydrogeologic investigation--Phase II: E.I. duPont de Nemours & Co., Savannah River Laboratory, Aiken, S.C., DPST-86-674, 293 p.

———1988, SRP baseline hydrogeologic investigation--Phase III: E.I. duPont de Nemours & Co., Savannah River Laboratory, Aiken, S.C., DPST-88-627, 294 p.

Bledsoe, H.W., Aadland, R.K., and Sargent, K.A., 1990, SRS baseline hydrogeologic investigation--summary report: Westinghouse Savannah River Company, Savannah River Site, Aiken, S.C., WSRC-RP-90-1010, 435 p.

Brantley, J.E., 1916, A report on the limestones and marls of the Coastal Plain of Georgia: Georgia Geological Survey Bulletin 21, 300 p.

Brooks, Rebekah, Clarke, J.S., and Faye, R.E., 1985, Hydrogeology of the Gordon aquifer system of east-central Georgia: Georgia Geologic Survey Information Circular 75, 41 p.

Buie, B.F., 1978, The Huber Formation of eastern-central Georgia, in Short contributions to the geology of Georgia: Georgia Geologic Survey Bulletin 93, p. 1-7.

Cahill, J.M., 1982, Hydrology of the low-level radioactive solid waste burial site and vicinity near Barnwell, South Carolina: U.S. Geological Survey Open-File Report 82-863, 109 p.

Carver, R.E., 1972, Stratigraphy of the Jackson Group in eastern Georgia: Southeastern Geology, v. 14, p. 153-181.

Christl, R.J., 1964, Storage of radioactive wastes in basement rock beneath the Savannah River Plant: E. I. DuPont de Nemours and Co., Report DP-844, 105 p.

Christopher, R.A., 1978, Quantitative palynologic correlation of three Campanian and Maastrichtian sections (Upper Cretaceous) from the Atlantic Coastal Plain: Palynology, v. 2, p. 1-27.

———1982, Palynostratigraphy of the basal Cretaceous units of the eastern Gulf and southern Atlantic Coastal Plains, in Arden, D.D., Beck, B.F., and Morrow, E., eds., Second symposium of the geology of the southeastern Coastal Plain proceedings: Georgia Geologic Survey Information Circular 53, p. 10-23.

Christopher, R.A., Owens, J.P., and Sohl, N.F., 1979, Late Cretaceous palynomorphs from the Cape Fear Formation of North Carolina: Southeastern Geology, v. 20, no. 3, p. 145-159.

Clarke, J.S., Brooks, Rebekah, and Faye, R.E., 1985, Hydrogeology of the Dublin and Midville aquifer systems of east central Georgia: Georgia Geologic Survey Information Circular 74, 62 p.

Clarke, J.S., Falls, W.F., Edwards, L.E., Frederiksen, N.O., Bybell, L.M., Gibson, T.G., and Litwin, R.J., 1994, Geologic, hydrologic and water-quality data for a multi-aquifer system in Coastal Plain sediments near Millers Pond, Burke County, Georgia: Georgia Geologic Survey Information Circular 96, 34 p.

Clarke, J.S., Falls, W.F., Edwards, L.E., Bukry, David, Frederiksen, N.O., Bybell, L.M., Gibson, T.G., Gohn, G.S., and Flemming, Farley, 1996, Hydrogeologic data and aquifer interconnectiveness in a multi-aquifer system in Coastal Plain sediments near Millhaven, Screven County, Georgia: Georgia Geologic Survey Information Circular 99, 43 p.

Colquhoun, D.J., coordinator, 1991, Southeastern Atlantic regional cross section, eastern and offshore, South Carolina and Georgia sector: American Association of Petroleum Geologists, Tulsa, Okla.

———1992, Observations on general allostratigraphy and tectonic framework of the southeastern Atlantic coast regional cross section (DNAG E-5 corridor) Georgia and South Carolina as they relate to the Savannah River Site, in Fallaw, W.C., and Price, Van, eds., Carolina Geological Society field trip guidebook, November 13-15, 1992, Geological investigations of the central Savannah River area, South Carolina and Georgia: U.S. Department of Energy and South Carolina Geological Survey, p. CGS-92-B-I-1-8.

Colquhoun, D.J., Woollen, I.D., Van Nieuwenhuise, D.S., Padgett, G.G., Oldham, R.W., Boylan, D.C., Bishop, J.W., and Howell, P.D., 1983, Surface and subsurface stratigraphy, structure and aquifers of the South Carolina Coastal Plain: Columbia, South Carolina, Department of Geology, University of South Carolina, Report to the Department of Health and Environmental Control, Ground-water Protection Division, published through the Office of the Governor, State of South Carolina, 79 p.

Colquhoun, D.J., and Steele, K.B., 1985, Chronostratigraphy and hydrostratigraphy of the northwestern South Carolina Coastal Plain: Project No. G868-05, Annual Cooperative Grant Agreement No. 13040 R-83-591, Interim Technical Report to Water Resources Research Institute, Clemson University, Clemson, S.C., 15 p.

Colquhoun, D.J., and Muthig, M.G., 1991, Stratigraphy and structure of the Paleocene and lower Eocene Black Mingo Group, in Horton, J.W., Jr., and Zullo, V.A., eds., Geology of the Carolinas: University of Tennessee Press, Knoxville, Tenn., p. 241-250.

Cooke, C.W., 1936, Geology of the Coastal Plain of South Carolina: U. S. Geological Survey Bulletin 867, 196 p.

———1943, Geology of the Coastal Plain of Georgia: U. S. Geological Survey Bulletin 941, 121 p.

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

Cooke, C.W., and MacNeil, F.S., 1952, Tertiary stratigraphy of South Carolina: U.S. Geological Survey Professional Paper 243-B, p. 19-29.

Cooper, H.H., and Jacob, C.E., 1946, A generalized graphical method for evaluating formation constants and summarizing well field history, Transactions of the American Geophysical Union, v. 27, p. 526-534.

Daniels, D.L., 1974, Geologic interpretation of geophysical maps, central Savannah River area, South Carolina and Georgia: U.S. Geological Survey Geophysical Investigations Map GP-893, 3 sheets, scale 1:250,000.

Dennehy, K.F., Prowell, D.C., and McMahon, P.B., 1989, Geohydrology of the Defense Waste Processing Facility and vicinity, Savannah River Plant, South Carolina: U.S. Geological Survey Water-Resources Investigation Report 88-4221, 90 p.

Edwards, L.E., 1992, Dinocysts from the lower Tertiary units in the Savannah River area, South Carolina and Georgia, in Zullo, V.A., Harris, W.B., and Price, Van, eds., Savannah River Region: transition between the Gulf and Atlantic Coastal Plains: Proceedings of the second Bald Head Island Conference on Coastal Plains Geology, Hilton Head Island, November 6-11, 1990, p. 97-99.

Fallaw, W.C., and Price, Van, 1992, Outline of stratigraphy at the Savannah River Site, in Fallaw, W.C., and Price, Van, eds., Geological investigations of the central Savannah River area, South Carolina and Georgia: Carolina Geological Society Field Trip Guidebook, 1992, CGS-92-II-1 - 33.

———1995, Stratigraphy of Savannah River Site and vicinity: Southeastern Geology, v. 35, no. 1, p. 21-58.

Fallaw, W.C., Price, Van, and Thayer, P.A., 1992a, Stratigraphy of the Savannah River Site, South Carolina, in Zullo, V.A., Harris, W.B., and Price, V., eds., Savannah River Region: Transition between the Gulf and Atlantic Coastal Plains: Proceedings of the second Bald Head Island Conference on Coastal Plains Geology, Hilton Head Island, November 6-11, 1990, p. 29-32.

———1992b, Cretaceous lithofacies of the Savannah River Site, South Carolina, in Zullo, V.A., Harris, W.B., and Price, Van, eds., Savannah River Region: Transition between the Gulf and Atlantic Coastal Plains: Proceedings of the second Bald Head Island Conference on Coastal Plains Geology, Hilton Head Island, November 6-11, 1990, p. 50-51.

Falls, W.F., Baum, J.S., and Prowell, D.C., 1997, Physical stratigraphy and hydrostratigraphy of Upper Cretaceous and Paleocene sediments, Burke and Screven Counties, Georgia: Southeastern Geology, v. 36, no. 4, p. 153-176.

Faye, R.E., and Prowell, D.C., 1982, Effects of Late Cretaceous and Cenozoic faulting on the geology and hydrology of the Coastal Plain near the Savannah River, Georgia and South Carolina: U.S. Geological Survey Open-File Report 82-156, 73 p.

Faye, R.E., and McFadden, K.W., 1986, Hydraulic characteristics of Upper Cretaceous and lower Tertiary aquifers--eastern Alabama, Georgia, and western South Carolina: U.S. Geological Survey Water-Resources Investigations Report 86-4210, 22 p.

Faye, R.E., and Mayer, G.C., 1990, Ground-water flow and stream-aquifer relations in the northern Coastal Plain of Georgia and adjacent parts of Alabama and South Carolina: U.S. Geological Survey Water-Resources Investigations Report 88-4143, 83 p.

Gellici, J.A., Reed, R.H., Logan, W.R., Aadland, R.K., and Simones, G.C., 1995, Hydrogeologic investigation and establishment of a permanent multi-observational well network in Aiken, Allendale, and Barnwell Counties, South Carolina -- eight-year interim report (1986-1994), volumes 1 and 2, State of South Carolina Department of Natural Resources, Water Resources Division Open File Report 1, 417 p., 9 plates.

Gohn, G.S., 1992, Revised nomenclature, definitions, and correlations for the Cretaceous Formations in USGS-Clubhouse Crossroads #1, Dorchester County, South Carolina: U.S. Geological Survey Professional Paper 1518, 39 p.

Harrelson, L.G., Falls, W.F., and Clarke, J.S., 1997, Selected well data in the vicinity of the Savannah River Site, South Carolina and Georgia: U.S. Geological Survey Open-File Report 96-657A, 215 p., 12 plates.

Harris, W.B., and Zullo, V.A., 1992, Sequence stratigraphy of Paleocene and Eocene deposits in the Savannah River region: in Zullo, V.A., Harris, W.B., and Price, Van, eds., Savannah River Region: Transition between the Gulf and Atlantic Coastal Plains. Proceedings of the second Bald Head Island Conference on Coastal Plains Geology, Hilton Head Island, November 6-11, 1990, p. 134-142.

Herrick, S.M., 1960, Some small foraminifera from Shell Bluff, Georgia: Bulletins of American Paleontology, v. 41, p. 117-127.

_____ 1961, Well logs of the Coastal Plain of Georgia: Georgia Geologic Survey Bulletin 70, 462 p.

_____ 1964, Upper Eocene small foraminifera from Shell Bluff and Griffins Landing, Burke County, Georgia: U.S. Geological Survey Professional Paper 501-C, p. C64-C65.

_____ 1972, Age and correlation of the Clinchfield Sand of Georgia: U.S. Geological Survey Bulletin 1354-E, 17 p.

Herrick, S.M., and Vorhis, R.C., 1963, Subsurface geology of the Georgia Coastal Plain: Georgia Geologic Survey Information Circular 25, 78 p.

Herrick, S.M., and Counts, H.B., 1968, Late Tertiary stratigraphy of eastern Georgia: Georgia Geological Society, 3d Field Trip Guidebook, 88 p.

Hetrick, J.H., 1992, A geologic atlas of the Wrens-Augusta area: Georgia Geologic Survey Geologic Atlas no. 8, 3 plates.

Huddlestun, P.F., 1982, The development of the stratigraphic terminology of the Claibornian and Jacksonian marine deposits of western South Carolina and eastern Georgia, in Nystrom, P.G., Jr., and Willoughby, R.H., eds., Geological investigations related to the stratigraphy in the kaolin mining district, Aiken County, South Carolina: South Carolina Geological Survey, Carolina Geological Society Field Trip Guidebook, 1982, p. 21-33.

_____ 1988, A revision of the lithostratigraphic units of the Coastal Plain of Georgia, Miocene through Holocene: Georgia Geologic Survey Bulletin 104: 162 p.

_____ 1992, Upper Claibornian coastal marine sands of eastern Georgia and the Savannah River area, in Fallaw, W.C., and Price, Van, eds., Carolina Geological Society field trip guidebook, November 13-15, Geological investigations of the central Savannah River area, South Carolina and Georgia: U.S. Department of Energy and South Carolina Geological Survey, p. CGS-92-B-XII-1-6.

Huddlestun, P.F., and Hetrick, J.H., 1978, Stratigraphy of the Tobacco Road sand - a new formation: Georgia Geologic Survey Bulletin 93, p. 56-77.

_____ 1979, The stratigraphy of the Barnwell Group in Georgia: Georgia Geologic Survey Open File Report 80-1, published for the 14th Field Trip of the Georgia Geological Society, 89 p.

———1986, Upper Eocene stratigraphy of central and eastern Georgia: Georgia Geologic Survey Bulletin 95, 78 p.

———1991, The stratigraphic framework of the Fort Valley Plateau and the central Georgia kaolin district: Georgia Geological Society, Guidebook for the 26th Annual Field Trip, v. 11, no. 1, 119 p.

Huddlestun, P.F., and Summerour, J.H., 1996, The lithostratigraphic framework of the uppermost Cretaceous and lower Tertiary of eastern Burke County, Georgia: Georgia Geologic Survey Bulletin 127, 94 p.

Hurst, V.J., Crawford, T.J., and Sandy, J., 1966, Mineral resources of the Central Savannah River Area: University of Georgia, volumes 1 and 2, 231 p.

Kidd, N.B., 1996, Determination of the hydraulic properties of Coastal Plain aquifers at Millers Pond and Millhaven, east-central Georgia: M.S. thesis, Clemson University, Clemson, South Carolina, 153 p.

Krause, R.E., and Randolph, R.B., 1989, Hydrology of the Floridan aquifer system in southeast Georgia and adjacent parts of Florida and South Carolina: U.S. Geological Survey Professional Paper 1403-D, 64 p.

LaMoreaux, P.E., 1946a, Geology of the Coastal Plain of east-central Georgia: Georgia Geologic Survey Bulletin 50, 26 p.

———1946b, Geology and ground-water resources of the Coastal Plain of east-central Georgia: Georgia Geologic Survey Bulletin 52, 173 p.

Leeth, D.C., Falls, W.F., Edwards, L.E., Frederiksen, N.O., and Fleming R.F., 1996, Geologic, hydrologic and water-quality data for a multi-aquifer system in Coastal Plain sediments near Girard, Burke County, Georgia: Georgia Geologic Survey Information Circular 100, 40 p.

Leeth, D.C., and Nagle, D.D., 1996, Shallow subsurface geology of part of the Savannah River alluvial valley in the upper Coastal Plain of Georgia and South Carolina: Southeastern Geology, v. 36, no. 1, p. 1-14.

LeGrand, H.E., and Furcon, A.S., 1956, Geology and ground-water resources of central-east Georgia: Georgia Geologic Survey Bulletin 64, 164 p.

Logan, W.R., and Euler, G.M., 1989, Geology and groundwater resources of Allendale, Bamberg, and Barnwell Counties and part of Aiken County, South Carolina: South Carolina Water Resources Commission Report 155, 113 p.

Lohman, S.W., 1979, Ground-water hydraulics: U.S. Geological Survey Professional Paper 708, 70 p.

Marine, I.W., 1979, Hydrology of buried crystalline rocks at the Savannah River Plant near Aiken, South Carolina: U.S. Geological Survey Open-File Report 79-1544, 160 p.

Marine, I.W., and Siple, G.E., 1974, Buried Triassic basin in the central Savannah River area, South Carolina and Georgia: Geological Society of America Bulletin, v. 85, p. 311-320.

McClelland, Scott, 1987, Surface and subsurface stratigraphy of Cretaceous and younger strata along the Savannah River from southern Richmond County through Burke County, Georgia: M.S. thesis, University of South Carolina, Columbia, S.C., 70 p.

Miller, J.A., 1986, Hydrogeologic framework of the Floridan aquifer system in Florida, and in parts of Georgia, Alabama, and South Carolina: U.S. Geological Survey Professional Paper 1403-B, 91 p.

Nystrom, P.G., Jr., and Willoughby, R.H., 1982, Geological investigations related to the stratigraphy in the kaolin mining district, Aiken County, South Carolina: South Carolina Geological Survey, Carolina Geological Society Field Trip Guidebook, 1982, 183 p.

———1992, Claibornian stratigraphy of the Savannah River Site and surrounding area, in Zullo, V.A., Harris, W.B., and Price, Van, eds., Savannah River Region: Transition between the Gulf and Atlantic Coastal Plains: Proceedings of the second Bald Head Island Conference on Coastal Plains Geology, Hilton Head Island, November 6-11, 1990, p. 56-61.

Nystrom, P.G., Jr.,Willoughby, R.H., and Kite, L.E., 1986, Cretaceous-Tertiary stratigraphy of the upper edge of the Coastal Plain between North Augusta and Lexington, South Carolina: South Carolina Geological Survey, Carolina Geological Society Field Trip Guidebook for 1986, 82 p.

Nystrom, P.G., Jr.,Willoughby, R.H., and Price, L.K., 1991, Cretaceous and Tertiary stratigraphy of the upper Coastal Plain, South Carolina, in Horton, J.W., Jr., and Zullo, V.A., eds., Geology of the Carolinas: University of Tennessee Press, Knoxville, Tennessee, p. 221-240.

Owens, J.P., 1989, Geology of the Cape Fear arch, Florence 2 degree sheet and northern half of Georgetown 2 degree sheet, North and South Carolina: U.S. Geological Survey Miscellaneous Investigations Series Map I-1948-A.

Price, Van, Fallaw, W.C., and McKinney, J.B., 1991, Geologic setting of the new production reactor reference site with the Savannah River Site (U): Westinghouse Savannah River Company - Savannah River Site, Report WSRC-RP-91-96, 80 p.

Price, Van, Fallaw, W.C., and Thayer, P.A., 1992, Lower Eocene strata at the Savannah River Site, South Carolina, in Zullo, V.A., Harris, W.B., and Price, Van, eds., Savannah River Region: Transition between the Gulf and Atlantic Coastal Plains: Proceedings of the second Bald Head Island Conference on Coastal Plains Geology, Hilton Head Island, November 6-11, 1990, p. 52-53.

Prowell, D.C., 1994, Preliminary geologic map of the Barnwell 30' x 60' quadrangle, South Carolina and Georgia: U.S. Geological Survey Open-File Report 94-673, 39 p., 1 plate.

Prowell, D.C., and O'Connor, B.J., 1978, Belair fault zone: Evidence of Tertiary fault displacement in eastern Georgia: Geology, v. 6, no. 11, p. 681-684.

Prowell, D.C., Christopher, R.A., Edwards, L.E., Bybell, L.M., and Gill, H.E., 1985, Geologic section of the updip Coastal Plain from central Georgia to western South Carolina: U.S. Geological Survey Map MF-1737.

Prowell, D.C., Edwards, L.E., and Frederiksen, N.O., 1985, The Ellenton Formation in South Carolina - A revised age designation from Cretaceous to Paleocene: U.S. Geological Survey Bulletin 1605-A, 63-69 p.

Robertson, C.G., 1990, A textural, petrographic, and hydrogeological study of the Congaree Formation at the Savannah River Site, South Carolina: M.S. thesis, University of North Carolina, Wilmington, N.C., 65 p.

Schroder, C.H., 1982, Trace fossils of the Oconee Group and basal Barnwell Group of east-central Georgia: Georgia Geologic Survey Bulletin 88, 125 p.

Scrudato, R.J., and Bond, T.A., 1972, Cretaceous-Tertiary boundary of east-central Georgia and west-central South Carolina: Southeastern Geology, v. 14, p. 233-239.

Siple, G.E., 1967, Geology and ground water of the Savannah River Plant and vicinity, South Carolina: U.S. Geological Survey Water-Supply Paper 1841, 113 p.

Sloan, Earle, 1908, Catalogue of mineral localities of South Carolina: South Carolina Geological Survey, ser. 4, Bulletin 2, p. 449-453.

Smith, G.E., III, 1979, Stratigraphy of the Aiken County Coastal Plain: South Carolina Geological Survey Open File Report 19, 34 p.

Snipes, D.S., 1965, Stratigraphy and sedimentation of the Middendorf Formation between Lynches River, South Carolina, and the Ocmulgee River Georgia: Ph.D. dissertation, University of North Carolina, Chapel Hill, North Carolina, 140 p.

Snipes, D.S., Fallaw, W.C., Price, Van, Jr., and Cumbest, R.J., 1993, The Pen Branch fault: Documentation of Late Cretaceous-Tertiary faulting in the Coastal Plain of South Carolina: Southeastern Geology, v. 33, no. 4: p. 195-218.

Snipes, D.S., Benson, S.M., and Price, Van, 1995, Hydrologic properties of aquifers in the central Savannah River area: Department of Geosciences, Clemson University, v. 1, 353 p.

Snipes, D.S., Benson, S.M., Price, Van, and Temples, T.J., 1996, Hydrologic properties of aquifers in the central

Savannah River area: Department of Geosciences, Clemson University, v. 2, 204 p.

Sohl, N.F., and Owens, J.P., 1991, Cretaceous stratigraphy of the Carolina Coastal Plain, in Horton, J.W., Jr., and Zullo, V.A., eds., Geology of the Carolinas: University of Tennessee Press, Knoxville, Tennessee, p. 191-220.

Steele, K.B., 1985, Lithostratigraphic correlation of Cretaceous and younger strata of the Atlantic Coastal Plain Province within Aiken, Allendale, and Barnwell Counties, South Carolina: M.S. thesis, University of South Carolina, Columbia, S.C., 174 p.

Stieve, Alice, and Stephenson, Dale, 1995, Geophysical evidence for post late Cretaceous reactivation of basement structures in the Central Savannah River Area: Southeastern Geology, v. 35, no. 1, p. 1-20.

Summerour, J.H., Shapiro, E.A., Lineback, J.A., Huddlestun, P.F., and Hughes, A.C., 1994, An investigation of tritium in the Gordon and other aquifers in Burke County, Georgia: Georgia Geologic Survey Information Circular 95, 93 p.

Terry, R.D., and Chilingar, G.V., 1955, Summary of "Concerning some additional aids in studying sedimentary formations," by M.S. Shvetsov: Journal of Sedimentary Petrology, v. 25, p. 229-234.

Theis, C.V., 1935, The relation between lowering of the piezometric surface and the rate and duration of the discharge of a well using groundwater storage: Transactions of the American Geophysical Union, v. 2, p. 519-524.

Van Nieuwenhuise, D.S., and Colquhoun D.J., 1982, The Paleocene-lower Eocene Black Mingo Group of the east-central Coastal Plain of South Carolina: South Carolina Geology, v. 26, no. 2, p. 47-67.

Veatch, Otto, and Stephenson, L.W., 1911, Preliminary report on the Coastal Plain of Georgia: Georgia Geologic Survey Bulletin 26, 446 p.

Vincent, H.R., 1982, Geohydrology of the Jacksonian aquifer in central and east-central Georgia: Georgia Geologic Survey Hydrologic Atlas 8, 3 sheets.

Wait, R.L., and Davis, M.E., 1986, Configuration and hydrology of pre-Cretaceous rocks underlying the Southeastern Coastal Plain aquifer system: U.S. Geological Survey Water Resources Investigation Report 86-4010, 1 sheet.

Westinghouse Savannah River Company, 1990, Savannah River Site Environmental Report: WSRC-IM-91-28, v. II, Groundwater Monitoring, p. 39-40.

Zullo, V.A., Willoughby, R.H., and Nystrom, P.G., Jr., 1982, A late Oligocene or early Miocene age for the Dry Branch Formation and Tobacco Road Sand in Aiken County, South Carolina, in Nystrom, P.G., Jr., and Willoughby, R.H., eds., Geological investigations related to the stratigraphy in the kaolin mining district, Aiken County, South Carolina: South Carolina Geological Survey, Carolina Geological Society Field Trip Guidebook for 1982, p. 34-46.

FIGURES 11-35

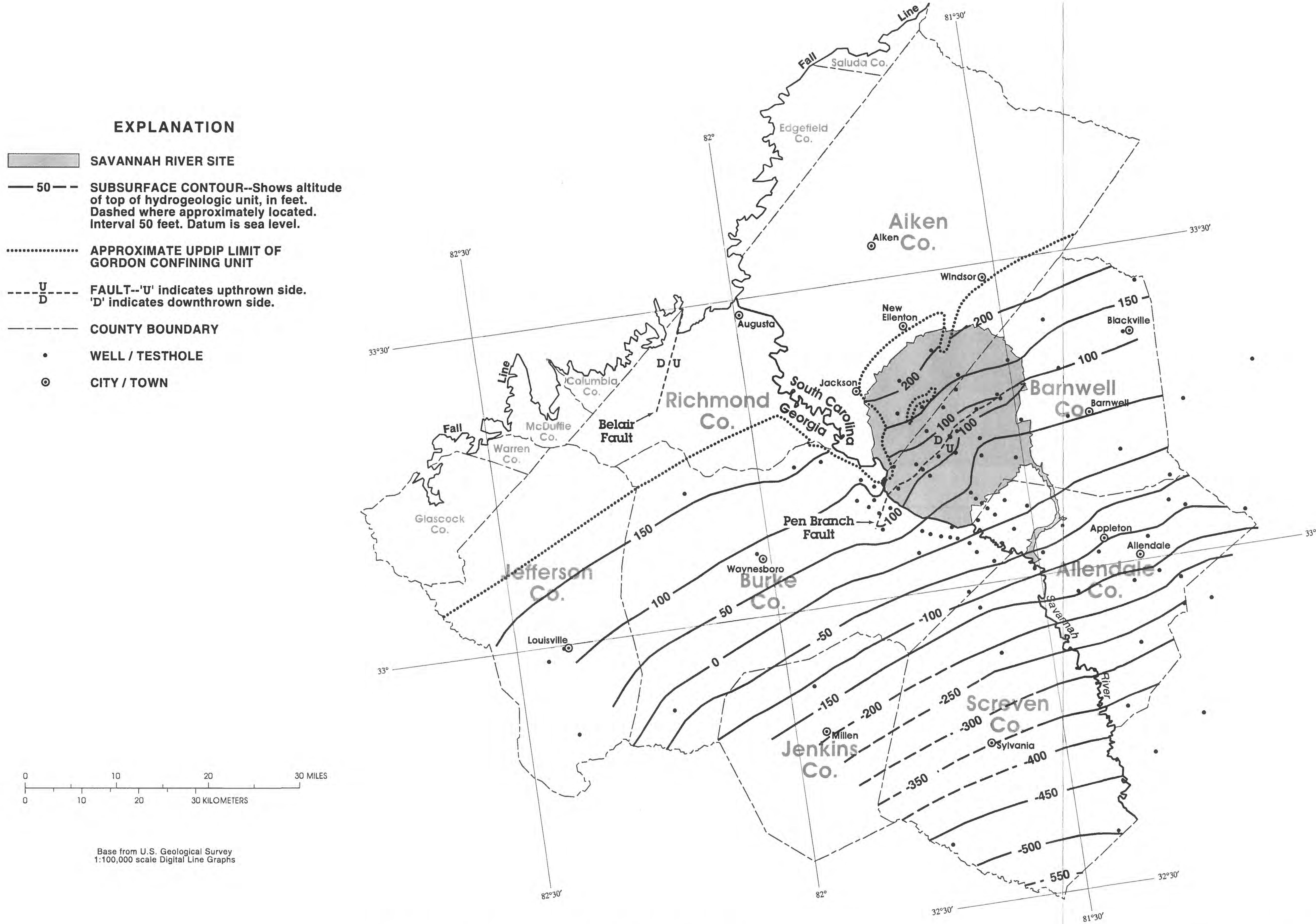


Figure 11. Altitude of the top of the Gordon confining unit.

-page 47 follows-

Figure 12. Thickness of the Gordon confining unit.

- page 49 follows -

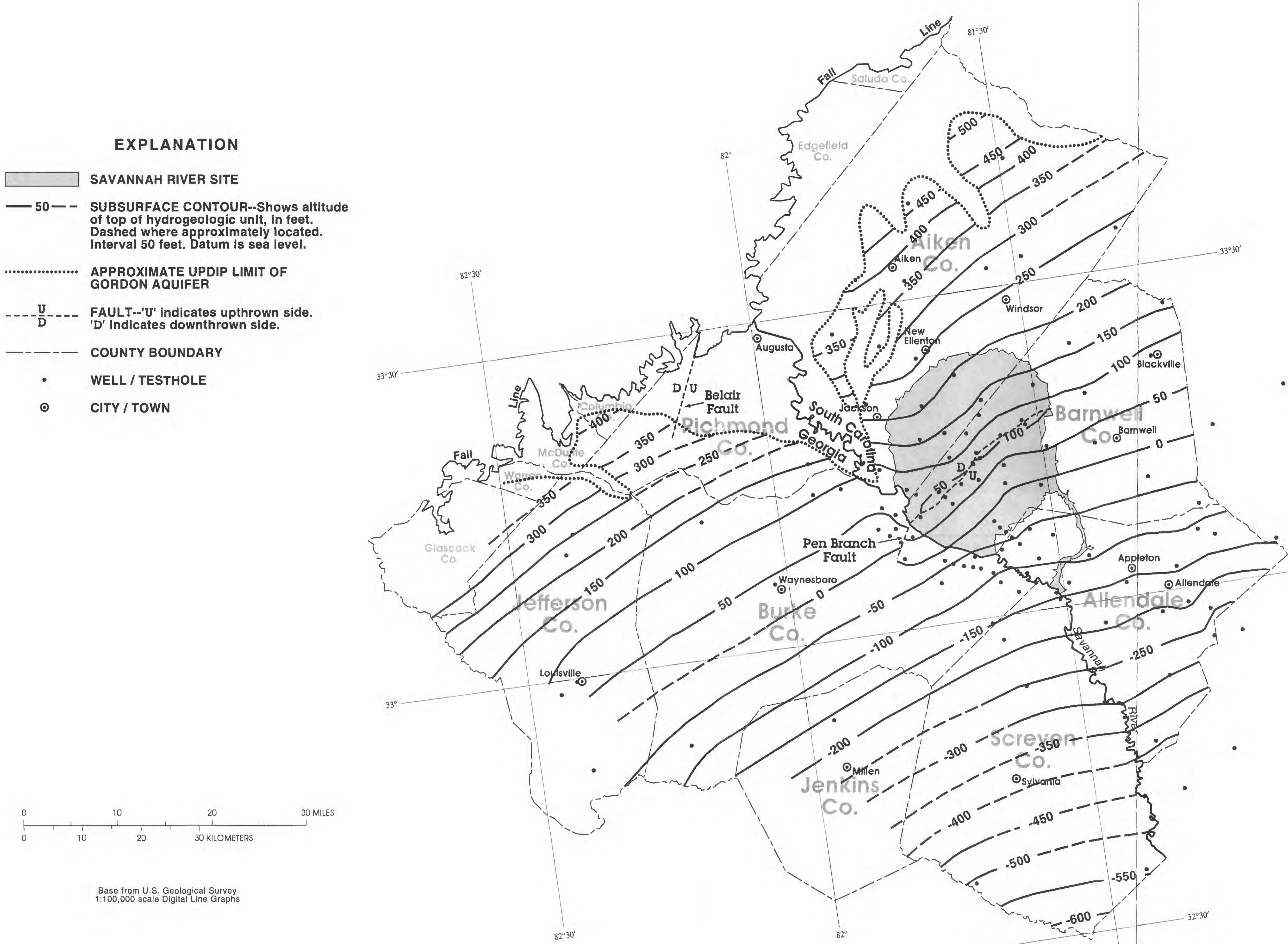


Figure 13. Altitude of the top of the Gordon aquifer.

- page 51 follows -

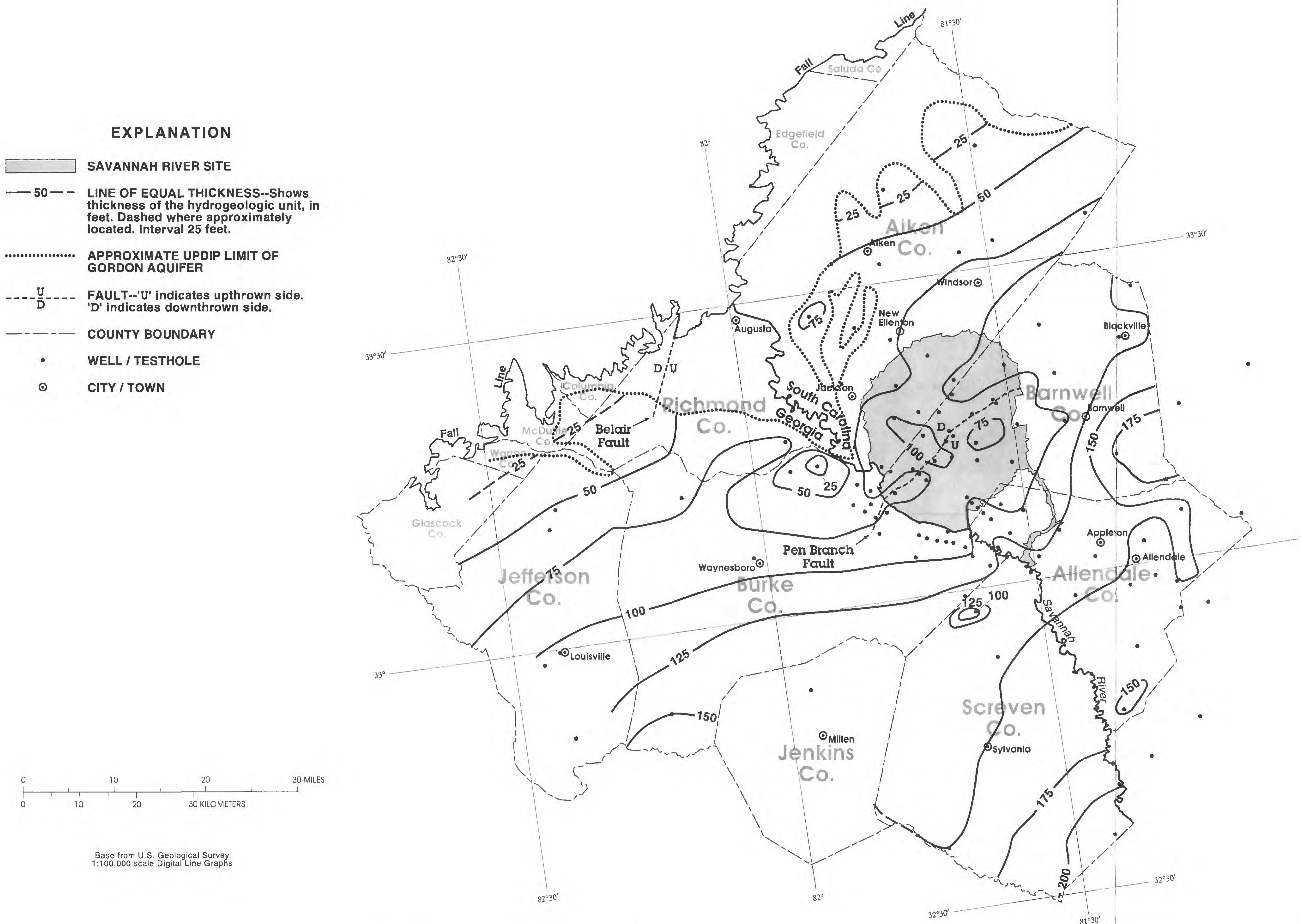


Figure 14. Thickness of the Gordon aquifer.

- page 53 follows -

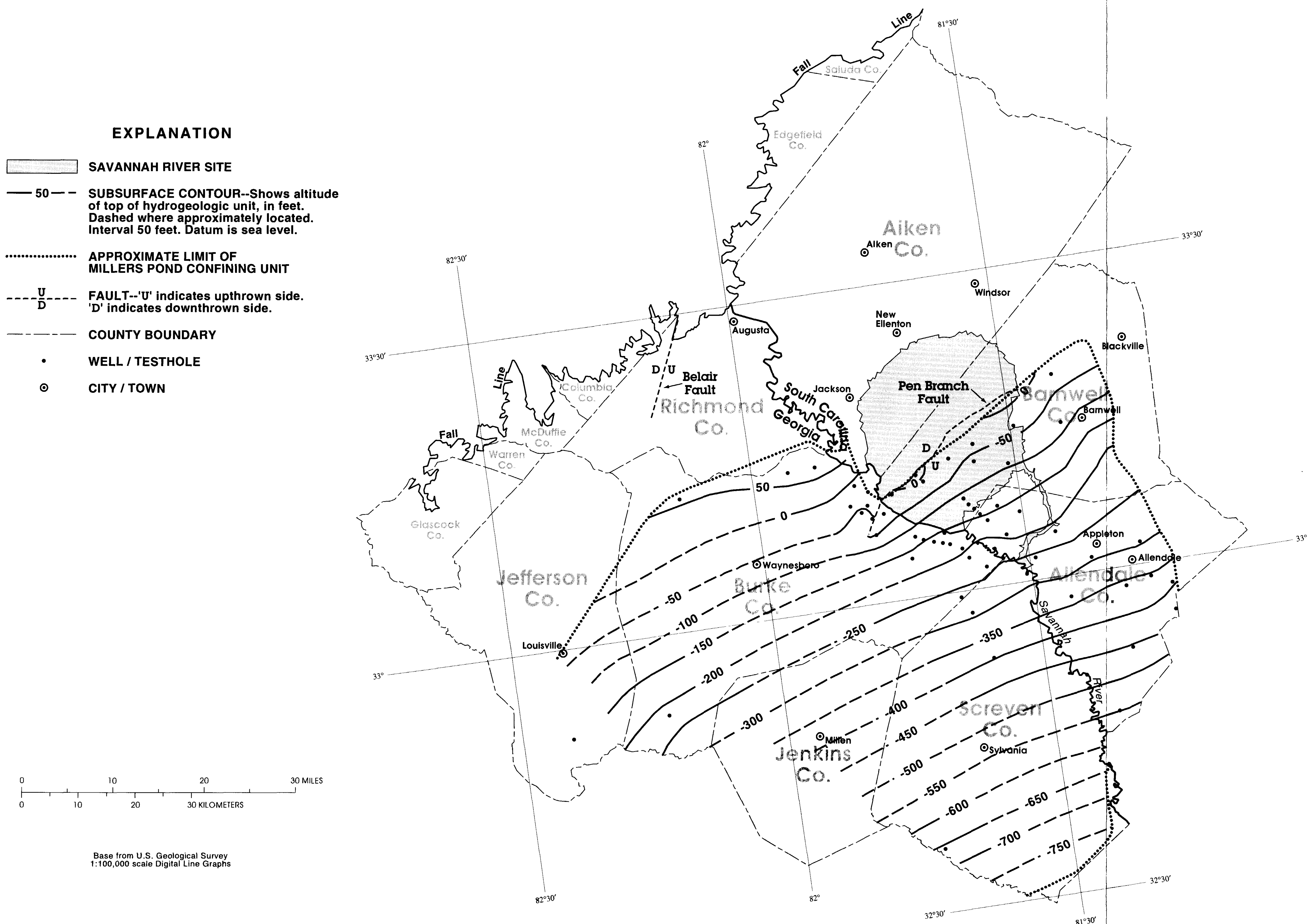


Figure 15. Altitude of the top of the Millers Pond confining unit.

- page 55 follows -

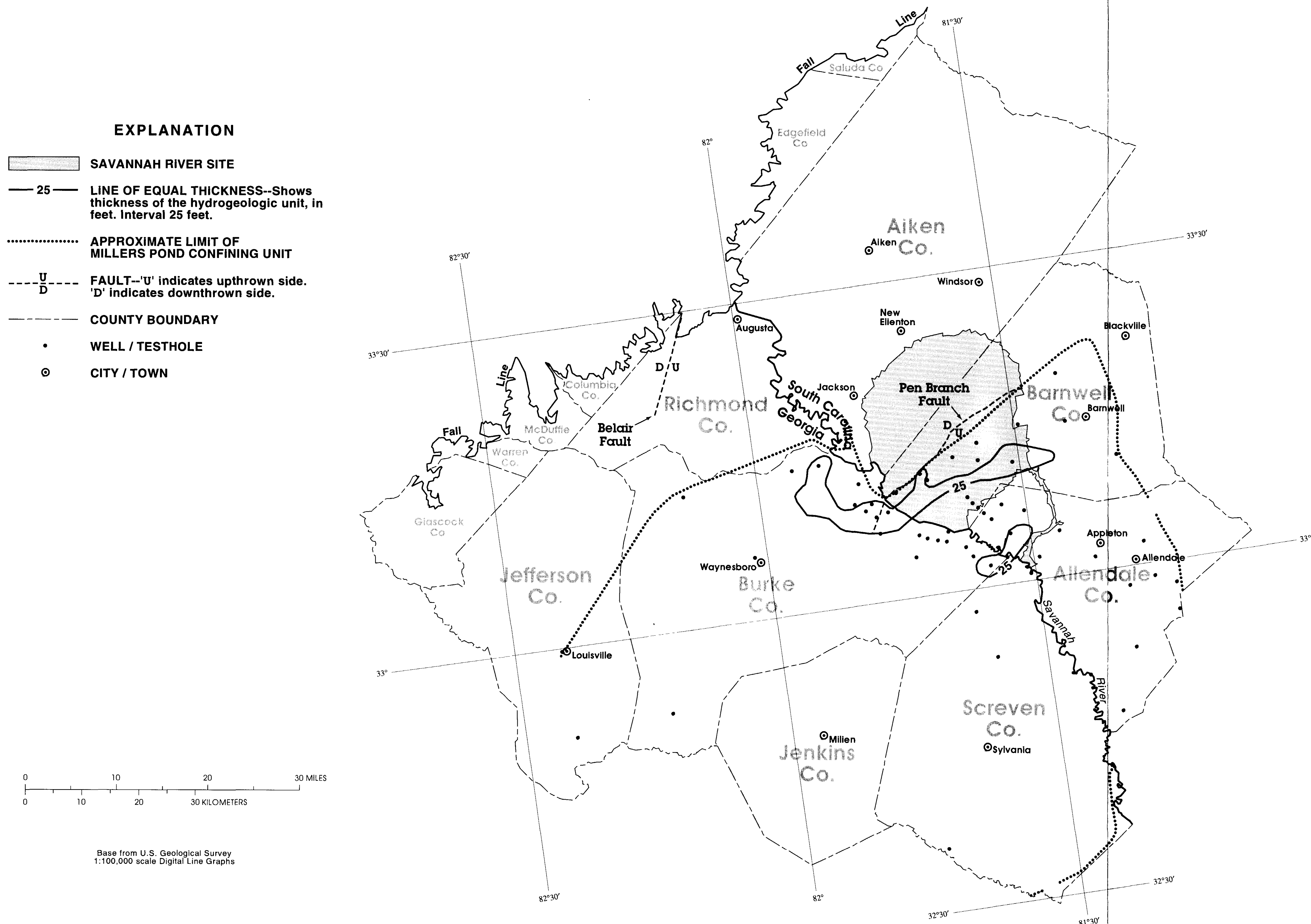


Figure 16. Thickness of the Millers Pond confining unit.

- page 57 follows -

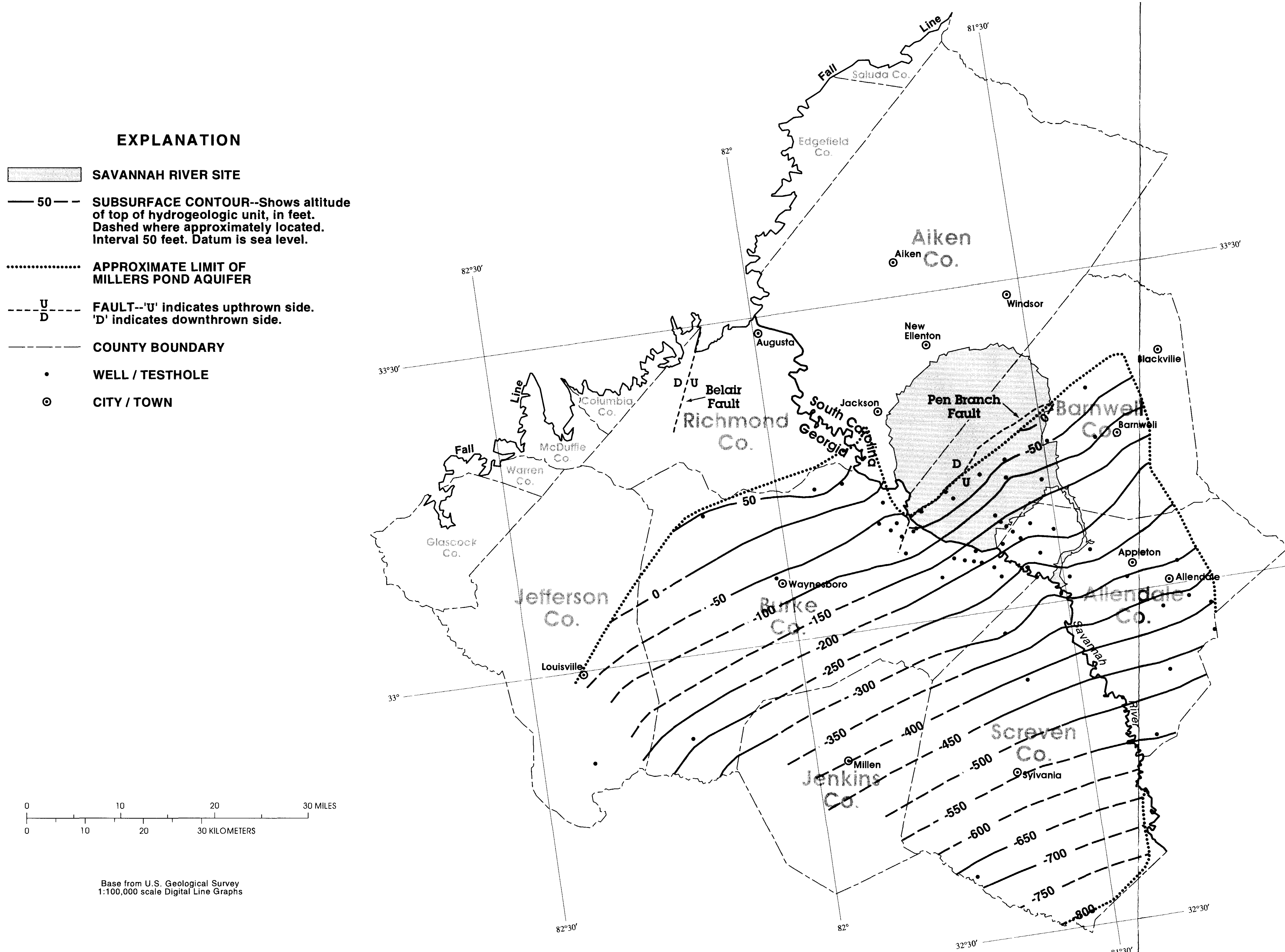


Figure 17. Altitude of the top of the Millers Pond aquifer.

- page 59 follows -

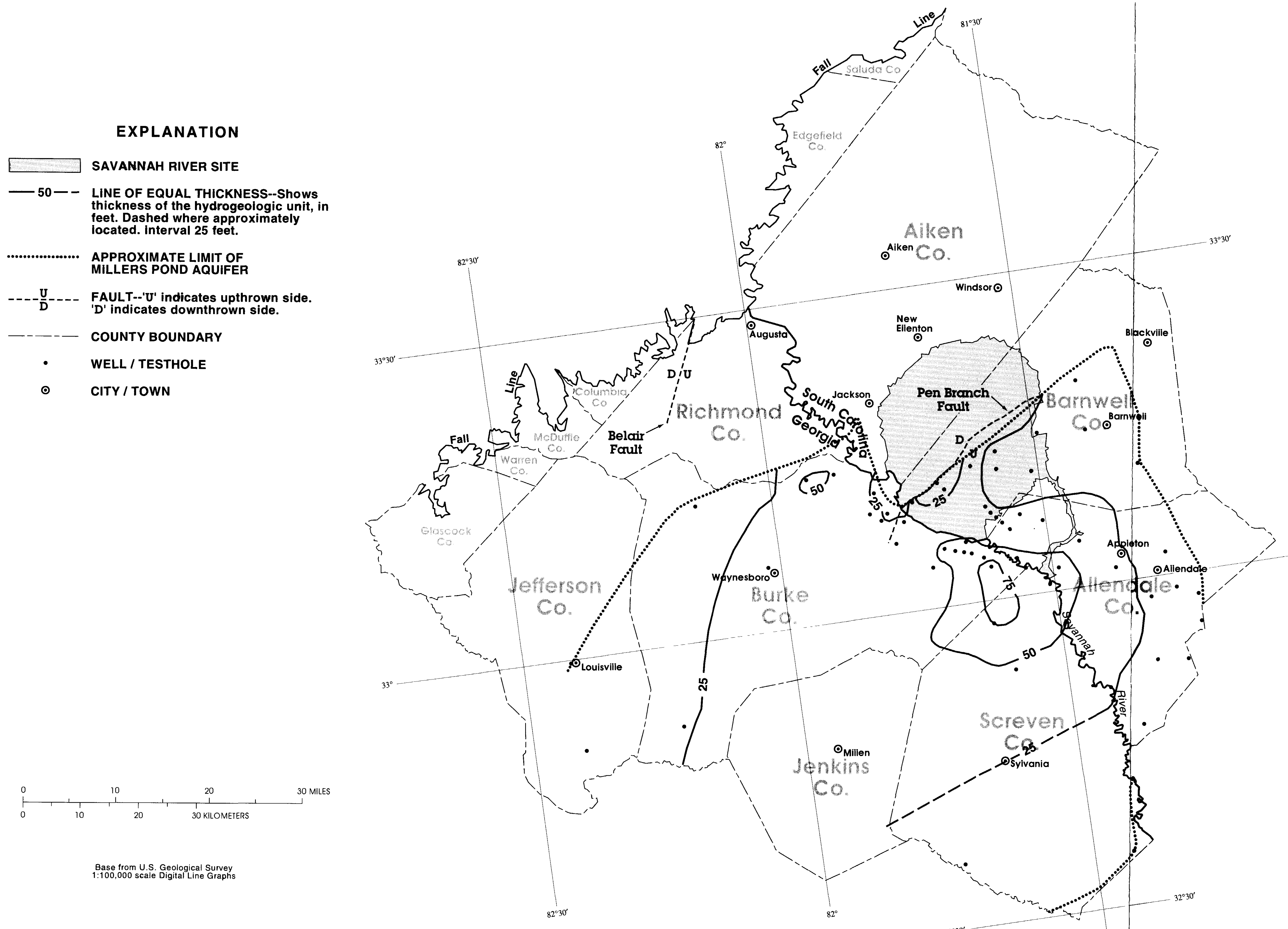


Figure 18. Thickness of the Millers Pond aquifer.

- page 61 follows -

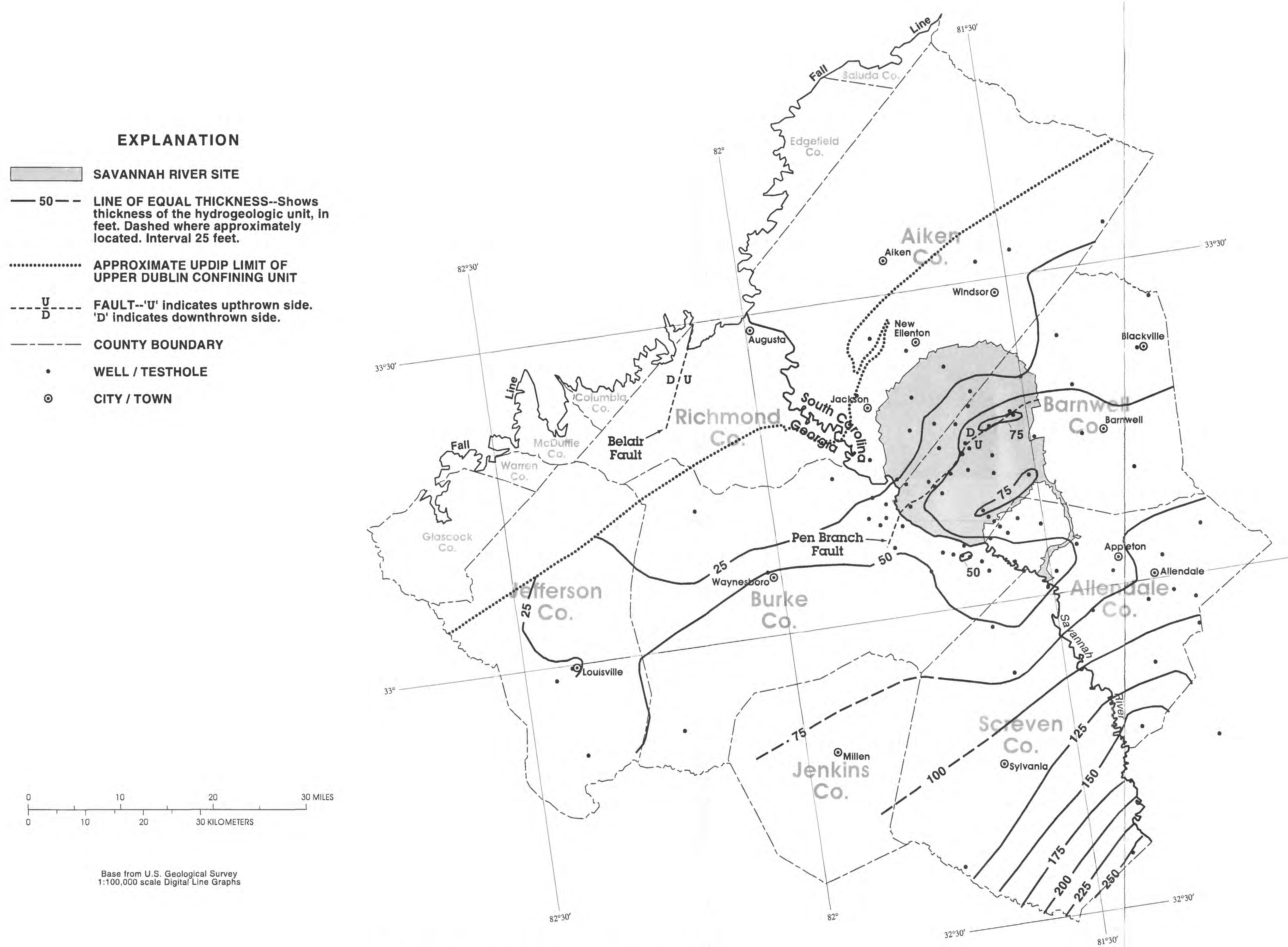


Figure 20. Thickness of the upper Dublin confining unit.

- page 65 follows -

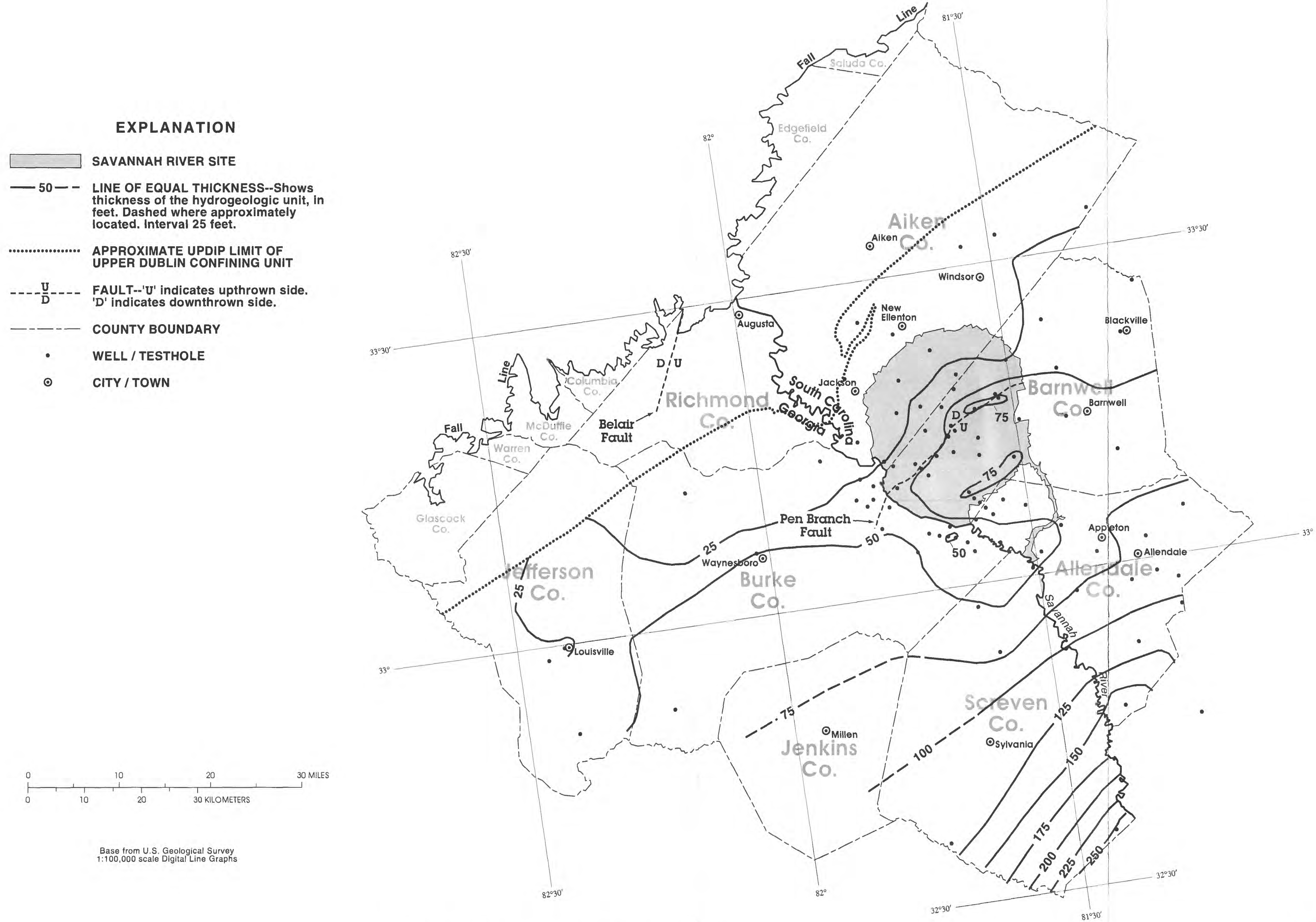
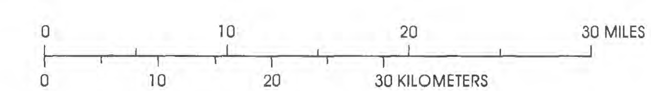


Figure 20. Thickness of the upper Dublin confining unit.

- page 65 follows -

EXPLANATION

(shaded box)	SAVANNAH RIVER SITE
—50— – –	SUBSURFACE CONTOUR--Shows altitude of top of hydrogeologic unit, in feet. Dashed where approximately located. Interval 50 feet. Datum is sea level.
················	APPROXIMATE UPDIP LIMIT OF UPPER DUBLIN AQUIFER
---U/D----	FAULT--'U' indicates upthrown side. 'D' indicates downthrown side.
—-—-—	COUNTY BOUNDARY
•	WELL / TESTHOLE
⊙	CITY / TOWN



Base from U.S. Geological Survey 1:100,000 scale Digital Line Graphs

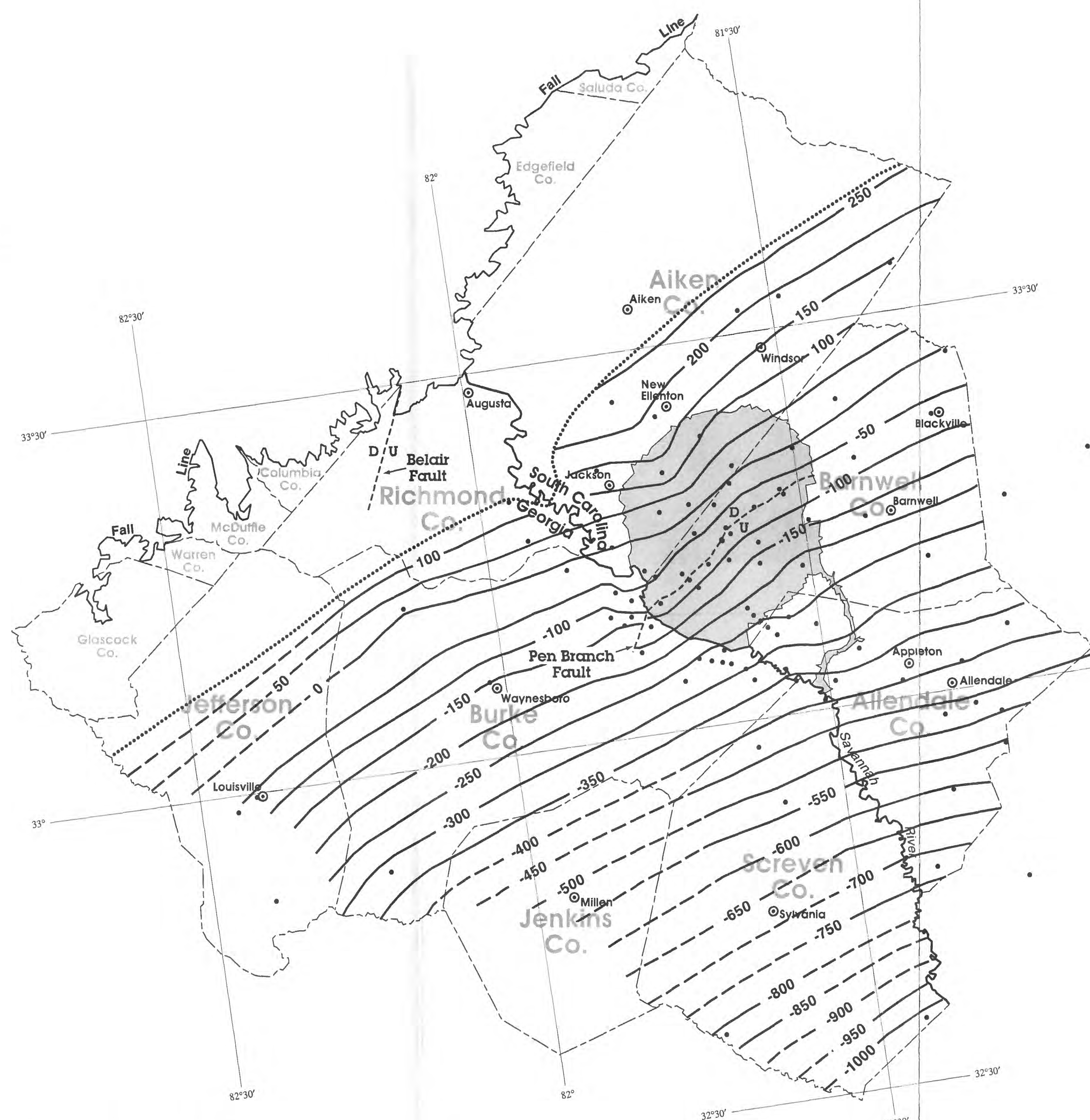


Figure 21. Altitude of the top of the upper Dublin aquifer.

- page 67 follows -

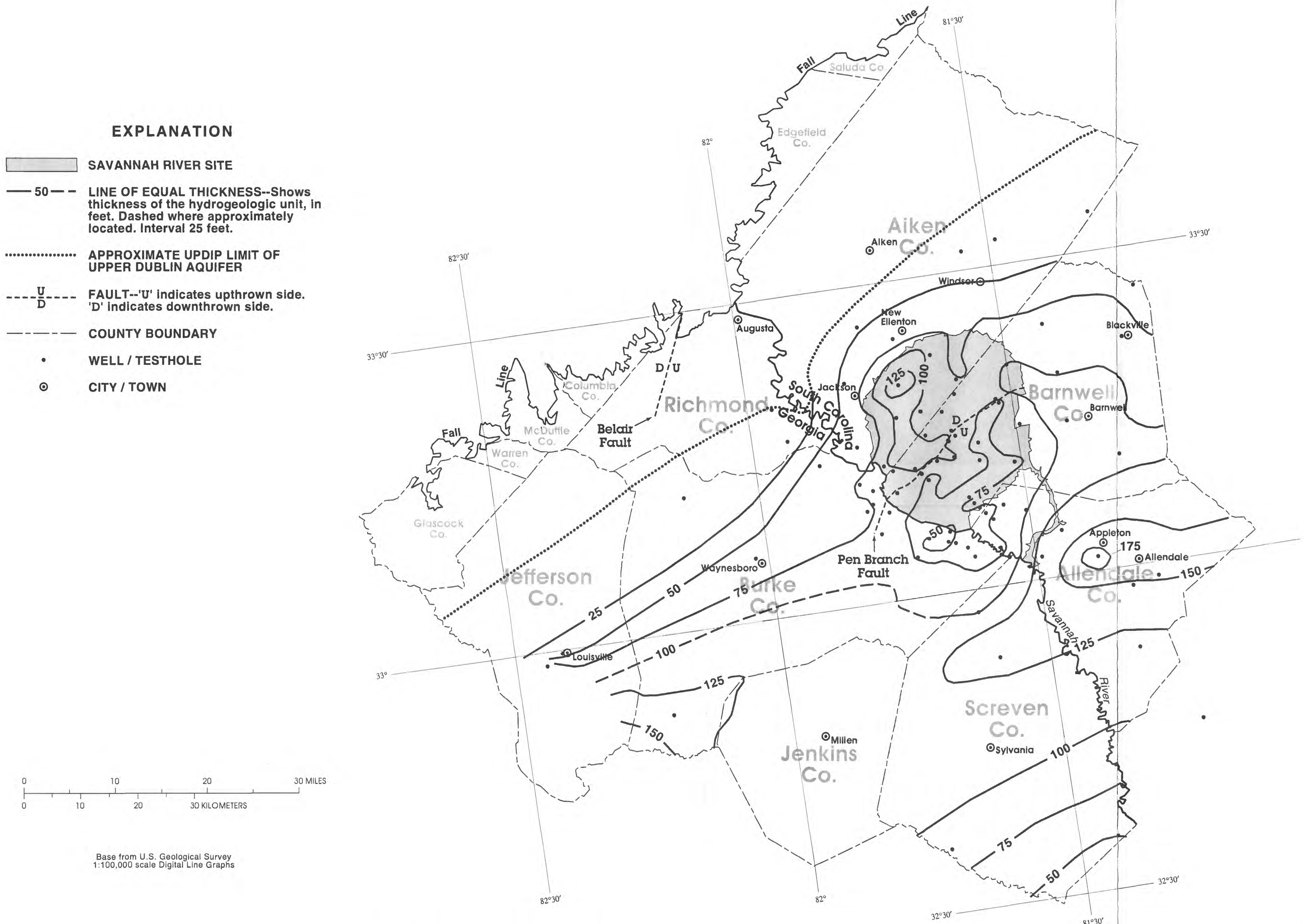


Figure 22. Thickness of the upper Dublin aquifer.

-page 69 follows-

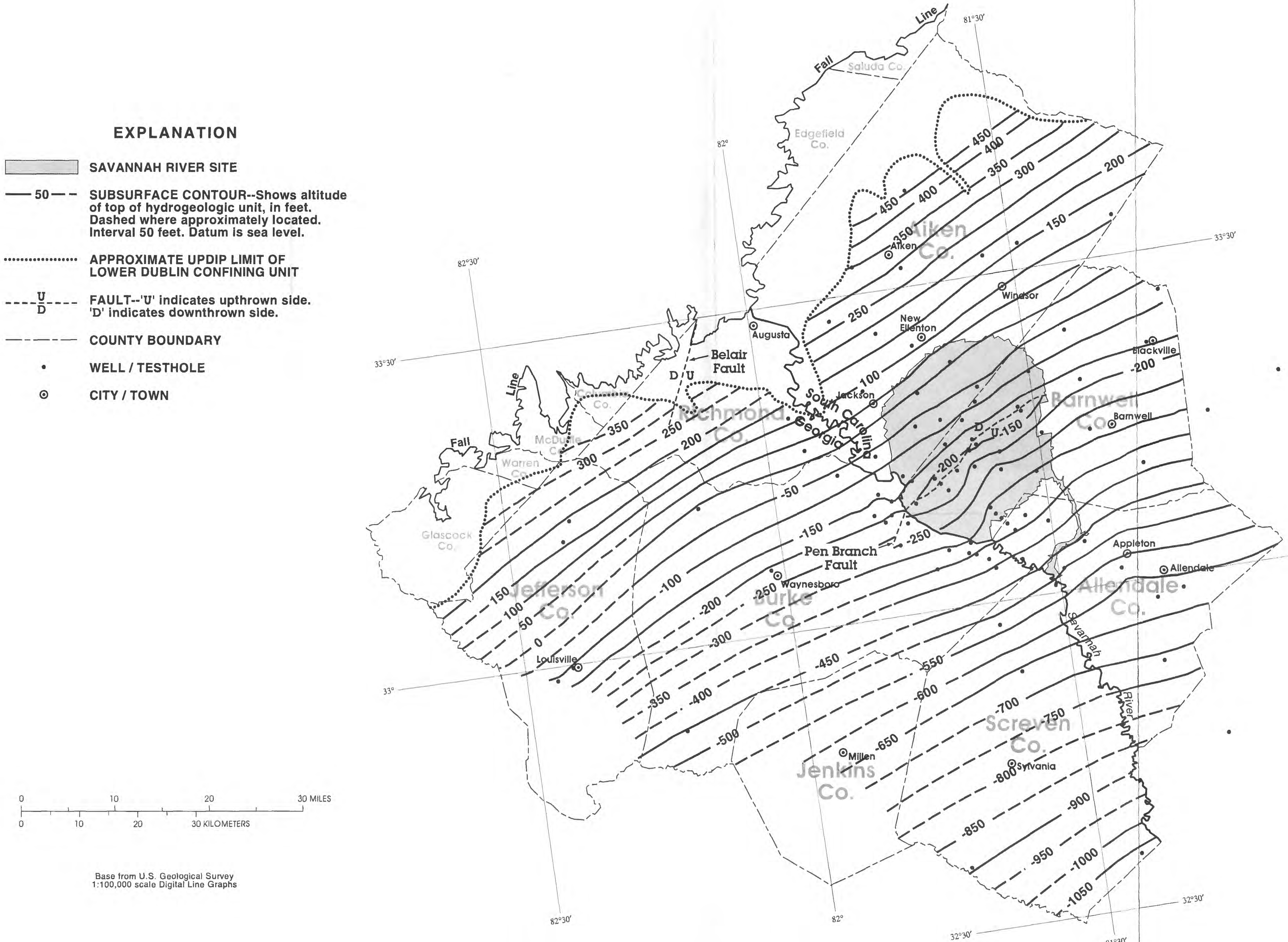


Figure 23. Altitude of the top of the lower Dublin confining unit.

- page 71 follows -

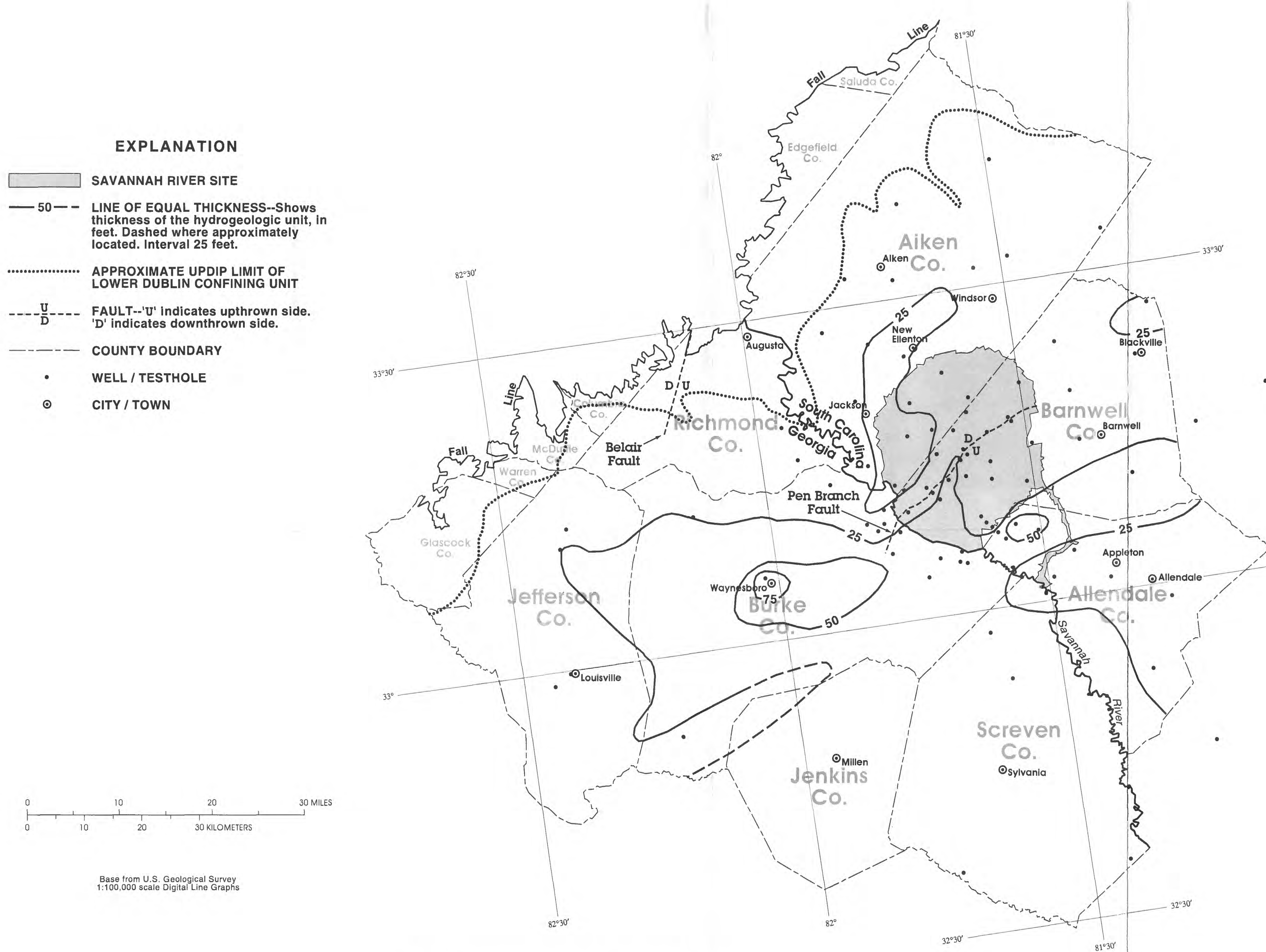


Figure 24. Thickness of the lower Dublin confining unit.

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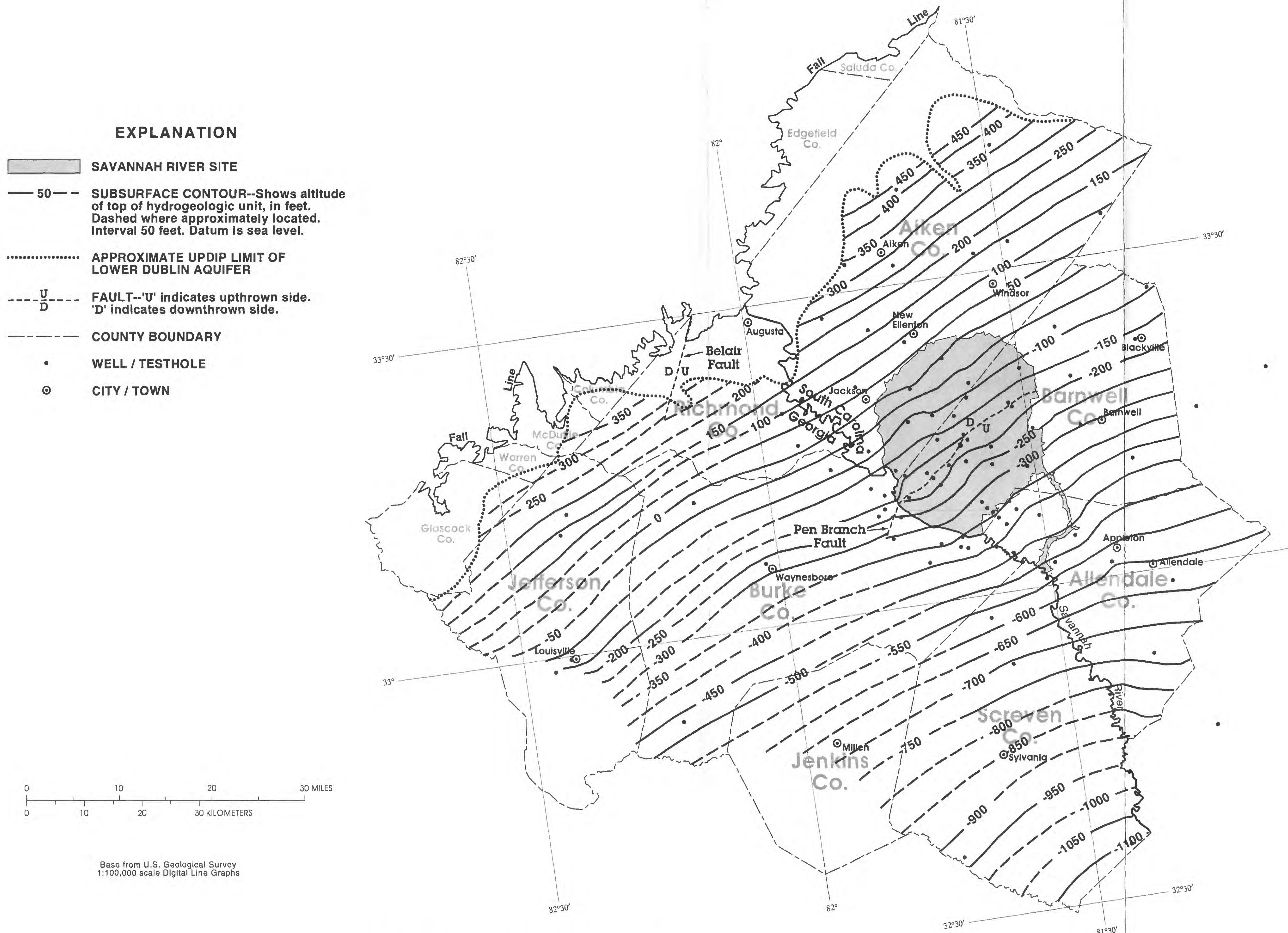

Figure 25. Altitude of the top of the lower Dublin aquifer.

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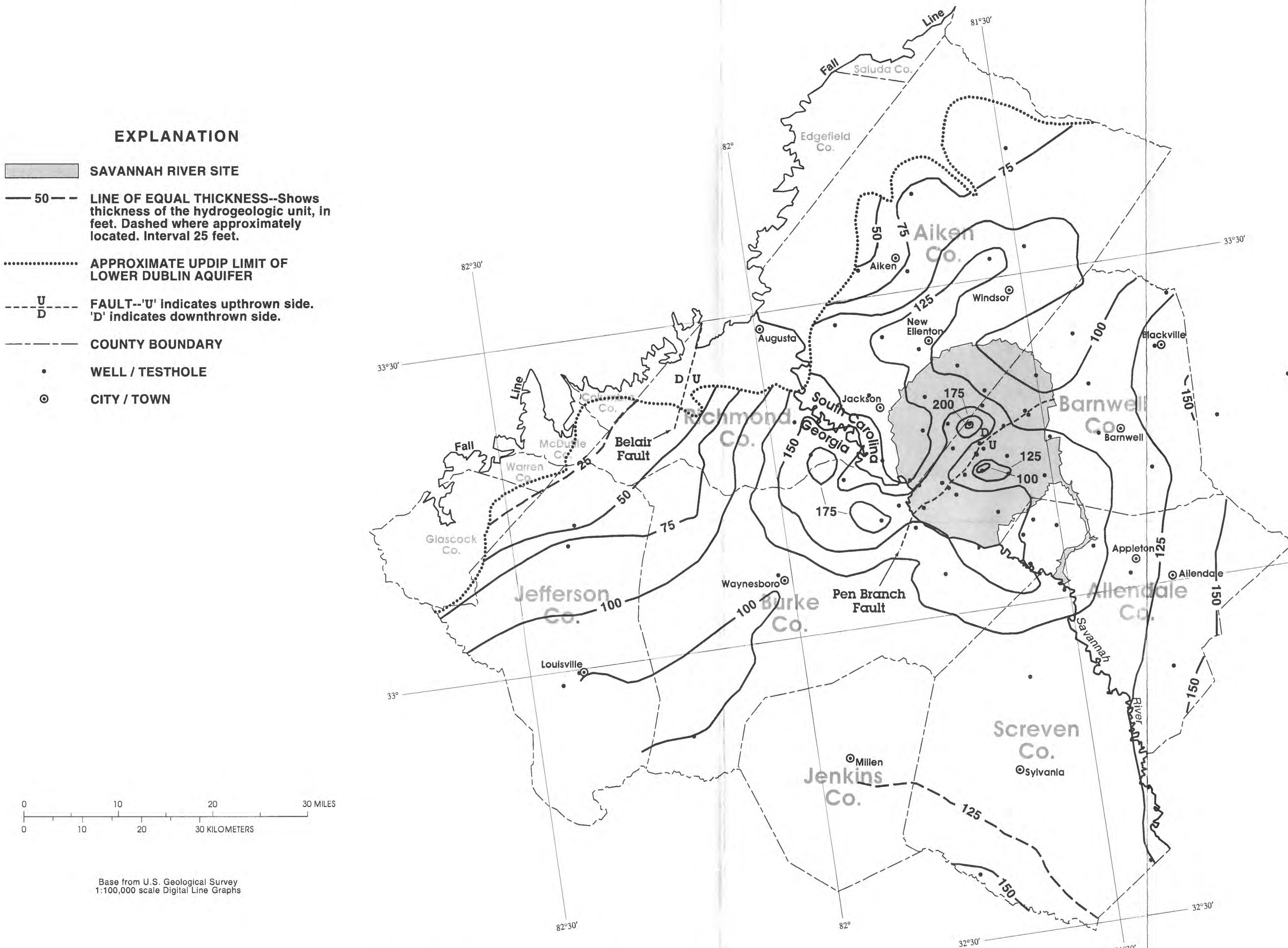

Figure 26. Thickness of the lower Dublin aquifer.

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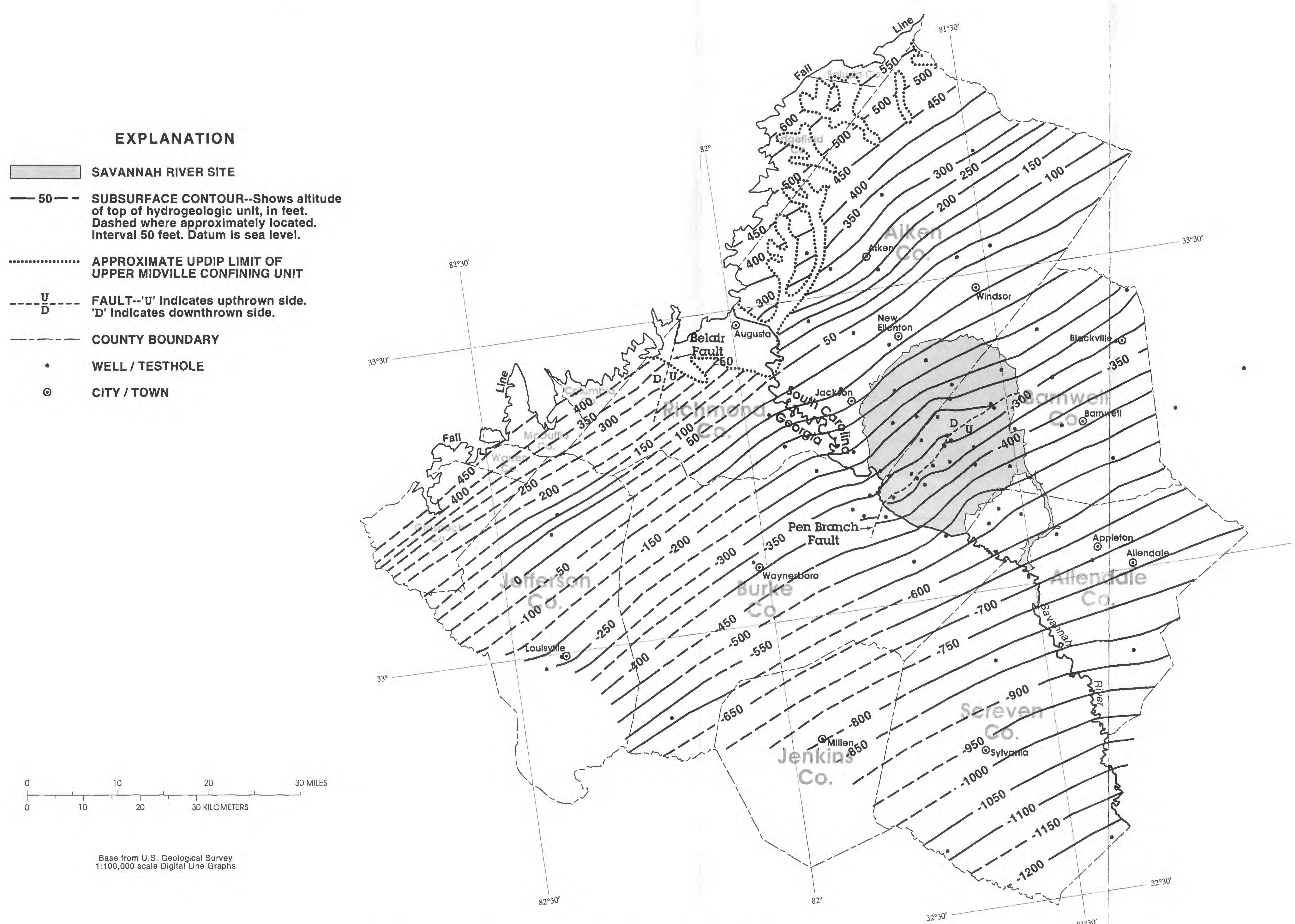

Figure 27. Altitude of the top of the upper Midville confining unit.

-page 79 follows-

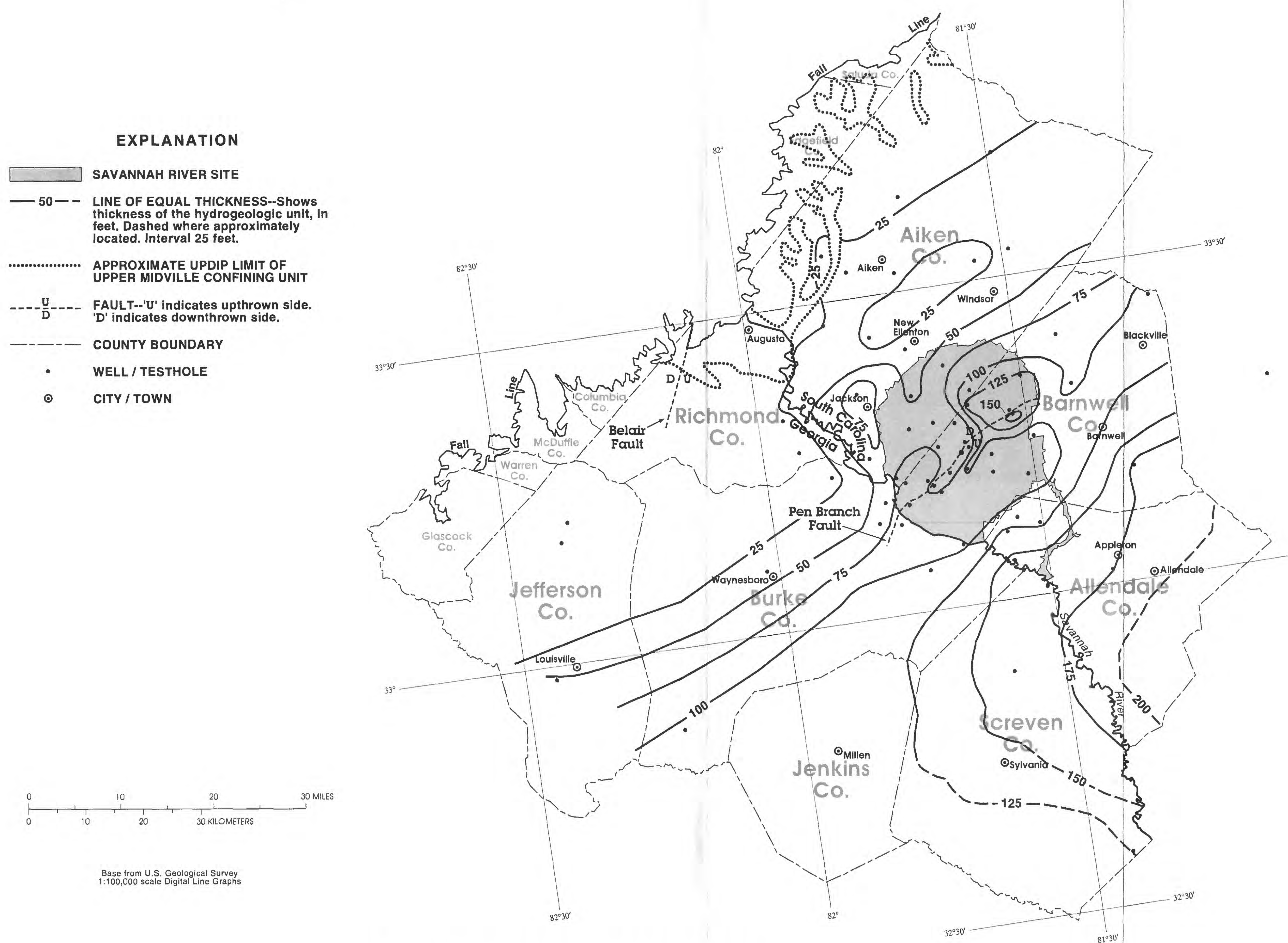

Figure 28. Thickness of the upper Midville confining unit.

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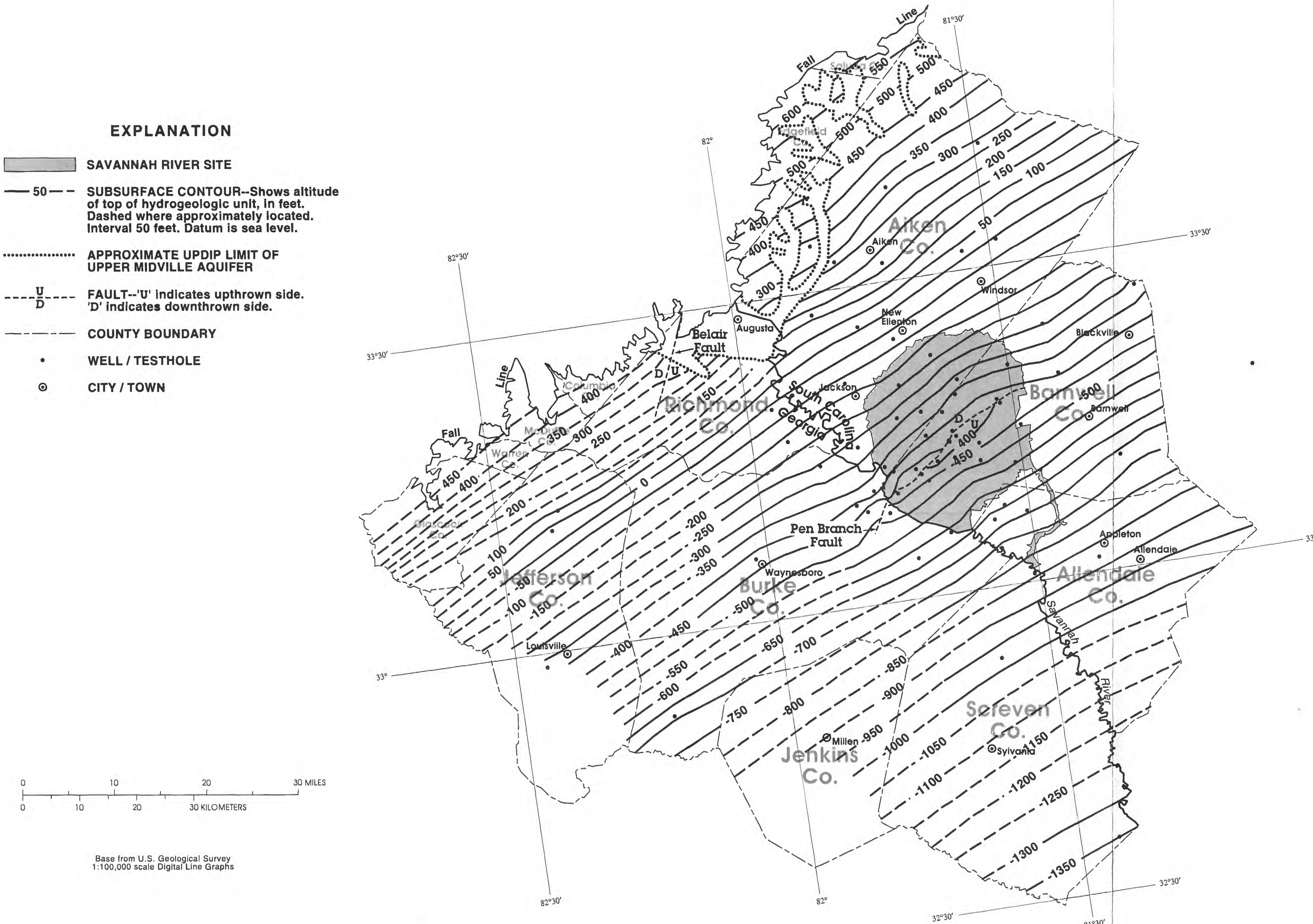

Figure 29. Altitude of the top of the upper Midville aquifer.

-page 83 follows-

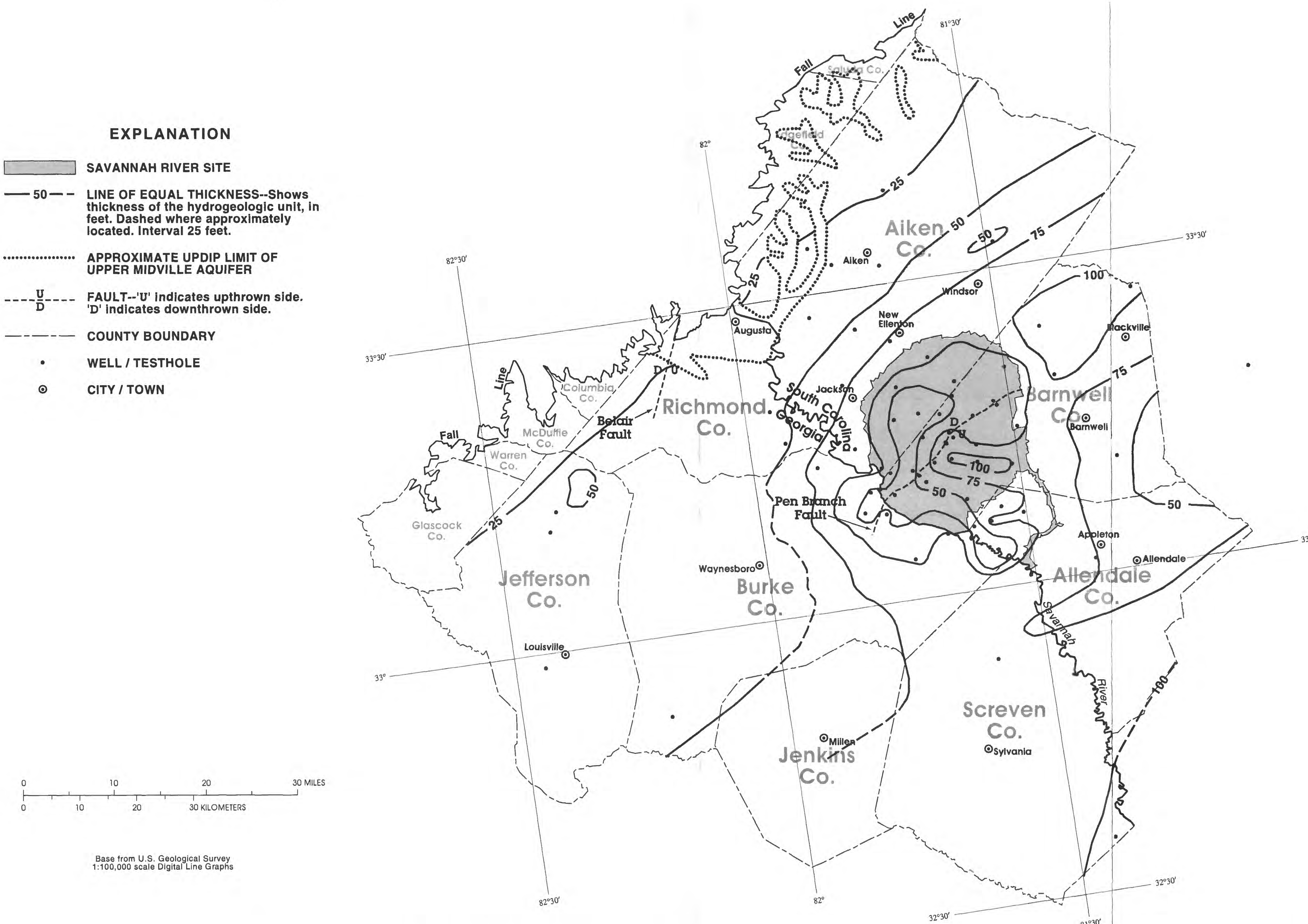

Figure 30. Thickness of the upper Midville aquifer.

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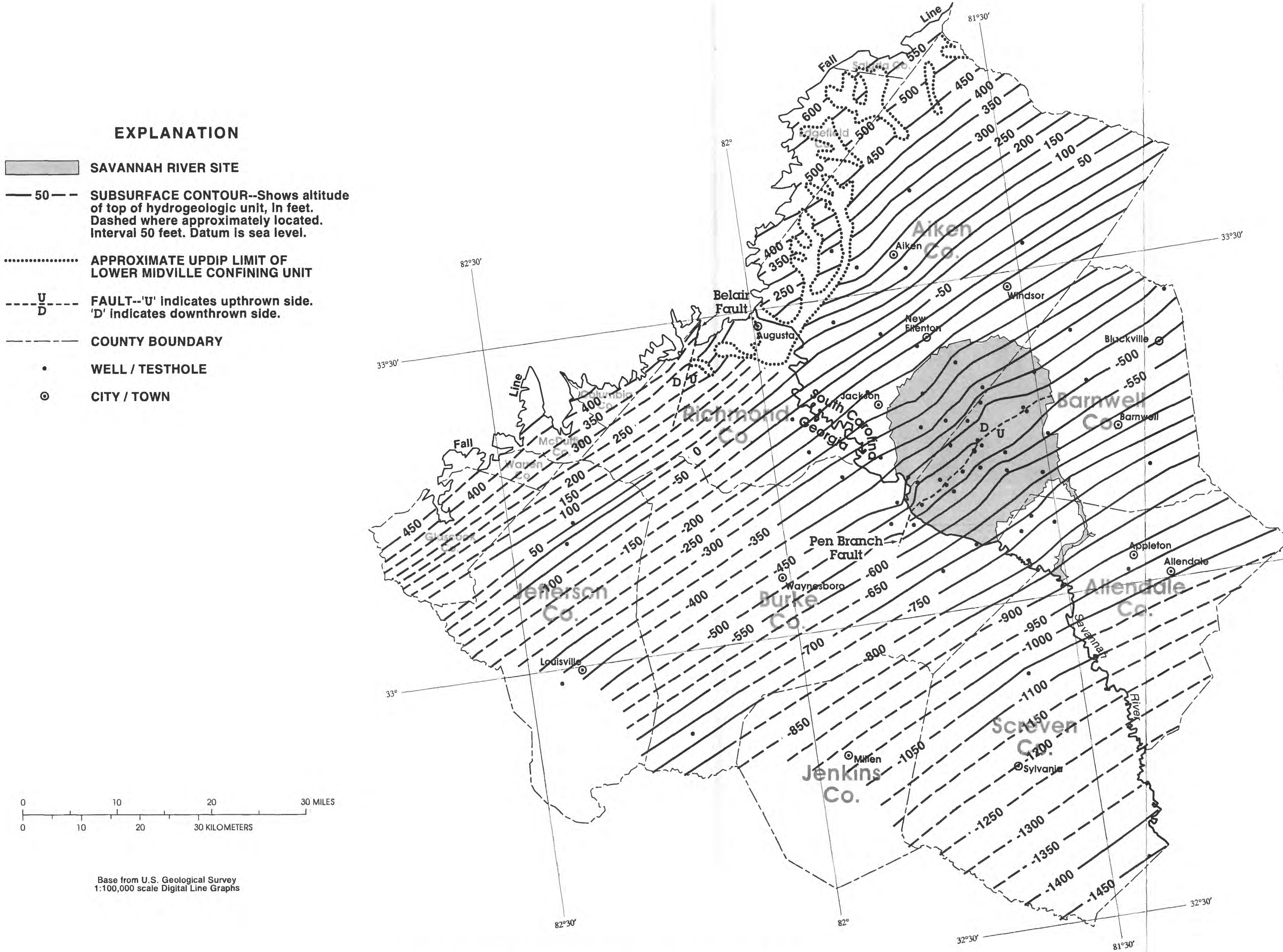

Figure 31. Altitude of the top of the lower Midville confining unit.

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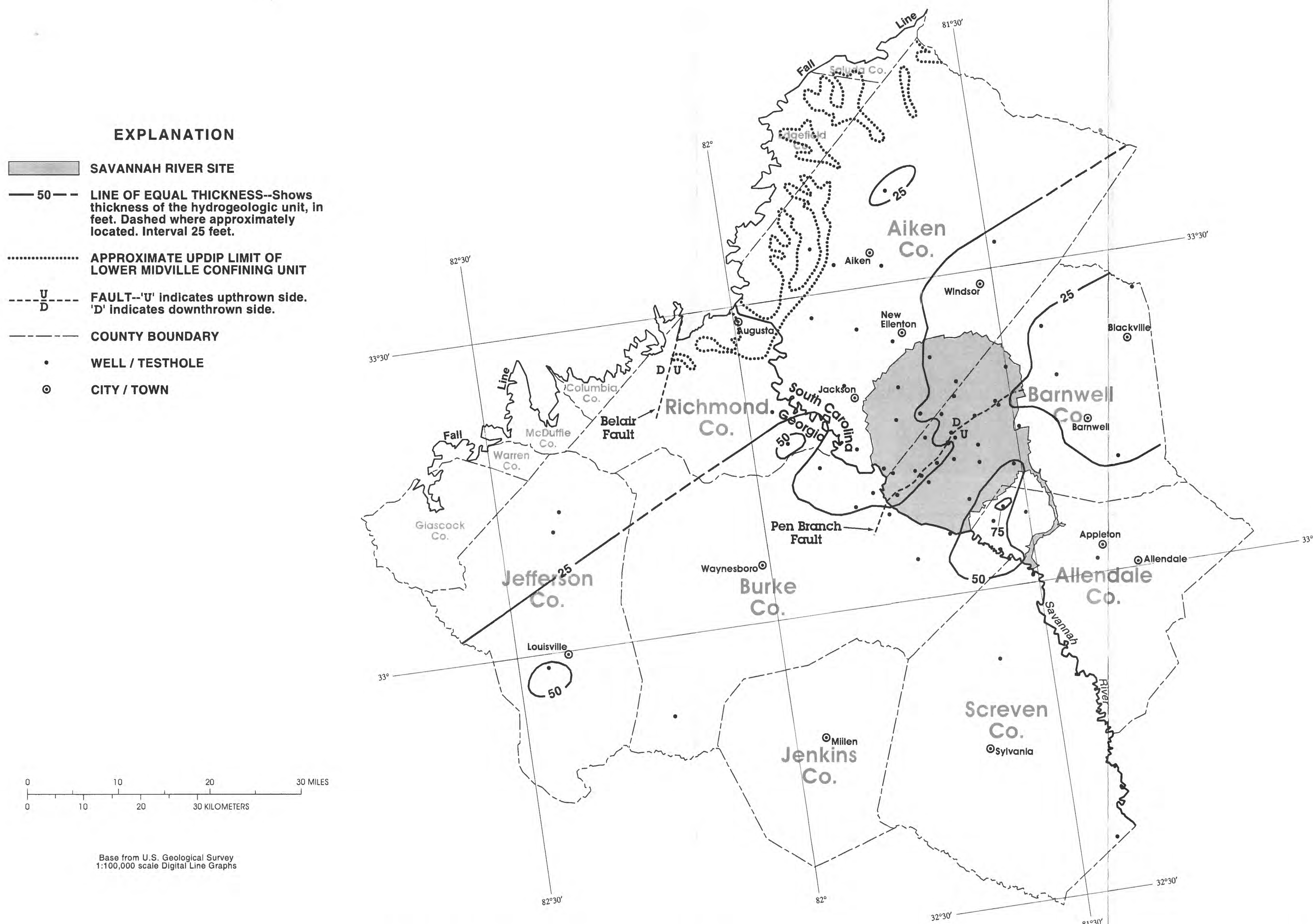

Figure 32. Thickness of the lower Midville confining unit.

- page 89 follows -

EXPLANATION

SAVANNAH RIVER SITE

—50— — SUBSURFACE CONTOUR--Shows altitude of top of hydrogeologic unit, in feet. Dashed where approximately located. Interval 50 feet. Datum is sea level.

APPROXIMATE UPDIP LIMIT OF LOWER MIDVILLE AQUIFER

FAULT--'U' indicates upthrown side. 'D' indicates downthrown side.

COUNTY BOUNDARY

WELL / TESTHOLE

CITY / TOWN

0 10 20 30 MILES

0 10 20 30 KILOMETERS

Base from U.S. Geological Survey 1:100,000 scale Digital Line Graphs

Figure 33. Altitude of the top of the lower Midville aquifer.

-page 91 follows-

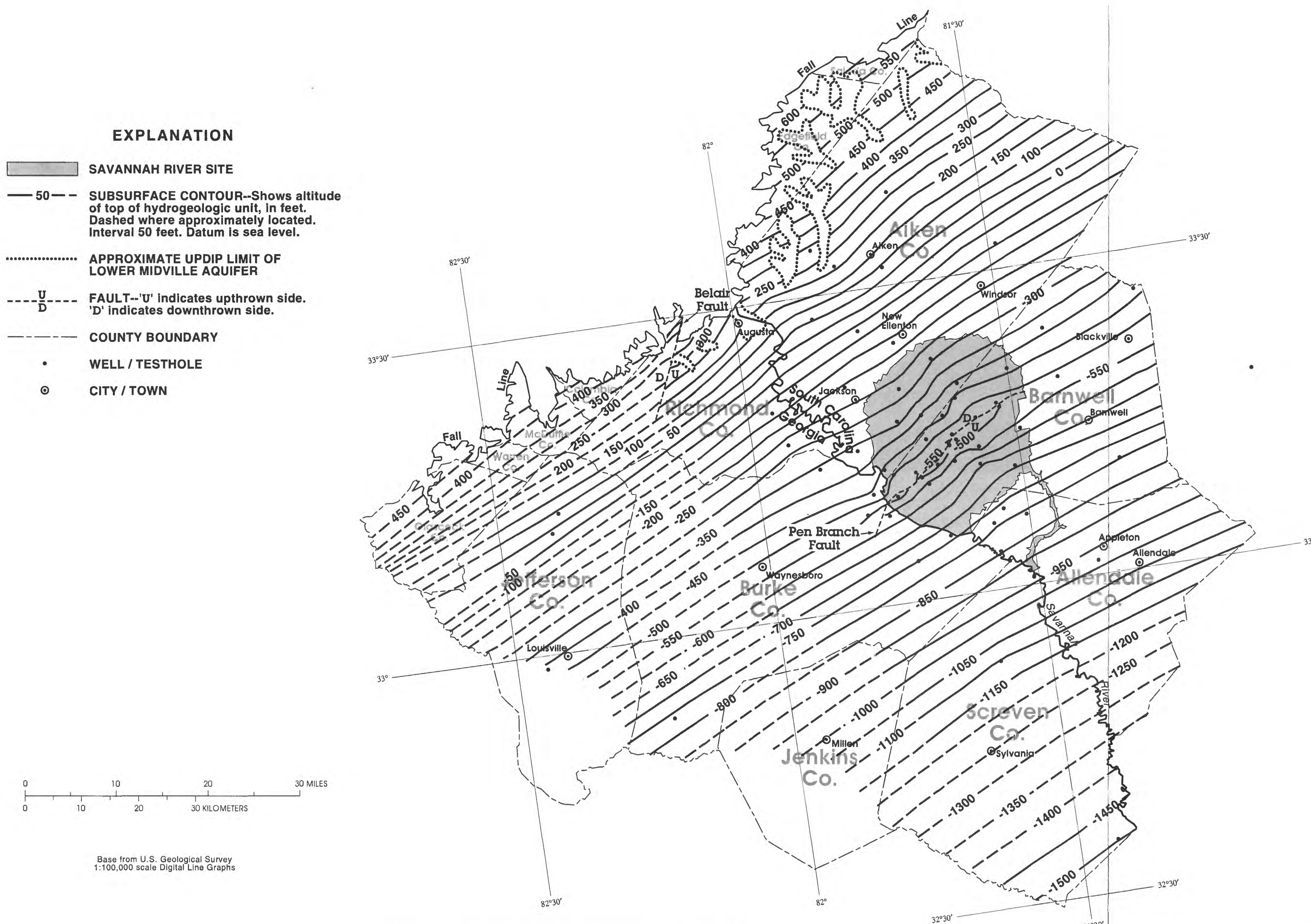

Figure 33. Altitude of the top of the lower Midville aquifer.

-page 91 follows-

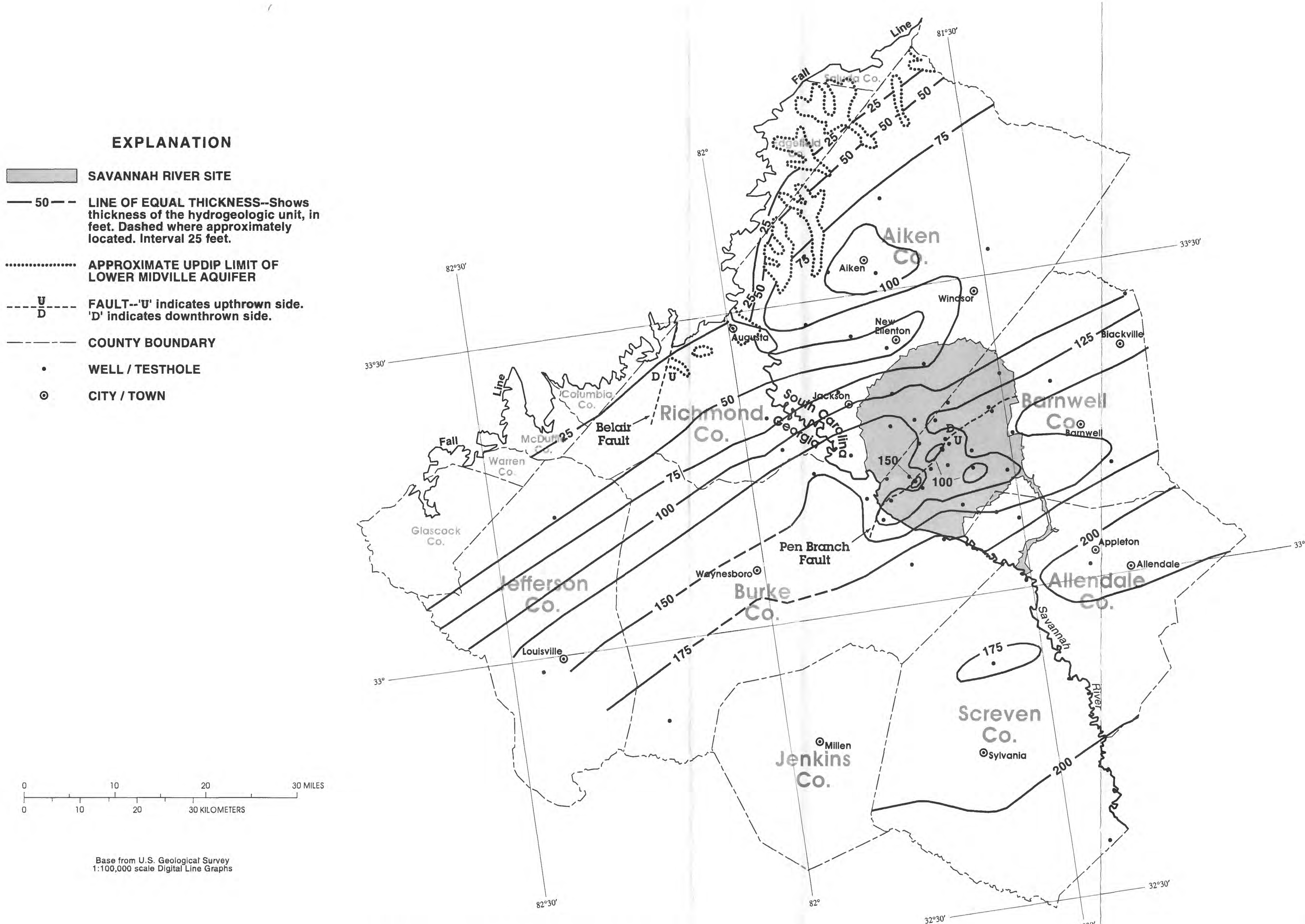

Figure 34. Thickness of the lower Midville aquifer.

- page 93 follows -

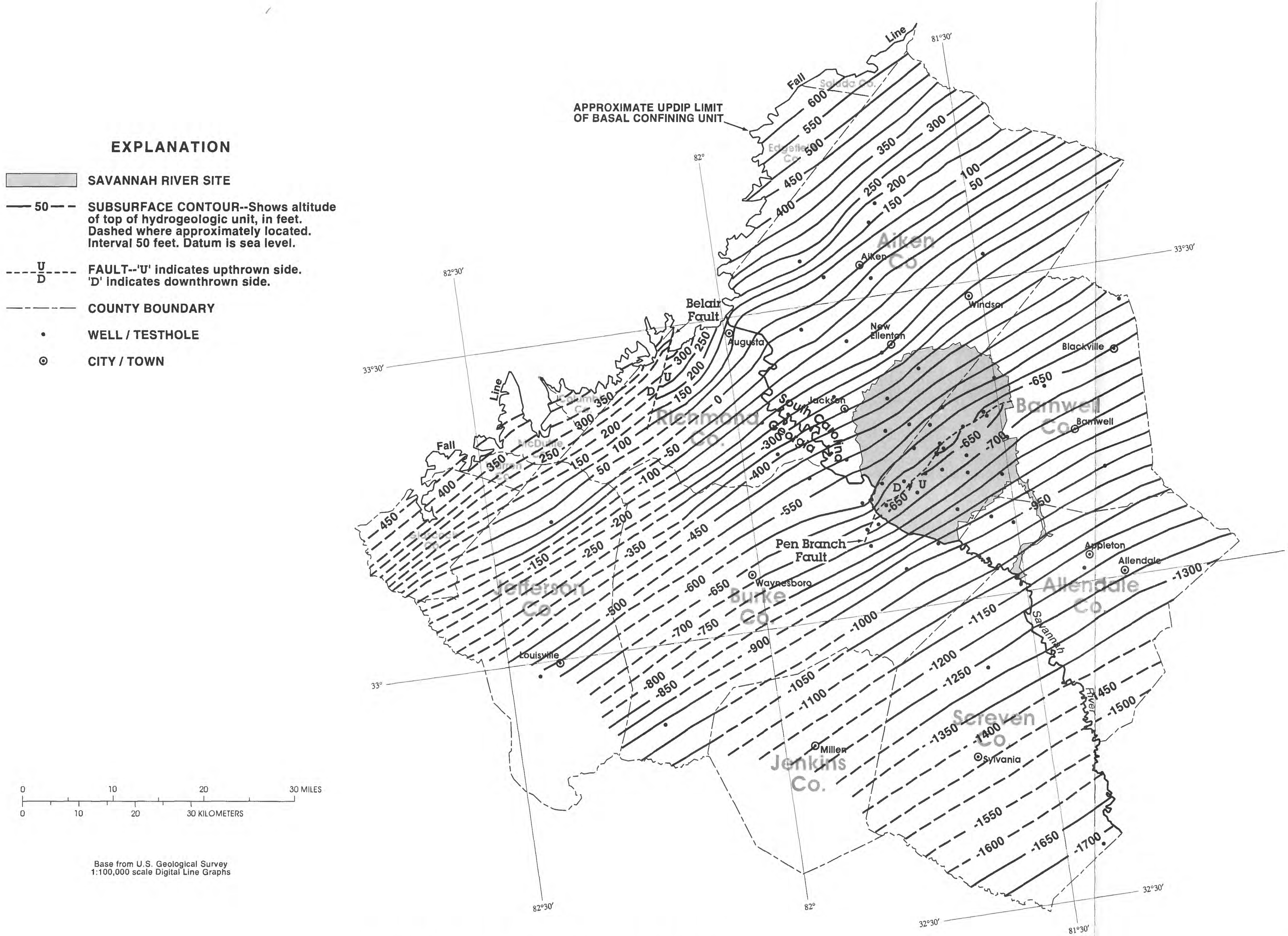

Figure 35. Altitude of the top of the basal confining unit.

- page 95 follows

TABLES 1-7

Table 1. Altitudes and depths of stratigraphic tops for geologic units and subunits in the Millhaven, Girard, Thompson Oak, Millers Pond, and McBean cores

[Altitude is given in feet above or below (-) sea level. Depth is given in feet below land surface. The Barnwell unit is exposed at land surface in each core. ND, not determined; NP, not penetrated]

Name of geologic unit	Altitude/depth of stratigraphic contact				
	Millhaven core	Girard core	Thompson Oak core	Millers Pond core	McBean core
Barnwell unit	110/0	250/0	245/0	245/0	297/0
Tinker/Santee unit	-118/228	0/250	115/130	163/82	185/112
Warley Hill/Congaree/ Fourmile Branch unit	-291/401	-75/325	63/182	89/156	111/186
Warley Hill Formation	-291/401	absent	absent	absent	absent
Congaree Formation	-352/462	-75/325	63/182	89/156	111/186
Fourmile Branch Formation	absent	-140/390	-6/251	absent	absent
Snapp Formation	-394/504	-173/423	absent	80/165	75/222
Ellenton Formation	-460/570	-231/481	-29/274	13/232	25/272
Steel Creek Formation	-532/642	-292/542	-79/324	-39/284	-8/305
Black Creek Group	-729/839	-392/642	-161/406	-87/322	NP
Subunit 3	-729/839	-392/642	-161/406	-87/322	NP
Subunit 2	-817/927	-482/733	ND	ND	NP
Subunit 1	-1,009/1,119	-659/909	ND	ND.	NP
Middendorf Formation	-1,062/1,172	-708/958	-440/685	-347/592	NP
Subunit 2	-1,062/1,172	-708/958	-440/685	-347/592	NP
Subunit 1	-1,162/1,272	-812/1,062	-480/725	-418/663	NP
Cape Fear Formation	-1,269/1,379	-913/1,163	-597/842	-507/752	NP
Bedrock	NP	-1,125/1,375	-751/996	-603/852	NP

Note: The stratigraphic contacts in the Thompson Oak and McBean cores are based on lithologic descriptions provided by Paul F. Huddlestun, Georgia Department of Natural Resources, Atlanta, Ga. The stratigraphic contacts and names for the Thompson Oak and McBean cores in this table represent the stratigraphic interpretations of the authors, and do not necessarily agree with Huddlestun's interpretations.

Table 2. Location of wells and cores used in study area--Continued

[USGS, U.S. Geological Survey; dms: degrees, minutes, seconds; SRS, Savannah River Site; SCDNR, South Carolina Department of Natural Resources; USDOE, U.S. Department of Energy]

USGS identifier	Well/core name	Elevation of land surface (feet above sea level)	Latitude (dms)	Longitude (dms)
	Barnwell County, S.C.--Continued			
BW-299	SRS P5A (P-21)	206	33 08 48	81 36 27
BW-302	Georgia Power VSC-2	202	33 08 10	81 35 59
BW-303	SRS P-19	297	33 14 45	81 36 58
BW-305	Georgia Power VSC-3	166	33 07 40	81 35 25
BW-308	SRS P-14	293	33 18 38	81 36 22
BW-312	SRS P-17	333	33 20 40	81 30 01
BW-314	SRS P-22	215	33 11 28	81 30 47
BW-316	SRS P-23	181	33 10 57	81 40 43
BW-349	SCDNR C-6	209	33 10 44	81 18 51
BW-357	SCDNR C-5	266	33 19 16	81 24 24
BW-375	SRS P-20	287	33 16 30	81 34 25
BW-379	SRS P-25	265	33 12 38	81 39 26
BW-386	Guy Suter	181	33 14 34	81 24 12
BW-391	SRS P-18	296	33 15 10	81 40 21
BW-417	SRS P-24	313	33 13 46	81 34 31
BW-430	SRS P-27	274	33 17 09	81 38 05
BW-800	SRS CFD-18	249	33 14 24	81 37 53
BW-801	SRS CFD-1	269	33 14 17	81 37 48
BW-814	SRS 905-136D	133	33 12 17	81 44 34
BW-888	SRS PBF-1	276	33 17 36	81 31 49
BW-889	SRS PBF-2	268	33 17 11	81 31 31
BW-890	SRS PBF-3	317	33 15 15	81 37 19
BW-891	SRS PBF-4	208	33 12 12	81 42 03
BW-892	SRS PBF-5	241	33 11 38	81 14 28
BW-893	SRS PBF-6	93	33 10 11	81 44 28

Table 2. Location of wells and cores used in study area--Continued

[USGS, U.S. Geological Survey; dms: degrees, minutes, seconds; SRS, Savannah River Site; SCDNR, South Carolina Department of Natural Resources; USDOE, U.S. Department of Energy]

USGS identifier	Well/core name	Elevation of land surface (feet above sea level)	Latitude (dms)	Longitude (dms)
		Hampton County, S.C.		
HM-25	Town of Brunson	135	32 55 32	81 11 11
HM-34	Town of Garnett	80	32 41 56	81 20 10
HM-92	Town of Estill	110	32 44 53	81 14 06
		Burke County, Ga.		
28X001	USGS TW-1 Midville	269	32 52 32	82 13 15
28Z006	Dyes Crossroads	328	33 12 39	82 08 35
29Y010	City of Waynesboro Highway 25	300	33 06 04	82 01 28
30Z017	GGS Millers Pond	245	33 13 48	81 52 44
30Z018	GGS Burke 5	297	33 13 41	81 55 52
31Y018	GGS TR92-3	195	33 06 35	81 46 54
31Z002	Georgia Power TW-1	219	33 08 28	81 45 42
31Z050	GGS TR92-4	192	33 11 30	81 48 34
31Z108	GGS TR92-6	245	33 10 42	81 47 10
31Z046	GGS TR92-1	235	33 09 37	81 49 19
31Z047	GGS TR92-2	285	33 09 27	81 47 23
31Z096	GGS TR92-5	235	33 08 09	81 47 03
31Z114	GGS TR92-7	255	33 08 51	81 48 09
32X042	Percy Dixon	217	32 59 33	81 38 21
32Y016	Georgia Power VG-3	166	33 04 54	81 39 32
32Y017	Georgia Power VG-2	251	33 05 08	81 40 31
32Y018	Georgia Power VG-4	150	33 05 28	81 41 38
32Y019	USGS Girard	250	33 03 53	81 43 15
32Y027	Georgia Power VG-1	157	33 04 41	81 38 42
32Y028	Georgia Power VG-7	251	33 05 54	81 42 31
32Y030	USGS Brighams Landing	85	33 05 48	81 39 11
33Y007	Georgia Power VG-6	217	33 03 11	81 36 47

Table 2. Location of wells and cores used in study area--Continued

[USGS, U.S. Geological Survey; dms: degrees, minutes, seconds; SRS, Savannah River Site; SCDNR, South Carolina Department of Natural Resources; USDOE, U.S. Department of Energy]

USGS identifier	Well/core name	Elevation of land surface (feet above sea level)	Latitude (dms)	Longitude (dms)
	Burke County, Ga.--Continued			
33Y008	Georgia Power VG-5	95	33 04 06	81 37 27
33Y011	Georgia Power VG-8	104	33 02 05	81 34 58
33Y012	USGS Stony Bluff Landing	82	33 02 38	81 32 58
	Jefferson County, Ga.			
26W001	Town of Wadley #1	230	32 51 34	82 24 19
26X011	City of Louisville #5	250	32 58 49	82 26 36
26X018	Georgia Petroleum Oil Company	225	32 58 49	82 26 36
26Z011	Town of Wrens #4	405	33 11 27	82 23 53
26Z012	J.M. Huber Corporation OW-1	458	33 13 15	82 22 55
	Jenkins County, Ga.			
30X006	Magnolia Springs State Park #2	213	32 52 54	81 57 12
	Richmond County, Ga.			
30AA01	Continental Can, Incorporated	164	33 19 41	81 57 12
30AA12	Kimberly-Clark, Incorporated PW-4	290	33 16 30	81 55 54
	Screven County, Ga.			
32U017	King Finishing Manufacturing #1	155	32 36 08	81 44 23
33X037	Millhaven Buena Vista #1	189	32 57 56	81 37 22
33X048	USGS Millhaven	110	32 53 25	81 35 43
34U001	McCain-Pryor Corporation	137	32 34 41	81 27 02

Table 3. Altitude for the top of each aquifer and confining unit in selected wells/cores

[All units in feet above or below (-) sea level; SRS, Savannah River Site; USDOE, U.S. Department of Energy; SCDNR, South Carolina Department of Natural Resources; USGS, U.S. Geological Survey; GGS, Georgia Geologic Survey; --, not included in hydrogeologic section; xxx, hydrogeologic top not penetrated by testhole]

Well identification	Well/core name	Upper-Three Run aquifer	Gordon confining unit	Gordon aquifer	Millers Pond confining unit	Millers Pond aquifer	Upper Dublin confining unit	Upper Dublin aquifer	Lower Dublin confining unit	Lower Dublin aquifer	Upper Midville confining unit	Upper Midville aquifer	Lower Midville confining unit	Lower Midville aquifer	Basal confining unit
Aiken County, S.C.															
AK-202	United Clay Mines	390	---	---	---	---	---	---	---	---	---	---	---	---	160
AK-266	City of Aiken	485	---	360	---	---	---	---	290	272	185	153	108	85	-34
AK-331	Aiken Youth Center	520	---	470	---	---	---	---	452	437	340	320	300	270	190
AK-435	Town of Howlandville #3	450	---	405	---	---	---	---	350	340	286	254	224	204	90
AK-445	Town of New Holland	525	---	425	---	---	---	---	395	375	315	290	xxx	xxx	xxx
AK-457	Town of Breezy Hill	475	---	---	---	---	---	---	---	---	365	335	295	285	205
AK-463	Town of Salley	360	---	236	---	---	157	136	120	96	xxx	xxx	xxx	xxx	xxx
AK-613	SRS P7A	274	167	145	---	---	39	11	-68	-89	-203	-303	-370	-404	xxx
AK-642	SRS P4A	105	---	80	---	---	5	0	-60	-80	-205	-275	-355	-371	-500
AK-643	SRS P-16	261	201	195	---	---	113	100	11	0	-117	-187	-271	-298	-371
AK-811	Weyerhause Corporation	400	---	294	---	---	220	205	172	157	26	10	xxx	xxx	xxx
AK-817	SCDNR C-2	419	---	313	---	---	240	233	190	165	32	13	-45	-62	-119

Table 3. Altitude for the top of each aquifer and confining unit in selected wells/cores--Continued

[All units in feet above or below (-) sea level; SRS, Savannah River Site; USDOE, U.S. Department of Energy; SCDNR, South Carolina Department of Natural Resources; USGS, U.S. Geological Survey; GGS, Georgia Geologic Survey; --, *not included in hydrogeologic section*; xxx, *hydrogeologic top not penetrated by testhole*]

Well identification	Well/core name	Upper-Three Run aquifer	Gordon confining unit	Gordon aquifer	Millers Pond confining unit	Millers Pond aquifer	Upper Dublin confining unit	Upper Dublin aquifer	Lower Dublin confining unit	Lower Dublin aquifer	Upper Midville confining unit	Upper Midville aquifer	Lower Midville confining unit	Lower Midville aquifer	Basal confining unit
Aiken County, S.C.--Continued															
AK-826	SCDNR C-3	295	---	267	---	---	207	193	164	146	29	-15	-55	-92	-190
AK-839	City of Beech Island	438	---	356	---	---	---	---	270	248	133	108	66	55	-20
AK-858	New Ellenton Seismic Test	435	---	267	---	---	193	189	129	95	-40	-73	-151	-169	-200
AK-865	SRS P-29	266	166	161	---	---	57	34	-81	-112	-220	-280	-322	-339	-480
AK-872	SRS P-26	151	---	80	---	---	-5	-30	-129	-167	-290	-370	-452	-456	xxx
AK-878	SRS P-28	285	155	142	---	---	57	29	-84	-112	-262	-323	-369	-405	-523
AK-892	SRS P-30	354	224	213	---	---	140	135	5	-5	-149	-196	-250	-272	-370
AK-902	SCDNR C-1	232	---	210	---	---	150	145	92	72	-41	-125	-198	-208	-286
Allendale County, S.C.															
AL-19	J.P. Stevens, Incorporated	161	-24	-79	-210	-224	-263	-323	-459	-471	-611	xxx	xxx	xxx	xxx
AL-22	Allendale Industrial Park	145	-155	-190	-354	-358	-382	-460	-632	-635	xxx	xxx	xxx	xxx	xxx
AL-27	Sandoz Chemical, Incorporated	168	-52	-132	-257	-263	-320	-358	-498	-512	xxx	xxx	xxx	xxx	xxx
AL-29	Town of Fairfax #4	140	-210	-248	-398	-400	-405	-496	xxx	xxx	xxx	xxx	xxx	xxx	xxx

Table 3. Altitude for the top of each aquifer and confining unit in selected wells/cores--Continued

[All units in feet above or below (-) sea level; SRS, Savannah River Site; USDOE, U.S. Department of Energy; SCDNR, South Carolina Department of Natural Resources; USGS, U.S. Geological Survey; GGS, Georgia Geologic Survey; --, not included in hydrogeologic section; xxx, hydrogeologic top not penetrated by testhole]

Well identification	Well/core name	Upper-Three Run aquifer	Gordon confining unit	Gordon aquifer	Millers Pond confining unit	Millers Pond aquifer	Upper Dublin confining unit	Upper Dublin aquifer	Lower Dublin confining unit	Lower Dublin aquifer	Upper Midville confining unit	Upper Midville aquifer	Lower Midville confining unit	Lower Midville aquifer	Basal confining unit
							Allendale County, S.C.--Continued								
AL-41	Town of Millet	140	-10	-90	-196	-240	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
AL-45	Ben Oswald Farm	190	-104	-130	-290	-296	-308	-390	xxx	xxx	xxx	xxx	xxx	xxx	xxx
AL-47	Groton Plantation	60	-374	-395	-542	-549	-560	-730	xxx	xxx	xxx	xxx	xxx	xxx	xxx
AL-48	Town of Ulmer	180	-77	-113	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
AL-49	Don Sharp	250	-172	-214	-366	-378	-390	-475	-622	xxx	xxx	xxx	xxx	xxx	xxx
AL-116	Butterfield Plantation	150	-146	-184	-326	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
AL-284	Kirkland Farms	160	-95	-138	---	---	-286	-364	xxx	xxx	xxx	xxx	xxx	xxx	xxx
AL-298	Russell Farms	135	-275	-300	-455	-467	-487	-607	-723	-735	-881	xxx	xxx	xxx	xxx
AL-306	W.F.Barnes	110	-250	-268	-424	-430	-440	-550	xxx	xxx	xxx	xxx	xxx	xxx	xxx
AL-317	Georgia Power	97	8	-71	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
AL-324	J.T. Duncan	203	23	-57	-145	-169	-197	-247	-329	-395	-527	-647	-702	-777	-927
AL-344	Georgia Power VSC-1	219	32	-48	-149	-165	-199	-258	-313	-351	xxx	xxx	xxx	xxx	xxx
AL-345	Georgia Power VSC-4	157	19	-62	-166	-188	-218	-269	-347	-392	-536	-663	-740	-793	xxx

Table 3. Altitude for the top of each aquifer and confining unit in selected wells/cores--Continued

[All units in feet above or below (-) sea level; SRS, Savannah River Site; USDOE, U.S. Department of Energy; SCDNR, South Carolina Department of Natural Resources; USGS, U.S. Geological Survey; GGS, Georgia Geologic Survey; --, not included in hydrogeologic section; xxx, hydrogeologic top not penetrated by testhole]

Well identification	Well/core name	Upper-Three Run aquifer	Gordon confining unit	Gordon aquifer	Millers Pond confining unit	Millers Pond aquifer	Upper Dublin confining unit	Upper Dublin aquifer	Lower Dublin confining unit	Lower Dublin aquifer	Upper Midville confining unit	Upper Midville aquifer	Lower Midville confining unit	Lower Midville aquifer	Basal confining unit
							Allendale County, S.C.--Continued								
AL-348	SCDNR C-10	290	-120	-154	-294	-303	-337	-394	-582	-596	-699	-872	-948	-985	1,194
AL-358	SCDNR C-7	252	14	-60	-171	-181	-217	-277	-375	-427	-572	-695	-777	-807	-967
AL-378	SCDNR C-13	78	-32	-108	-242	-254	-314	-342	-402	-448	-585	-752	-778	-832	xxx
AL-382	Cohens Landing	60	-280	-298	-470	-484	-510	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
							Bamberg County, S.C.								
BM-27	Town of Bamberg	150	55	45	---	---	-114	-166	-292	-306	-472	-630	-680	-710	xxx
BM-68	River Bridge State Park	108	-92	-122	---	---	-298	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
BM-76	Town of Govan	215	45	13	---	---	-171	-225	-305	-315	-505	xxx	xxx	xxx	xxx
							Barnwell County, S.C.								
BW-75	Town of Blackville	294	113	86	---	---	-24	-66	-144	-168	-298	xxx	xxx	xxx	xxx
BW-76	Allied General O-1	255	64	60	-22	-46	-69	-135	-217	-241	-377	-460	-530	-571	-720
BW-78	Town of Williston	340	177	167	---	---	51	23	-70	-80	-157	-247	-357	-380	xxx
BW-239	USDOE/ VPI SAL-1 Test	205	185	161	---	---	18	-12	-67	-97	-215	-323	-425	-435	-535

Table 3. Altitude for the top of each aquifer and confining unit in selected wells/cores--Continued

[All units in feet above or below (-) sea level; SRS, Savannah River Site; USDOE, U.S. Department of Energy; SCDNR, South Carolina Department of Natural Resources; USGS, U.S. Geological Survey; GGS, Georgia Geologic Survey; --, not included in hydrogeologic section; xxx, hydrogeologic top not penetrated by testhole]

Well identification	Well/core name	Upper-Three Run aquifer	Gordon confining unit	Gordon aquifer	Millers Pond confining unit	Millers Pond aquifer	Upper Dublin confining unit	Upper Dublin aquifer	Lower Dublin confining unit	Lower Dublin aquifer	Upper Midville confining unit	Upper Midville aquifer	Lower Midville confining unit	Lower Midville aquifer	Basal confining unit
Barnwell County, S.C.--Continued															
BW-243	SRS P-13	252	34	12	-82	-92	-110	-176	-271	-281	-404	-487	-597	-643	-726
BW-246	SRS P-15	253	98	82	-18	-22	-57	-119	-223	-233	-333	-437	-537	-571	-677
BW-295	E.F. Sanders	195	-40	-79	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
BW-299	SRS P5A (P-21)	206	46	-38	-121	-134	-159	-239	-312	-330	-497	-584	-638	-684	-814
BW-302	Georgia Power VSC-2	202	40	-32	-148	-152	-190	-244	-326	-341	xxx	xxx	xxx	xxx	xxx
BW-303	SRS P-19	297	120	102	---	---	15	-53	-148	-166	-295	-357	-445	-485	-595
BW-305	Georgia Power VSC-3	166	37	-39	-148	-172	-199	-250	-321	-336	xxx	xxx	xxx	xxx	xxx
BW-308	SRS P-14	293	147	139	---	---	23	-3	-87	-108	-247	-376	-428	-461	-567
BW-312	SRS P-17	333	157	140	---	---	25	0	-100	-120	-214	-340	-399	-432	-542
BW-314	SRS P-22	215	39	-4	-94	-123	-145	-227	-301	-314	-460	-545	-645	-697	-813
BW-316	SRS P-23	181	86	57	-2	-27	-42	-110	-175	-201	-375	-455	-520	-565	-685
BW-349	SCDNR C-6	209	16	-30	---	---	-224	-280	-384	-424	-540	-720	-775	-799	-954
BW-357	SCDNR C-5	266	103	95	-14	-17	-29	-77	-175	-181	-294	-390	-495	-516	-664
BW-375	SRS P-20	287	87	72	---	---	-12	-93	xxx	xxx	xxx	xxx	xxx	xxx	xxx
BW-379	SRS P-25	265	115	94	---	---	-15	-69	-160	-190	-330	-390	-475	-495	-611
BW-386	Guy Suter	181	61	21	-73	-81	-89	-153	-271	-294	-405	xxx	xxx	xxx	xxx

Table 3. Altitude for the top of each aquifer and confining unit in selected wells/cores--Continued

[All units in feet above or below (-) sea level; SRS, Savannah River Site; USDOE, U.S. Department of Energy; SCDNR, South Carolina Department of Natural Resources; USGS, U.S. Geological Survey; GGS, Georgia Geologic Survey; --, not included in hydrogeologic section; xxx, hydrogeologic top not penetrated by testhole]

Well identification	Well/core name	Upper-Three Run aquifer	Gordon confining unit	Gordon aquifer	Millers Pond confining unit	Millers Pond aquifer	Upper Dublin confining unit	Upper Dublin aquifer	Lower Dublin confining unit	Lower Dublin aquifer	Upper Midville confining unit	Upper Midville aquifer	Lower Midville confining unit	Lower Midville aquifer	Basal confining unit
Barnwell County, S.C.--Continued															
BW-391	SRS P-18	296	127	112	---	---	-3	-47	-144	-160	-330	-399	-461	-484	-609
BW-417	SRS P-24	313	59	32	-40	-44	-60	-133	-196	-207	-348	-430	-505	-533	-677
BW-430	SRS P-27	274	131	127	---	---	49	-30	-115	-126	-331	-384	-420	-448	-585
BW-800	SRS CFD-18	249	69	51	---	---	-37	-88	-200	-226	-363	-437	-527	-562	-659
BW-801	SRS CFD-1	269	110	89	---	---	0	-68	-144	-162	-306	-372	-451	-472	-595
BW-814	SRS 905-136D	133	72	65	---	---	-27	-43	-139	-167	-341	-440	-494	-503	-638
BW-888	SRS PBF-1	276	108	86	---	---	-7	-73	-169	-184	-290	-416	-484	-520	-658
BW-889	SRS PBF-2	268	125	110	---	---	12	-65	-131	-152	-254	-405	-474	-500	-636
BW-890	SRS PBF-3	317	72	54	---	---	-22	-94	-187	-195	-350	-413	-492	-535	-650
BW-891	SRS PBF-4	208	65	41	---	---	-54	-94	-215	-230	-385	-480	-523	-545	-687
BW-892	SRS PBF-5	241	104	79	6	-27	-39	-87	-163	-184	-340	-403	-477	-500	-654
BW-893	SRS PBF-6	93	---	59	-7	-15	-41	-87	-165	-180	-344	-430	-459	-477	-598
Hampton County, S.C.															
HM-25	Town of Brunson	135	-275	-290	---	---	-449	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
HM-34	Town of Garnett	80	-420	-446	---	---	-630	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
HM-92	Town of Estill	110	-408	-425	---	---	-628	-750	-874	-905	xxx	xxx	xxx	xxx	xxx

Table 3. Altitude for the top of each aquifer and confining unit in selected wells/cores--Continued

[All units in feet above or below (-) sea level; SRS, Savannah River Site; USDOE, U.S. Department of Energy; SCDNR, South Carolina Department of Natural Resources; USGS, U.S. Geological Survey; GGS, Georgia Geologic Survey; --, not included in hydrogeologic section; xxx, hydrogeologic top not penetrated by testhole]

Well identification	Well/core name	Upper-Three Run aquifer	Gordon confining unit	Gordon aquifer	Millers Pond confining unit	Millers Pond aquifer	Upper Dublin confining unit	Upper Dublin aquifer	Lower Dublin confining unit	Lower Dublin aquifer	Upper Midville confining unit	Upper Midville aquifer	Lower Midville confining unit	Lower Midville aquifer	Basal confining unit
							Burke County, Ga.								
28X001	USGS TW-1 Midville	269	-22	-72	-222	-242	-262	-325	-462	-482	-582	-692	-732	-772	-957
28Z006	Dyes Crossroads	328	163	136	64	43	20	2	-16	-41	xxx	xxx	xxx	xxx	xxx
29Y010	City of Highway 25	300	80	30	-60	-65	-100	-150	-215	-290	-393	-430	xxx	xxx	xxx
30Z017	GGS Millers Pond	245	138	89	80	38	-2	-12	-85	-90	-235	-255	-347	-358	-507
30Z018	GGS Burke 5	297	162	111	75	69	11	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
31Y018	GGS TR92-3	195	100	35	-50	-75	-117	-160	-250	-295	xxx	xxx	xxx	xxx	xxx
31Z002	Georgia Power TW-1	219	119	55	-27	-57	-85	-127	-221	-252	-378	-472	-527	-556	-665
31Z050	GGS TR92-4	192	102	52	-17	-30	-43	-68	-148	-178	xxx	xxx	xxx	xxx	xxx
31Z108	GGS TR92-6	245	118	63	---	---	-25	-55	-153	-165	-335	-390	-440	-452	-597
31Z046	GGS TR92-1	235	97	32	-31	-55	-85	-115	xxx	xxx	xxx	xxx	xxx	xxx	xxx
31Z047	GGS TR92-2	285	97	20	-40	-85	-100	-130	-205	-220	xxx	xxx	xxx	xxx	xxx
31Z096	GGS TR92-5	235	78	8	-55	-83	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
31Z114	GGS TR92-7	255	83	11	-55	-85	-120	-147	-199	-218	-393	-460	-505	-540	xxx
32X042	Percy Dixon	217	-70	-150	-285	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx

Table 3. Altitude for the top of each aquifer and confining unit in selected wells/cores--Continued

[All units in feet above or below (-) sea level; SRS, Savannah River Site; USDOE, U.S. Department of Energy; SCDNR, South Carolina Department of Natural Resources; USGS, U.S. Geological Survey; GGS, Georgia Geologic Survey; --, not included in hydrogeologic section; xxx, hydrogeologic top not penetrated by testhole]

Well identification	Well/core name	Upper-Three Run aquifer	Gordon confining unit	Gordon aquifer	Millers Pond confining unit	Millers Pond aquifer	Upper Dublin confining unit	Upper Dublin aquifer	Lower Dublin confining unit	Lower Dublin aquifer	Upper Midville confining unit	Upper Midville aquifer	Lower Midville confining unit	Lower Midville aquifer	Basal confining unit
Burke County, Ga.--Continued															
32Y016	Georgia Power VG-3	166	5	-73	-167	-191	-244	-298	-331	-361	xxx	xxx	xxx	xxx	xxx
32Y017	Georgia Power VG-2	251	3	-73	-171	-187	-241	-267	xxx	xxx	xxx	xxx	xxx	xxx	xxx
32Y018	Georgia Power VG-4	150	21	-51	-150	-160	-226	-268	-305	-345	xxx	xxx	xxx	xxx	xxx
32Y019	USGS Girard	250	6	-75	-173	-189	-231	-281	-350	-385	-523	-634	-708	-752	-950
32Y027	Georgia Power VG-1	157	2	-80	-176	-199	-251	-293	-353	-386	xxx	xxx	xxx	xxx	xxx
32Y028	Georgia Power VG-7	251	39	-33	-124	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
32Y030	USGS Brighams Landing	85	20	-55	-152	-170	-221	-268	-305	-357	-515	-610	-691	-727	-915
33Y007	Georgia Power VG-6	217	-33	-111	-211	-223	-305	-333	-403	xxx	xxx	xxx	xxx	xxx	xxx
33Y008	Georgia Power VG-5	95	-18	-93	-192	-211	-262	-297	-363	xxx	xxx	xxx	xxx	xxx	xxx

Table 3. Altitude for the top of each aquifer and confining unit in selected wells/cores--Continued

[All units in feet above or below (-) sea level; SRS, Savannah River Site; USDOE, U.S. Department of Energy; SCDNR, South Carolina Department of Natural Resources; USGS, U.S. Geological Survey; GGS, Georgia Geologic Survey; --, not included in hydrogeologic section; xxx, hydrogeologic top not penetrated by testhole]

Well identification	Well/core name	Upper-Three Run aquifer	Gordon confining unit	Gordon aquifer	Millers Pond confining unit	Millers Pond aquifer	Upper Dublin confining unit	Upper Dublin aquifer	Lower Dublin confining unit	Lower Dublin aquifer	Upper Midville confining unit	Upper Midville aquifer	Lower Midville confining unit	Lower Midville aquifer	Basal confining unit
Burke County, Ga.--Continued															
33Y011	Georgia Power VG-8	104	-39	-118	-239	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
33Y012	USGS Stony Bluff Landing	82	-33	-111	-246	-275	-331	-361	-441	-459	-621	-778	-828	-896	-1058
Jefferson County, Ga.															
26W001	Town of Wadley #1	230	67	-13	-125	-135	-143	-186	xxx	xxx	xxx	xxx	xxx	xxx	xxx
26X011	City of Louisville #5	250	119	80	---	---	-36	-60	-106	-118	-220	xxx	xxx	xxx	xxx
26X018	Georgia Petroleum Oil Company	225	105	56	---	---	-50	-73	-155	-161	-280	-337	-374	-441	-575
26Z011	Town of Wrens #4	405	---	211	---	---	---	---	156	131	32	23	-13	-27	xxx
26Z012	J.M. Huber Corporation OW-1	458	---	253	---	---	---	---	190	172	123	100	53	43	8
Jenkins County, Ga.															
30X006	Magnolia Springs State Park #2	213	-111	-157	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx

Table 3. Altitude for the top of each aquifer and confining unit in selected wells/cores--Continued

[All units in feet above or below (-) sea level; SRS, Savannah River Site; USDOE, U.S. Department of Energy; SCDNR, South Carolina Department of Natural Resources; USGS, U.S. Geological Survey; GGS, Georgia Geologic Survey; --, not included in hydrogeologic section; xxx, hydrogeologic top not penetrated by testhole]

Well identification	Well/core name	Upper-Three Run aquifer	Gordon confining unit	Gordon aquifer	Millers Pond confining unit	Millers Pond aquifer	Upper Dublin confining unit	Upper Dublin aquifer	Lower Dublin confining unit	Lower Dublin aquifer	Upper Midville confining unit	Upper Midville aquifer	Lower Midville confining unit	Lower Midville aquifer	Basal confining unit
Richmond County, Ga.															
30AA01	Continental Can, Incorporated	164	---	---	---	---	---	140	120	100	-47	-69	-117	-129	-198
30AA12	Kimberly-Clark, Incorporated PW-4	290	170	151	---	---	63	53	30	20	-158	-169	-215	-281	-395
Screven County, Ga.															
32U017	King Finishing Manufacturing #1	155	-473	-515	-665	-683	-693	-811	-899	-937	-1089	xxx	xxx	xxx	xxx
33X037	Millhaven Buena Vista #1	189	-140	-180	-280	-295	-370	-425	-525	-565	xxx	xxx	xxx	xxx	xxx
33X048	USGS Millhaven	110	-222	-255	-394	-414	-460	-524	-666	-710	-824	-982	-1,062	-1,102	-1,269
34U001	McCain-Pryor Corporation	137	-490	-543	---	---	-763	1,013	-1,063	-1,103	-1,223	-1,348	-1,450	-1,495	-1,723

Table 4. Total thickness of each aquifer and confining unit in selected wells/cores

[All units in feet; SRS, Savannah River Site; SCDNR, South Carolina Department of Natural Resources: USGS, U.S. Geological Survey; GGS, Georgia Geologic Survey; ---, not included in hydrogeologic section; xxx, hydrogeologic top not penetrated by testhole]

Well identification	Well/core name	Upper-Three Runs aquifer	Gordon confining unit	Gordon aquifer	Millers Pond confining unit	Millers Pond aquifer	Upper Dublin confining unit	Upper Dublin aquifer	Lower Dublin confining unit	Lower Dublin aquifer	Upper Midville confining unit	Upper Midville aquifer	Lower Midville confining unit	Lower Midville aquifer	Basal confining unit
Aiken County, S.C..															
AK-202	United Clay Mines	---	---	---	---	---	---	---	---	---	---	---	---	---	xxx
AK-266	City of Aiken	300	---	70	---	---	---	---	18	87	32	45	23	119	xxx
AK-331	Aiken Youth Center	180	---	18	---	---	---	---	15	97	20	20	30	80	xxx
AK-435	Town of Howlandville #3	164	---	55	---	---	---	---	10	54	32	30	20	114	xxx
AK-445	Town of New Holland	210	---	30	---	---	---	---	20	60	25	xxx	xxx	xxx	xxx
AK-457	Town of Breezy Hill	110	---	---	---	---	---	---	---	---	30	40	10	80	xxx
AK-463	Town of Salley	203	---	79	---	---	21	16	24	xxx	xxx	xxx	xxx	xxx	xxx
AK-613	SRS P7A	107	22	106	---	---	28	79	21	113	101	67	34	xxx	xxx
AK-642	SRS P4A	100	---	75	---	---	5	60	20	125	70	80	16	129	xxx
AK-643	SRS P-16	60	26	82	---	---	13	89	11	117	70	84	27	73	xxx
AK-811	Weyerhauser Corporation	180	---	74	---	---	15	33	15	131	16	xxx	xxx	xxx	xxx
AK-817	SCDNR C-2	179	---	73	---	---	7	43	25	133	19	58	17	57	xxx
AK-826	SCDNR C-3	88	---	60	---	---	14	29	18	117	44	40	37	98	xxx
AK-839	City of Beech Island	305	---	86	---	---	---	---	22	113	25	42	11	75	xxx
AK-858	New Ellenton Seismic Test	242	---	74	---	---	4	60	34	135	33	78	18	31	xxx

Table 4. Total thickness of each aquifer and confining unit in selected wells/cores--Continued

[All units in feet; SRS, Savannah River Site; SCDNR, South Carolina Department of Natural Resources: USGS, U.S. Geological Survey; GGS, Georgia Geologic Survey; ---, not included in hydrogeologic section; xxx, hydrogeologic top not penetrated by testhole]

Well identification	Well/core name	Upper-Three Runs aquifer	Gordon confining unit	Gordon aquifer	Millers Pond confining unit	Millers Pond aquifer	Upper Dublin confining unit	Upper Dublin aquifer	Lower Dublin confining unit	Lower Dublin aquifer	Upper Midville confining unit	Upper Midville aquifer	Lower Midville confining unit	Lower Midville aquifer	Basal confining unit
							Aiken County, S.C..--Continued								
AK-865	SRS P-29	100	5	104	---	---	15	115	31	108	60	42	17	141	xxx
AK-872	SRS P-26	156	---	85	---	---	25	99	38	123	80	82	4	xxx	xxx
AK-878	SRS P-28	130	13	85	---	---	28	113	28	150	61	46	36	118	xxx
AK-892	SRS P-30	130	11	73	---	---	5	130	10	144	47	54	22	98	xxx
AK-902	SCDNR C-1	82	---	60	---	---	5	53	20	113	84	73	10	78	xxx
							Allendale County, S.C								
AL-19	J.P. Stevens, Incorporated	185	55	131	14	39	60	136	12	140	xxx	xxx	xxx	xxx	xxx
AL-22	Allendale Industrial Park	300	35	164	2	24	78	172	3	xxx	xxx	xxx	xxx	xxx	xxx
AL-27	Sandoz Chemical, Incorporated	200	80	125	6	57	38	140	14	xxx	xxx	xxx	xxx	xxx	xxx
AL-29	Town of Fairfax #4	350	38	150	2	5	91	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
AL-41	Town of Millet	150	80	106	44	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
AL-45	Ben Oswald Farm	294	26	160	6	12	82	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
AL-47	Groton Plantation	434	21	147	7	11	70	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
AL-48	Town of Ulmer	257	35	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
AL-49	Don Sharp	422	42	152	12	12	85	147	xxx	xxx	xxx	xxx	xxx	xxx	xxx
AL-116	Butterfield Plantation	296	38	142	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx

Table 4. Total thickness of each aquifer and confining unit in selected wells/cores--Continued

[All units in feet; SRS, Savannah River Site; SCDNR, South Carolina Department of Natural Resources: USGS, U.S. Geological Survey; GGS, Georgia Geologic Survey; ---, not included in hydrogeologic section; xxx, hydrogeologic top not penetrated by testhole]

Well identification	Well/core name	Upper-Three Runs aquifer	Gordon confining unit	Gordon aquifer	Millers Pond confining unit	Millers Pond aquifer	Upper Dublin confining unit	Upper Dublin aquifer	Lower Dublin confining unit	Lower Dublin aquifer	Upper Midville confining unit	Upper Midville aquifer	Lower Midville confining unit	Lower Midville aquifer	Basal confining unit
Allendale County, S.C.--Continued															
AL-284	Kirkland Farms	255	43	148	---	---	78	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
AL-298	Russell Farms	410	25	155	12	20	120	116	12	146	xxx	xxx	xxx	xxx	xxx
AL-306	W.F.Barnes	360	18	156	6	10	110	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
AL-317	Georgia Power	89	79	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
AL-324	J.T. Duncan	180	80	88	24	28	50	82	66	132	120	55	75	150	xxx
AL-344	Georgia Power VSC-1	187	80	101	16	34	59	55	38	xxx	xxx	xxx	xxx	xxx	xxx
AL-345	Georgia Power VSC-4	138	81	104	22	30	51	78	45	144	127	77	53	xxx	xxx
AL-348	SCDNR C-10	410	34	140	9	34	57	188	14	103	173	76	37	209	xxx
AL-358	SCDNR C-7	240	74	100	10	36	60	98	52	145	123	82	30	160	xxx
AL-378	SCDNR C-13	110	76	134	12	60	28	60	46	137	167	26	54	xxx	xxx
AL-382	Cohens Landing	340	18	172	14	26	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
Bamberg County, S.C.															
BM-27	Town of Bamberg	95	10	159	---	---	52	126	14	166	158	50	30	xxx	xxx
BM-68	River Bridge State Park	200	30	176	---	---	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
BM-76	Town of Govan	170	32	158	---	---	54	80	10	190	xxx	xxx	xxx	xxx	xxx

Table 4. Total thickness of each aquifer and confining unit in selected wells/cores--Continued

[All units in feet; SRS, Savannah River Site; SCDNR, South Carolina Department of Natural Resources: USGS, U.S. Geological Survey; GGS, Georgia Geologic Survey; ---, not included in hydrogeologic section; xxx, hydrogeologic top not penetrated by testhole]

Well identification	Well/core name	Upper-Three Runs aquifer	Gordon confining unit	Gordon aquifer	Millers Pond confining unit	Millers Pond aquifer	Upper Dublin confining unit	Upper Dublin aquifer	Lower Dublin confining unit	Lower Dublin aquifer	Upper Midville confining unit	Upper Midville aquifer	Lower Midville confining unit	Lower Midville aquifer	Basal confining unit
Barnwell County, S.C.															
BW-75	Town of Blackville	181	27	110	---	---	42	78	24	130	xxx	xxx	xxx	xxx	xxx
BW-76	Allied General O-1	191	4	82	24	23	66	82	24	136	83	70	41	149	xxx
BW-78	Town of Williston	163	10	116	---	---	28	93	10	77	90	110	23	xxx	xxx
BW-239	USDOE/VPI SAL-1 Test	20	24	143	---	---	30	55	30	118	108	102	10	100	xxx
BW-243	SRS P-13	218	22	94	10	18	66	95	10	123	83	110	46	83	xxx
BW-246	SRS P-15	155	16	100	4	35	62	104	10	100	104	100	34	106	xxx
BW-295	E.F. Sanders	235	39	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
BW-299	SRS P5A (P-21)	160	84	83	13	25	80	73	18	164	87	54	46	130	xxx
BW-302	Georgia Power VSC-2	162	72	116	4	38	54	82	15	xxx	xxx	xxx	xxx	xxx	xxx
BW-303	SRS P-19	177	18	87	---	---	68	95	18	129	62	88	40	110	xxx
BW-305	Georgia Power VSC-3	129	76	109	24	27	51	71	14	xxx	xxx	xxx	xxx	xxx	xxx
BW-308	SRS P-14	146	8	116	---	---	26	84	21	139	129	52	33	106	xxx
BW-312	SRS P-17	176	17	115	---	---	25	100	20	94	126	59	33	110	xxx
BW-314	SRS P-22	176	43	90	29	22	82	74	13	146	85	100	52	116	xxx
BW-316	SRS P-23	95	29	59	25	15	68	65	26	174	80	65	45	120	xxx
BW-349	SCDNR C-6	193	46	194	---	---	56	104	40	116	180	55	24	155	xxx
BW-357	SCDNR C-5	163	8	109	3	12	48	98	6	113	96	105	21	148	xxx

Table 4. Total thickness of each aquifer and confining unit in selected wells/cores--Continued

[All units in feet; SRS, Savannah River Site; SCDNR, South Carolina Department of Natural Resources: USGS, U.S. Geological Survey; GGS, Georgia Geologic Survey; ---, not included in hydrogeologic section; xxx, hydrogeologic top not penetrated by testhole]

Well identification	Well/core name	Upper-Three Runs aquifer	Gordon confining unit	Gordon aquifer	Millers Pond confining unit	Millers Pond aquifer	Upper Dublin confining unit	Upper Dublin aquifer	Lower Dublin confining unit	Lower Dublin aquifer	Upper Midville confining unit	Upper Midville aquifer	Lower Midville confining unit	Lower Midville aquifer	Basal confining unit
Barnwell County, S.C.--Continued															
BW-375	SRS P-20	200	15	84	---	---	81	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
BW-379	SRS P-25	150	21	109	---	---	54	91	30	140	60	85	20	116	xxx
BW-386	Guy Suter	120	40	94	8	8	64	118	23	111	xxx	xxx	xxx	xxx	xxx
BW-391	SRS P-18	169	15	115	---	---	44	97	16	170	69	62	23	125	xxx
BW-417	SRS P-24	254	27	72	4	16	73	63	11	141	82	75	28	144	xxx
BW-430	SRS P-27	143	4	77	---	---	45	80	11	205	54	36	28	137	xxx
BW-800	SRS CFD-18	180	18	88	---	---	51	112	26	137	74	90	35	97	xxx
BW-801	SRS CFD-1	159	21	89	---	---	68	76	18	144	66	79	21	123	xxx
BW-814	SRS 905-136D	61	7	92	---	---	28	96	28	174	99	54	9	135	xxx
BW-888	SRS PBF-1	168	22	93	---	---	66	96	15	106	126	68	36	138	xxx
BW-889	SRS PBF-2	143	15	98	---	---	77	66	21	102	151	69	26	136	xxx
BW-890	SRS PBF-3	245	18	76	---	---	72	93	19	144	63	79	43	115	xxx
BW-891	SRS PBF-4	143	24	95	---	---	40	121	15	155	95	43	22	142	xxx
BW-892	SRS PBF-5	137	25	73	33	12	48	76	21	156	63	74	23	154	xxx
BW-893	SRS PBF-6	---	---	66	8	26	46	78	15	164	86	29	18	121	xxx
Hampton County, S.C.															
HM-25	Town of Brunson	410	15	159	---	---	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
HM-34	Town of Garnett	500	26	184	---	---	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
HM-92	Town of Estill	518	17	203	---	---	122	124	31	xxx	xxx	xxx	xxx	xxx	xxx

Table 4. Total thickness of each aquifer and confining unit in selected wells/cores--Continued

[All units in feet; SRS, Savannah River Site; SCDNR, South Carolina Department of Natural Resources: USGS, U.S. Geological Survey; GGS, Georgia Geologic Survey; ---, not included in hydrogeologic section; xxx, hydrogeologic top not penetrated by testhole]

Well identification	Well/core name	Upper-Three Runs aquifer	Gordon confining unit	Gordon aquifer	Millers Pond confining unit	Millers Pond aquifer	Upper Dublin confining unit	Upper Dublin aquifer	Lower Dublin confining unit	Lower Dublin aquifer	Upper Midville confining unit	Upper Midville aquifer	Lower Midville confining unit	Lower Midville aquifer	Basal confining unit
							Burke County, Ga.								
28X001	USGS TW-1 , Midville	290	50	150	20	20	63	137	20	100	110	40	40	185	xxx
28Z006	Dyes Crosroads	165	27	72	21	23	18	18	25	xxx	xxx	xxx	xxx	xxx	xxx
29Y010	City of Waynesboro Highway 25	220	50	90	5	35	50	65	75	103	37	xxx	xxx	xxx	xxx
30Z017	GGS Millers Pond	107	49	11	42	40	10	73	5	145	20	92	11	149	xxx
30Z018	GGS Burke 5	135	51	36	6	58	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
31Y018	GGS TR92-3	95	65	85	25	42	43	90	45	xxx	xxx	xxx	xxx	xxx	xxx
31Z002	Georgia Power TW-1	100	64	82	30	28	42	94	31	126	94	55	29	109	xxx
31Z050	GGS TR92-4	90	50	69	13	13	25	80	30	xxx	xxx	xxx	xxx	xxx	xxx
31Z108	GGS TR92-6	127	55	88	---	---	30	98	12	170	55	50	12	145	xxx
31Z046	GGS TR92-1	138	65	63	24	30	30	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
31Z047	GGS TR92-2	188	77	60	45	15	30	75	15	xxx	xxx	xxx	xxx	xxx	xxx
31Z096	GGS TR92-5	157	70	63	28	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
31Z114	GGS TR92-7	172	72	66	30	35	27	52	19	175	67	45	35	xxx	xxx
32X042	Percy Dixon	287	80	135	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
32Y016	Georgia Power VG-3	161	78	94	24	53	54	33	30	xxx	xxx	xxx	xxx	xxx	xxx
32Y017	Georgia Power VG-2	248	76	98	16	54	26	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx

Table 4. Total thickness of each aquifer and confining unit in selected wells/cores--Continued

[All units in feet; SRS, Savannah River Site; SCDNR, South Carolina Department of Natural Resources: USGS, U.S. Geological Survey; GGS, Georgia Geologic Survey; ---, not included in hydrogeologic section; xxx, hydrogeologic top not penetrated by testhole]

Well identification	Well/core name	Upper-Three Runs aquifer	Gordon confining unit	Gordon aquifer	Millers Pond confining unit	Millers Pond aquifer	Upper Dublin confining unit	Upper Dublin aquifer	Lower Dublin confining unit	Lower Dublin aquifer	Upper Midville confining unit	Upper Midville aquifer	Lower Midville confining unit	Lower Midville aquifer	Basal confining unit
Burke County, Ga.--Continued															
32Y018	Georgia Power VG-4	129	72	99	10	66	42	37	40	xxx	xxx	xxx	xxx	xxx	xxx
32Y019	USGS Girard	244	81	98	16	42	50	69	33	138	111	74	44	198	xxx
32Y027	Georgia Power VG-1	155	82	96	23	52	42	60	33	xxx	xxx	xxx	xxx	xxx	xxx
32Y028	Georgia Power VG-7	212	72	91	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
32Y030	USGS Brighams Landing	65	75	97	18	51	47	37	52	158	95	81	36	188	xxx
33Y007	Georgia Power VG-6	250	78	100	12	82	28	70	xxx	xxx	xxx	xxx	xxx	xxx	xxx
33Y008	Georgia Power VG-5	113	75	99	19	51	35	66	xxx	xxx	xxx	xxx	xxx	xxx	xxx
33Y011	Georgia Power VG-8	143	79	121	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
33Y012	USGS Stony Bluff Landing	115	78	135	29	56	30	80	18	162	157	50	68	162	xxx
Jefferson County, Ga.															
26W001	Town of Wadley #1	163	80	112	10	8	43	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
26X011	City of Louisville #5	131	39	116	---	---	24	46	12	102	xxx	xxx	xxx	xxx	xxx
26X018	Georgia Petroleum Oil Company	120	49	106	---	---	23	82	6	119	57	37	67	134	

Table 4. Total thickness of each aquifer and confining unit in selected wells/cores--Continued

[All units in feet; SRS, Savannah River Site; SCDNR, South Carolina Department of Natural Resources: USGS, U.S. Geological Survey; GGS, Georgia Geologic Survey; ---, not included in hydrogeologic section; xxx, hydrogeologic top not penetrated by testhole]

Well identification	Well/core name	Upper-Three Runs aquifer	Gordon confining unit	Gordon aquifer	Millers Pond confining unit	Millers Pond aquifer	Upper Dublin confining unit	Upper Dublin aquifer	Lower Dublin confining unit	Lower Dublin aquifer	Upper Midville confining unit	Upper Midville aquifer	Lower Midville confining unit	Lower Midville aquifer	Basal confining unit
Jefferson County, Ga.--Continued															
26Z011	Town of Wrens #4	380	---	55	---	---	---	---	25	99	9	36	14	xxx	xxx
26Z012	J.M. Huber Corporation OW-1	214	---	63	---	---	---	---	18	49	23	47	10	35	xxx
Jenkins County, Ga.															
30X006	Magnolia Springs State Park #2	324	46	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
Richmond County, Ga.															
30AA01	Continental Can, Incorporated	24	---	---	---	---	---	20	20	147	22	48	12	69	xxx
30AA12	Kimberly-Clark, Incorporated PW-4	120	19	87	---	---	10	23	10	178	11	46	66	114	xxx
Screven County, Ga.															
32U017	King Finishing Manufacturing #1	628	42	150	18	10	118	88	38	152	xxx	xxx	xxx	xxx	xxx
33X037	Millhaven Buena Vista #1	329	40	100	15	75	55	100	40	xxx	xxx	xxx	xxx	xxx	xxx
33X048	USGS Millhaven	332	33	139	20	36	64	142	44	114	158	80	40	167	xxx
34U001	McCain-Pryor Corporation	627	53	220	---	---	250	50	40	120	125	102	45	228	xxx

Table 5. Hydraulic properties for selected wells in the trans-river flow study area

[USGS, U.S. Geological Survey; SRS, Savannah River Site; GGS, Georgia Geologic Survey; dms: degrees, minutes, seconds; ft, feet; ft^2/d, square feet per day; ft/d, feet per day]

USGS well identifier	Well name	Latitude (dms)	Longitude (dms)	Elevation of land surface (feet above sea level)	Well depth (ft)	Screened internal (feet below land surface)	Aquifer assignment for screened interval	Thickness of aquifer (ft)	Transmissivity (ft^2/d)	Hydraulic conductivity (ft/d)
					Aiken County, S.C.					
AK-266	City of Aiken Pine Log Road	33 31 51	81 42 19	485	335	240-250 270-280 290-300 310-330	lower Dublin	90	8,750	98
AK-516	SRS PW 905-101F	33 17 14	81 40 28	318	855	600-630 670-720 830-850	upper/lower Midville	250	12,300	48
AK-747	Town of Breezy Hill Hayes 2	33 31 26	81 52 35	350	240	160-240	lower Midville	80	16,100	200
AK-750	Town of Breezy Hill Ascauga Lake 9	33 34 08	81 50 46	465	300	200-300	lower Midville	100	7,400	74
AK-901	SRS PW 905-102F	33 17 06	81 40 26	308	783	605-615 623-633 651-662 680-690 703-714 723-774	upper/lower Midville	200	29,200	145
					Barnwell County, S.C.					
BW-284	SRS PW 905-104L	33 12 49	81 37 24	250	590	447-462 480-505 510-550 560-580	upper/lower Dublin	214	10,200	47
BW-285	SRS PW 905-105L	33 12 45	81 37 21	260	602	430-470 484-504 552-592	upper/lower Dublin	214	8,900	42
BW-363	Town of Williston Halford Street	33 23 39	81 26 23	350	450	370-450	upper/lower Dublin	190	7,000	37

Table 5. Hydraulic properties for selected wells in the trans-river flow study area--Continued

[USGS, U.S. Geological Survey; SRS, Savannah River Site; GGS, Georgia Geologic Survey; dms: degrees, minutes, seconds; ft, feet; ft^2/d, square feet per day; ft/d, feet per day]

USGS well identifier	Well name	Latitude (dms)	Longitude (dms)	Elevation of land surface (feet above sea level)	Well depth (ft)	Screened internal (feet below land surface)	Aquifer assignment for screened interval	Thickness of aquifer (ft)	Transmis-sivity (ft^2/d)	Hydraulic conductivity (ft/d)
Barnwell County, S.C.--Continued										
BW-469	SRS PW 905-108G	33 20 14	81 33 59	280	200	175-195	Gordon	90	1,600	18
BW-811	SRS Area 100	33 13 24	81 37 02	300	277	260-270	Gordon	100	180	2
Burke County, Ga.										
30Z021	USGS Millers Pond TW-2	33 13 48	81 52 44	242	635	595-625	lower Midville	193	1,550	8
30Z022	USGS Millers Pond TW-4	33 13 48	81 52 44	242	110	80-100	Upper Three Runs	107	840	8
30Z023	USGS Millers Pond TW-3	33 13 48	81 52 44	242	558	528-548	upper Midville	52	1,570	30
30Z025	USGS Millers Pond TW-6	33 13 48	81 52 44	242	336	299-325	upper Dublin	73	50	.7
30Z026	USGS - Millers Pond TW-7	33 13 48	81 52 44	242	480	445-475	lower Dublin	145	57	.4
30Z028	USGS Millers Pond TW-5A	33 13 48	81 52 44	242	260	210-250	Millers Pond	40	270	7
31Z110	GGS TR92-6B Thompson Oak	33 10 44	81 47 09	250	211	180-200	Gordon	92	180	2
31Z111	GGS TR92-6C Thompson Oak	33 10 44	81 47 09	252	500	450-500	lower Dublin	170	1,900	12

Table 5. Hydraulic properties for selected wells in the trans-river flow study area--Continued

[USGS, U.S. Geological Survey; SRS, Savannah River Site; GGS, Georgia Geologic Survey; dms: degrees, minutes, seconds; ft, feet; ft^2/d, square feet per day; ft/d, feet per day]

USGS well identifier	Well name	Latitude (dms)	Longitude (dms)	Elevation of land surface (feet above sea level)	Well depth (ft)	Screened internal (feet below land surface)	Aquifer assignment for screened interval	Thickness of aquifer (ft)	Transmis-sivity (ft^2/d)	Hydraulic conductivity (ft/d)
Burke County, Ga.--Continued										
31Z112	GGS TR92-6D Thompson Oak	33 10 44	81 47 09	252	853	800-831	lower Midville	205	1,300	9
32Y029	USGS Girard TW-2	33 03 53	81 43 15	250	774	743-773	lower Dublin	138	3,900	38
32Y030	USGS Brighams Landing TW-1	33 05 48	81 39 11	85	982	920-970	lower Midville	188	15,000	80
32Y031	USGS Brighams Landing TW-2	33 05 48	81 39 11	85	562	502-552	lower Dublin	158	8,900	56
32Y032	USGS Girard TW-3	33 03 54	81 43 15	250	1,143	1,070-1,122	lower Midville	198	1,100	6
32Y033	USGS Brighams Landing TW-3	33 05 48	81 39 11	85	210	150-200	Gordon	97	3,500	36

Table 6. Water-level altitude and (date) of water-level measurement for selected well clusters

[All units in feet above mean sea level; SRS, Savannah River Site; Ga., Georgia; S.C., South Carolina; A, aquifer absent; B, cluster does not have a well screened in this aquifer; --, no data]

Aquifer	Millers Pond, Ga. (Sept. 1993)	Thompson Oak, Ga.	Girard, Ga. (Mar. 1995)	Brighams Landing, Ga.	Millhaven, Ga. (Mar. 1995)	SRS P-19, S.C. (May 1992)	SRS P-21, S.C. (May 1992)	SRS P-22 S.C. (May 1992)	SRS P-23 S.C. (May 1992)	SRS P-26 S.C. (May 1992)	SRS P-30 S.C. (May 1992)
Upper Three Runs	--	--	--	--	99.5	--	--	--	--	--	--
	180.2	B	217.7	B	99.6	267.3	159.9	170.9	145.0	119.9	259.9
	--	--	--	--	102.2	266.2	--	171.4	--	--	--
Gordon	B	89.9 (Oct. 1994)	B	122.3	B	266.2	136.6	153.9	139.0	119.6	211.7
Millers Pond	137.7	A	B	B	B	A	136.7	154.3	147.7	A	A
Upper Dublin	159.2	B	B	B	B	180.6	168.1	177.1	164.9	149.6	209.8
Lower Dublin	159.4	156.4 (Apr. 1995)	160.2	154.2	150.4	181.3	168.4	177.1	165.2	156.0	208.9
Upper Midville	159.4	B	B	B	B	181.1	180.3	190.1	170.4	196.5	200.4
Lower Midville	158.9	159.5	175.1	175.0	185.2	179.9	182.3	189.8	171.7	173.3	190.5
	159.2	(July 1995)	--	--	--	--	--	--	--	--	190.5

Note: Water levels are from Clarke and others (1994, 1996), Leeth and others (1996), and Harrelson and others (1997) for the Georgia clusters and from Westinghouse Savannah River Company (Ralph Nichols, written commun., May 1992) for the SRS clusters.

Table 7. Drawdown response in pumping and observation wells at the end of each 72-hour aquifer test at the Millers Pond test site, Burke County, Ga. (Modified from Clarke and others, 1994)

[gal/min, gallons per minute; NM, well not monitored for water-level change; A, a well is not screened in this unit]

Aquifer	Test well number (flow in pumping well, gal/min)	Drawdown response in pumping and observation wells (in feet)						
		TW-4 aquifer test	TW-5a aquifer test	TW-6 aquifer test	TW-7 aquifer test	TW-3 aquifer test	TW-2 aquifer test	TW-1 aquifer test
Upper Three Runs	TW-4 (8)	5.25	<0.01	<0.01	<0.01	NM	NM	NM
Gordon	A	A	A	A	A	A	A	A
Millers Pond	TW-5a (41)	<.01	70.54	<.01	<.01	NM	NM	NM
Upper Dublin	TW-6 (12)	<.01	<.01	190.30	.33	NM	NM	NM
Lower Dublin	TW-7 (19)	NM	NM	0.23	137.80	0.20	0.13	NM
Upper Midville	TW-3 (165)	NM	NM	NM	.88	209.98	.66	<0.01
Lower Midville	TW-2 (65)	NM	NM	NM	.13	.23	88.59	.13
	TW-1 (178)	NM	NM	NM	.06	.10	.56	147.64

Note: Data from Jerry Moore, Clemson University, written commun., 1993.