**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)**

VOLUME 1 - CLUSTER-SITE DESCRIPTION

**STATE OF SOUTH CAROLINA
DEPARTMENT OF NATURAL RESOURCES
WATER RESOURCES DIVISION
OPEN-FILE REPORT 1
MAY 1995**

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(1986 - 1994)**

VOLUME 1 - CLUSTER-SITE DESCRIPTION

by

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Rolf K. Aadland, and Gregory C. Simones**

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**STATE OF SOUTH CAROLINA
DEPARTMENT OF NATURAL RESOURCES**

**WATER RESOURCES DIVISION
OPEN-FILE REPORT 1
MAY 1995**

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ABSTRACT

Continuous core and downhole geophysical data from seven well-cluster sites delineate the lithostratigraphic and hydrostratigraphic units peripheral to the Savannah River Site (SRS) in west-central South Carolina. Thirteen lithostratigraphic and nine hydrostratigraphic units are identified. Data collected from the ongoing study include 146 paleontologic and palynologic age dates, 100 x-ray diffraction analyses of clay and bulk mineralogy, 442 sieve analyses, 6,040 ft (feet) of detailed core description, mineral composition and porosity determined from thin-section analyses, and continuous water level data.

Sediments range in age from Upper Cretaceous (Coniacian) to Holocene and are mostly of marine origin. The Cretaceous section is 350 to 1,000 ft thick and consists of unconsolidated siliciclastic sediments with minor amounts of carbonate mud. The basal Cape Fear Formation is absent at updip sites, pinching out along a line that extends from Windsor, S.C. to the confluence of Town and Long Branch Creeks, located north of Jackson, S.C. The Black Creek Formation is well dated (Campanian). Dates from other Cretaceous formations are sparse. High clay content in the Black Creek and Steel Creek Formations in the southeastern part of the study area suggests that the eastern flank of a delta complex extends along a line from Williston to Allendale, S.C.

The Tertiary section is 100 to 700 ft thick and consists of siliciclastic and calcareous sediments. Calcareous sediments are most abundant in the middle Eocene section. Lithofacies relationships indicate three major transgressive sequences in the Eocene epoch that occurred during: 1) lower Eocene to early, middle Eocene (Congaree/Fourmile time); 2) late, middle Eocene (Santee time); and 3) upper Eocene (Dry Branch time). Palynological data from a sample in the Tobacco Road Formation indicates an Oligocene age, suggesting that the formation may be younger than originally thought.

The basal McQueen Branch aquifer is the coarsest grained and most productive aquifer in the study area. Well yields as great as 1,500 gpm (gallons per minute) are available. Transmissivity as great as 50,000 ft²/d (feet squared per day) and hydraulic conductivity of 210 ft/d (feet per day) are indicated for this aquifer by pumping tests. Sediments of the Crouch Branch aquifer are slightly finer grained than those of the McQueen Branch. Well yields as large as 1,000 gpm can be obtained. Transmissivity as great as 19,000 ft²/d and hydraulic conductivity of 140 ft/d are indicated by pumping tests. Wells in the Gordon aquifer can yield 400 gpm. This aquifer's transmissivity and hydraulic conductivity are as high as 5,000 ft²/d and 40 ft/d, respectively. Yields decrease downdip, owing to an increase in clay content and a decrease in grain size. The Upper Three Runs aquifer contains the water table and generally does not yield great amounts of water (< 50 gpm). Downdip, however, where the aquifer is confined, yields of 500 gpm are recorded, owing to lithofacies changes in the Santee Limestone. The Ocala Limestone, a major water-bearing formation of the Upper Floridan aquifer in coastal areas, is present in the southern region of the study area but is thin and discontinuous and is, therefore, not an important aquifer in the region.

Maximum water-level fluctuations (12 ft) occur in the water table aquifer and minimum fluctuations (< 1 ft) in the basal McQueen Branch aquifer. Continuous water-level measurements made in the upper and lower parts of each aquifer are similar and fluctuate together, indicating a high degree of vertical hydraulic continuity in each aquifer. During the drought of 1993, water levels were not dramatically affected. Declines occurred during the summer months, but these declines were not significantly greater than in previous years.

INTRODUCTION

The South Carolina Department of Natural Resources, Water Resources Division (SCWRD), in collaboration with the United States Department of Energy (USDOE), is conducting a hydrogeologic investigation of the ground-water system peripheral to the Savannah River Site (SRS). The study area is located in the Southeastern Coastal Plain hydrogeologic province in Aiken, Allendale, and Barnwell Counties, S.C. (Fig. 1). Ground-water movement, quality, and availability are being evaluated in order to better protect and manage this valuable resource in the region.

The framework of the investigation is a well-cluster system comparable to one constructed on SRS (Bledsoe, 1984, 1987, and 1988). Cluster sites are situated outside SRS on the basis of study objectives, proximity to the plant's borders, land availability, and the need to uniformly space sites along the entire length of the border to optimize hydrogeologic control. At each cluster site, one well is continuously cored and geophysically logged from land surface to 10 ft (feet) into unweathered, crystalline basement rock. Data obtained from the core and logs are analyzed to determine the number, depth, and thickness of aquifers in the area. One to three monitoring wells are completed in each major aquifer.

As originally envisioned, the final project will include 11 cluster sites consisting of 82 monitoring wells. Presently (1995), seven sites have been established; three in Aiken County, two in Barnwell County, and two in Allendale County (Fig. 1). More than 7,200 ft of sediments have been cored and 41 monitoring wells constructed. Most of the wells are equipped with automatic, digital water-level recorders and submersible pumps.

Data generated from this project, in conjunction with data acquired on and off the site, will be utilized to construct a detailed hydrogeologic framework of west-central South Carolina (Aadland and others, in press). This framework will provide the basis for determining ground-water flow rates, volumes, and directions within and between aquifers. The project will also provide a long-term observation network to: continually monitor water levels, head relationships, and flow paths; monitor water quality; and detect changes in these parameters as ground-water pumpage changes in west-central South Carolina. This report is a compilation and interpretation of the "C-well" data that have been generated from the project and that will be used to model and characterize the aquifers and confining units in the region.

Scope of Work

Geologic data were obtained by continuously coring one exploratory well at each cluster site from land surface through the Coastal Plain sediments and into crystalline bedrock. A 5-ft, CP-wireline core barrel was used, producing a 3 1/4-in (inch) diameter core. The core samples were described in the field by SCWRD hydrologists. Cores were wrapped in plastic, labeled in 5-ft intervals, and placed on a polyvinyl chloride (PVC) tray. The tray was then inserted into a 5-ft section of Schedule-40 PVC that was capped on both ends, labeled, and transported to the South Carolina Geological Survey (SCGS) where it is stored in the State's rock/sediment repository.

After coring operations were completed, the borings were geophysically logged either by SCWRD or USGS personnel. Onsite digital logs were also acquired from each core hole at a 1/2-ft sampling interval and are available upon request from SCWRD. Logs obtained are listed below.

Figure 1. Location of study area and well-cluster sites, 1995.

- natural gamma-radiation
- single-point resistance
- 12- and 64-inch normal resistivity
- 72-inch lateral resistivity
- spontaneous-potential
- caliper

Upon examination of the geologic samples and geophysical logs and after consultation with geologists from SRS and WSRC (Westinghouse Savannah River Company), the appropriate zones to be screened were determined. Grain-size analyses were made on these sections of the core (Appendix 1). The boring was then reamed to 12 1/4 in and 6-in diameter galvanized steel casing was set and pressure-grouted from the top of the screen setting to land surface. After allowing the grout to set, a 5 5/8-in diameter hole was drilled to a depth of 15 to 30 ft below the bottom of the 6-in casing. A 10-ft section of 4-in diameter screen, equipped with 5 ft of blank-pipe sump and about 40 ft of overlap pipe, was installed in the bore hole. The top of the overlap pipe was fitted with a neoprene packer to isolate the screened zone. Well-construction diagrams are provided in Appendix 2.

Wells completed in the project are all natural-filter designed. Wire-wound, 4-in diameter well screens with 0.010 in openings were generally used in the monitoring wells (Appendix 2). Wells deeper than 300 ft were constructed with standard threaded and coupled Schedule-40 galvanized steel casing and stainless steel screens. Wells less than 300 ft were mainly constructed with threaded-joint PVC casing and screens.

After the screens were installed, the wells were logged with a caliper tool to verify that the screens had been properly set at the selected depths. Wells were then developed by surging with air until clear, sand-free discharge was obtained.

Data Analysis

Core was transported from SCGS to the hydrogeologic laboratory at SCWRD where it was macroscopically and microscopically described at 1-ft intervals (Volume 2), using a methodology developed at SRS. The following sediment parameters were described:

- lithology
- grain size
- grain shape
- grain sorting
- induration
- color
- porosity
- fossils
- structure

Prior to the completion of the hydrogeologic laboratory at SCWRD, core samples were described by WSRC personnel. Cores from sites C-2, C-6, and C-10 were described at SRS by geologist Mary Harris. Cores from sites C-1, C-3, C-5, and C-7 were described at SCWRD by hydrologists Greg Simones and Greg Kuntz. Greg Simones described all of the core from sites C-1, C-3, and C-7 and the upper 700 ft from site C-5. Greg Kuntz described the lower 500 ft of core from site C-5.

Color slides of 3,304 core samples were made at the SCWRD lab at macroscopic and microscopic scales. Each slide is cataloged by well site and depth, and a brief description accompanies each slide. A breakdown by cluster site is listed below.

NUMBER OF COLOR SLIDES FROM CORE SAMPLES	
<u>Cluster site</u>	<u>Number of slides</u>
C-1	407
C-2	221
C-3	317
C-5	709
C-6	493
C-7	737
C-10	420

Grain-size distribution parameters, derived from sieve analyses, were determined for 442 core samples. Samples were sieved at 1-phi intervals through seven sieve trays, corresponding to a range in grain size from <-1 phi to >4.0 phi (gravel to mud). Samples that contained more than 10 percent mud were wet-sieved. Folk and Ward (1957) and Trask (1930) grain-size parameters, including mean and median grain size and sorting, and percent gravel, sand, and mud were determined for each sample (Appendix 3). A breakdown by cluster site is listed below.

NUMBER OF SIEVE ANALYSES FROM CORE SAMPLES	
<u>Cluster site</u>	<u>Number of sieve analyses</u>
C-1	22
C-2	57
C-3	60
C-5	186
C-6	45
C-7	33
C-10	39

Permeability and porosity were calculated from grain-size distribution parameters (median grain size and Trask sorting) using the methodology of Beard and Weyl (1973) (Appendix 3). Descriptive statistics of grain size, sorting, permeability and porosity, and gravel, sand, and mud percentages were calculated for each hydrologic unit.

Core samples were collected at various intervals from sites C-2, C-5, C-6, C-7, and C-10 for thin-section analysis (Thayer, 1989 and personal communication). All thin sections were impregnated with blue-dyed epoxy to facilitate identification of porosity and all were stained with alizarin red-S to facilitate identification of carbonate minerals and allochems. Volume-percent composition was determined for the consolidated rocks and number-percent composition was determined for the unconsolidated sand thin sections (Thayer, 1989). In addition to quantitative compositional analysis, all thin sections were studied for sedimentary structures, texture (grain size, sorting, roundness, and two-dimensional sphericity), fabric (grain orientation and packing), pore type and size, and diagenetic features (compaction, cementation, and replacement, and grain/cement dissolution).

Core samples were also collected at various intervals from six of the seven cluster sites for paleontologic and palynologic age analysis and for environmental interpretation. These analyses were performed by outside professionals, most of whom had previous experience

working in the SRS area. Dates from 146 samples were obtained. Only downdip sites had diagnostic fossil assemblages. A breakdown by cluster site is listed below.

NUMBER OF AGE DATES FROM CORE SAMPLES	
<u>Cluster site</u>	<u>Number of age dates</u>
C-6	42
C-7	21
C-10	83

Core Laboratories (1992) conducted petrophysical analyses on core samples from the confining units (Appendix 4). Included are vertical and horizontal permeability, porosity, mineralogy, and laser particle-size analysis. The Earth Science Resources Institute at the University of South Carolina analyzed 100 clay and sandy clay samples for clay and bulk mineralogy with x-ray diffraction techniques (Gelting, 1990) (Appendix 5).

The following technical and professional reports and abstracts used data generated by the project and are available from SCWRD:

Aadland, R. K., Gellici, J. A., and Thayer, P. A., (in press), Hydrogeologic framework of west-central South Carolina.

Core Laboratories, 1992, Petrophysical catalog for South Carolina Water Resources Commission, C-10 site.

Edwards, L. E., and Frederiksen, N. O., 1993, Paleontologic analysis of ten sediment samples from the South Carolina Water Resources Commission's C-10 site.

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Gellici, J. A., and Logan, W. R., 1993, Preliminary stratigraphic and hydrostratigraphic correlation of four deep coreholes east of the Savannah River Site in Allendale, Barnwell, and Aiken Counties.

Gelting, Jack, 1990, X-ray diffractograms, wells C2, C3, C5, C6, and C10.

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Kuntz, G. B., Griffin, W. T., Greaney, Teresa, and Gellici, J. A., 1989, Hydrogeologic investigation and establishment of a permanent multi-observational well network in Aiken, Allendale, and Barnwell Counties, S.C. -- Phase III.

Laws, R. A., 1988, Report on samples from cores "C6 and C2" for the Water Resources Commission.

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- Lucas-Clark, Joyce, 1988, Palynological analysis of eleven core samples, C-6 well, South Carolina Water Resources Commission.
- _____. 1989a, Palynological analysis of twenty-eight core samples C-10 well, South Carolina.
- _____. 1989b, Palynological analysis of forty-two core samples C-2, C-6, and 5S-F1 wells.
- _____. 1993, Palynological analysis of eighty-three core samples from South Carolina Water Resources well C-10.
- Simones, G. C., 1992a, Hydrogeologic investigation and establishment of a permanent multi-observational well network in Aiken, Allendale, and Barnwell Counties, S.C. -- Phase V.
- _____. 1992b, Application of ichnology to hydrogeology with examples from the Cape Fear Formation (Cretaceous) of South Carolina.
- Thayer, P. A., 1989, Petrography of selected samples from South Carolina Water Resources Commission wells C-2 and C-6, Aiken and Barnwell Counties, South Carolina.
- _____. 1995, Petrography of selected samples from South Carolina Water Resources Commission wells C-5 and C-10, Allendale and Barnwell Counties, South Carolina (in preparation).
- Waanders Palynology, 1993, Palynology analysis of samples from South Carolina Water Resources Commission cores C-3, C-7, C-10, MHV-25, and MHV-26.
- Waddell, M. G., 1992, Results of a series of high-resolution shallow reflection surveys in Aiken, Allendale, and Barnwell Counties, South Carolina.
- Zullo, V. A., 1988, Lithostratigraphy, megafossil biostratigraphy, and preliminary analysis of sequence stratigraphy, cores C-2 and C-6, Barnwell County, South Carolina.

Background

The ongoing investigation, known as the Lower Savannah River Project, was initiated by the South Carolina Water Resources Commission (SCWRC) in 1986 and is scheduled to continue through 1997. Annual progress reports documented the drilling and analytical activities that occurred during various phases of the investigation (Logan, 1987; Kuntz and Griffin, 1988; Kuntz and others, 1989; Gellici, 1990; Simones, 1992a).

Phase I - During Phase I of the study (August 1, 1986 to July 31, 1987), two well-cluster sites were established in areas that would initially provide the most useful data (Logan, 1987). Cluster site C-2 is located 5 mi (miles) west-northwest of the town of New Ellenton in Aiken County and 15 mi northwest of the center of SRS (Figs. 1 and 2). Cluster site C-6 is located 5 mi southeast of the town of Barnwell in Barnwell County and 19 mi southeast of the center of SRS (Figs. 1 and 3). Land altitude is 419 ft at site C-2 and 209 ft at site C-6 (Table 1).

Figure 2. Location of well-cluster site C-2, Aiken County.

An exploratory well at site C-2 (AIK-817) was continuously cored and geophysically logged to a depth of 561 ft (-142 ft msl, mean sea level). Core recovery was 458 ft, or 82 percent of the total cored interval. Saprolite was encountered at a depth of 538 ft (-118 ft msl) and unweathered, crystalline basement rock at a depth of 553 ft (-133 ft msl). Basement at C-2 is medium-grained, well-foliated, quartzofeldspathic gneiss (Price, written communication). The cored hole was completed as a monitoring well in the McQueen Branch aquifer (Middendorf Formation). A second monitoring well (AIK-818) was also completed in the McQueen Branch during the initial phase of the project (Table 1).

Figure 3. Location of well-cluster site C-6, Barnwell County.

An exploratory well at site C-6 (BRN-349) was continuously cored and geophysically logged to a depth of 1,385 ft (-1,180 ft msl). Core recovery was 1,197 ft, or 86 percent of the total cored interval. Top of saprolite occurred at a depth of 1,327 ft (-1,123 ft msl) and unweathered, crystalline basement rock at a depth of 1,373 ft (-1,168 ft msl). Basement rock at site C-6 is gneiss. The cored hole was completed as a monitoring well in the lower part of the McQueen Branch aquifer (Middendorf Formation). Two additional wells (BRN-350 and BRN-351) were drilled at site C-6 and completed as monitoring wells in the Upper Three Runs aquifer (Barnwell Group sediments) (Table 1).

Table 1. Summary of well-construction data for the "C" wells

Well site	Well / grid	Latitude	Longitude	Land surface altitude (ft, msl)	Well depth (ft)	Top of screen (ft, lsd)	Bottom of screen (ft, lsd)	Hydrologic unit	Hydrologic system	Formation
C-1	AIK-2378 40W-q2	33 21 09	81 48 36	235 (T)	185	170	180	Crouch Branch aquifer	Dublin-Midville	Black Creek
C-1	AIK-2379 40W-q3	33 21 09	81 48 36	235 (T)	266	251	261	Crouch Branch aquifer	Dublin-Midville	Black Creek
C-1	AIK-2380 40W-q4	33 21 10	81 48 35	235 (T)	385	370	380	McQueen Br. aquifer	Dublin-Midville	Middendorf
C-1	AIK-902 40W-q1	33 21 10	81 48 35	235 (T)	511	496	506	McQueen Br. aquifer	Dublin-Midville	Middendorf
C-2	AIK-823 40V-s4	33 26 15	81 46 17	415 (T)	168	153	163	Dry hole	Floridan-Midville	Congaree/ Fourmile
C-2	AIK-825 40V-s6	33 26 16	81 46 14	418.8	231	216	226	Crouch Branch aquifer	Floridan-Midville	Black Creek
C-2	AIK-824 40V-s5	33 26 16	81 46 15	418.6	365	350	360	Crouch Branch aquifer	Floridan-Midville	Black Creek
C-2	AIK-818 40V-s3	33 26 17	81 46 14	418.3	425	410	420	McQueen Br. aquifer	Floridan-Midville	Middendorf
C-2	AIK-817 40V-s2	33 26 17	81 46 15	418.9	535	520	530	McQueen Br. aquifer	Floridan-Midville	Middendorf
C-3	AIK-849 36U-o6	33 32 32	81 29 06	301.6	97	82	92	Steed Pond aquifer	Floridan-Midville	Lang Syne/Sawdust Landing
C-3	AIK-848 36U-o5	33 32 33	81 29 07	299.7	131	116	126	Crouch Branch aquifer	Floridan-Midville	Steel Creek
C-3	AIK-847 36U-o4	33 32 34	81 29 07	299.0	193	178	188	Crouch Branch aquifer	Floridan-Midville	Black Creek
C-3	AIK-846 36U-o3	33 32 33	81 29 08	297.8	255	240	250	Crouch Branch aquifer	Floridan-Midville	Black Creek
C-3	AIK-845 36U-o2	33 32 35	81 29 08	296.9	356	341	351	McQueen Br. aquifer	Floridan-Midville	Middendorf
C-3	AIK-826 36U-o1	33 32 30	81 29 05	294.9	500	485	495	McQueen Br. aquifer	Floridan-Midville	Middendorf
C-5	BRN-360 35X-e4	33 19 15	81 24 27	264.3	140	125	134	Upper Three Runs aquifer	Floridan-Dublin	Dry Branch
C-5	BRN-359 35X-e3	33 19 16	81 24 27	265.5	214	199	209	Gordon aquifer	Floridan-Dublin	Congaree/ Fourmile
C-5	BRN-367 35X-e7	33 19 15	81 24 28	263.8	285	270	280	Gordon aquifer	Floridan-Dublin	Congaree/ Fourmile
C-5	BRN-368 35X-e8	33 19 14	81 24 28	265.1	443	428	438	Crouch Branch aquifer	Floridan-Dublin	Steel Creek
C-5	BRN-365 35X-e5	33 19 15	81 24 28	263.5	539	524	534	Crouch Branch aquifer	Floridan-Dublin	Black Creek
C-5	BRN-366 35X-e6	33 19 14	81 24 28	266.7	715	700	710	McQueen Br. aquifer	Midville	Black Creek

Table 1. Continued

Well site	Well / grid	Latitude	Longitude	Well altitude (ft, msl)	Well depth (ft)	Top of screen (ft, lsd)	Bottom of screen (ft, lsd)	Hydrologic unit	Hydrologic system	Formation
C-5	BRN-358 35X-e02	33 19 14	81 24 28	265.6	847	832	842	McQueen Br. aquifer	Midville	Middendorf
C-6	BRN-351 34Y-x3	33 10 43	81 18 53	207.3	95	80	90	Upper Three Runs aquifer	Floridan	Dry Branch
C-6	BRN-350 34Y-x2	33 10 45	81 18 54	207.4	170	155	165	Upper Three Runs aquifer	Floridan	Clinchfield
C-6	BRN-352 34Y-x4	33 10 44	81 18 53	207.1	293	278	288	Gordon aquifer	Floridan	Congaree/ Fourmile
C-6	BRN-354 34Y-x6	33 10 44	81 18 54	207.6	411	396	406	Gordon aquifer	Floridan	Snapp
C-6	BRN-353 34Y-x5	33 10 43	81 18 54	207.7	588	573	583	Crouch Branch aquifer	Dublin	Steel Creek
C-6	BRN-355 34Y-x7	33 10 44	81 18 55	208.0	701	686	696	Crouch Branch aquifer	Dublin	Black Creek
C-6	BRN-356 34Y-x8	33 10 43	81 18 56	208.6	929	914	924	McQueen Br. aquifer	Midville	Black Creek
C-6	BRN-349 34Y-x1	33 10 42	81 18 55	208.6	1,045	1,030	1,040	McQueen Br. aquifer	Midville	Middendorf
C-7	ALL-363 37Z-14	33 06 50	81 30 21	252 (T)	105	90	100	Upper Three Runs aquifer	Floridan	Dry Branch
C-7	ALL-364 37Z-15	33 06 50	81 30 21	252 (T)	225	210	220	Upper Three Runs aquifer	Floridan	Clinchfield
C-7	ALL-365 37Z-16	33 06 49	81 30 21	252 (T)	333	318	328	Gordon aquifer	Floridan	Warley Hill - Congaree/ Fourmile
C-7	ALL-366 37Z-17	33 06 48	81 30 20	252 (T)	400	385	395	Gordon aquifer	Floridan	Congaree/ Fourmile
C-7	ALL-367 37Z-18	33 06 48	81 30 20	252 (T)	566	551	561	Crouch Branch aquifer	Dublin	Steel Creek
C-7	ALL-368 37Z-19	33 06 49	81 30 20	252 (T)	691	676	686	Crouch Branch aquifer	Dublin	Steel Creek
C-7	ALL-369 37Z-110	33 06 47	81 30 21	252 (T)	800	785	795	Crouch Branch aquifer	Dublin	Black Creek
C-7	ALL-370 37Z-111	33 06 48	81 30 20	252 (T)	975	960	970	McQueen Br. aquifer	Midville	Black Creek
C-7	ALL-358 37Z-13	33 06 48	81 30 21	252 (T)	1,123	1,108	1,118	McQueen Br. aquifer	Midville	Middendorf
C-10	ALL-347 35AA-q2	33 01 30	81 23 03	290.0	1,423	1,408	1,418	McQueen Br. aquifer	Midville	Middendorf
C-10	ALL-348 35AA-q3	33 01 30	81 23 04	289.6	1,605	1,575	1,600	Appleton con- fining system	Appleton	Cape Fear

T, measured from a topographic map

lsd, measurement made relative to land surface datum

msl, measurement made relative to mean sea level

Phase II - During Phase II of the study (August 1, 1987 to July 31, 1988), two additional cluster sites were established (Kuntz and Griffin, 1988). Site locations were selected on the basis of data obtained during Phase I of the study (Fig. 1). Site C-3 is located 4 mi north of the town of Windsor in Barnwell County and 20 mi northwest of the center of SRS (Figs. 1 and 4). Site C-5 is located 6 mi northwest of the town of Barnwell in Barnwell County and 15 mi east of the center of SRS (Figs. 1 and 5). Land altitude is 295 ft at site C-3 and 265 ft at site C-5 (Table 1).

An exploratory well at C-3 (AIK-826) was continuously cored to a depth of 541 ft (-246 ft msl). Core recovery was 389 ft, or 72 percent of the total cored interval. Top of saprolite was encountered at a depth of 520 ft (-225 ft msl) and unweathered, crystalline basement rock at a depth of 530 ft (-235 ft msl). Basement rock at site C-3 is fine-grained, pyritiferous schist (Price, written communication). Core hole AIK-826 was finished as a monitoring well in the basal McQueen Branch aquifer (Middendorf Formation).

Figure 4. Location of cluster site C-3, Aiken County.

At site C-5, exploratory well BRN-357 was continuously cored to a depth of 1,085 ft (-820 ft msl). Core recovery was 843 ft, or 78 percent of the total cored interval. Top of saprolite occurred at a depth of 1,031 ft (-766 ft msl) and unweathered, crystalline basement rock at a depth of 1,064 (-799 ft msl). Basement rock at site C-5 is epidote-chlorite gneiss and amphibolite (Price, written communication). Due to difficulties removing temporary casing, well BRN-357 was abandoned and plugged with cement. In its place, well BRN-358 was drilled and completed as a monitoring well at the base of the McQueen Branch aquifer (Middendorf

Formation). Two shallow wells were also constructed at site C-5 during the second phase of the project. Well BRN-359 was completed in the lower part of the Upper Three Runs aquifer (Dry Branch Formation) and well BRN-360, in the upper part of the aquifer (Tobacco Road Formation).

Figure 5. Location of cluster site C-5, Barnwell County.

Three additional monitoring wells were drilled at site C-2, and five at site C-6, during Phase II of the study (Table 1). At site C-2, well AIK-823 was screened in an aquifer zone of the Crouch Branch confining unit (Lang Syne/Sawdust Landing Formation). This well is dry and has never produced water. Wells AIK-824 and AIK-825 were screened in the lower and upper parts of the Crouch Branch aquifer, respectively (Black Creek Formation). A total of five monitoring wells are completed at site C-2 (Appendix 6); no additional wells are scheduled to be drilled at this site.

At site C-6, well BRN-352 was screened in the upper part of the Gordon aquifer (Congaree Formation) and well BRN-354, in the lower part of the aquifer (Fourmile?). Wells BRN-353 and BRN-355 were completed in the upper and lower parts of the Crouch Branch aquifer, respectively (Steel Creek and Black Creek Formations), and well BRN-356 was completed in the upper part of the McQueen Branch aquifer (Black Creek Formation). A total

of eight monitoring wells are finished at site C-6 (Appendix 6); no additional wells are scheduled to be drilled at this site.

Phase III - Phase III of the project (August 1, 1988 to July 31, 1989) was a cooperative effort with microbiologists from USDOE's "Deep Probe" research project (Kuntz and others, 1989). Two deep wells were drilled at cluster site C-10, located 5 mi west-northwest of the town of Allendale in Allendale County and 21 mi southeast of the center of SRS (Figs. 1 and 6). Land altitude at site C-10 is 290 ft (Table 1). The first hole (ALL-347) was continuously cored from land surface to 1,482 ft (-1,192 ft msl); the second hole (ALL-348, also referred to as C-10A in previous SCWRD reports) was cored from 1,086 (-796 ft msl) to 1,734 ft (-1,444 ft msl) and was sampled by microbiologists at selected intervals. Core recovery was 1,614 ft, or 93 percent of the total cored interval. Top of saprolite was encountered at a depth of 1,720 ft (-1,430 ft msl) and unweathered, crystalline basement rock at a depth of 1,726 ft (-1,436 ft msl). Basement rock at site C-10 is biotite granite (Price, written communication). Both wells were geophysically logged by SCWRD and USGS and completed as deep Cretaceous monitoring wells. Well ALL-348 was screened in a 25-ft clayey sand bed of the basal Appleton confining system (Cape Fear Formation) and well ALL-347 was screened in the lower part of

the McQueen Branch aquifer (Middendorf Formation) (Table 1). Seven additional monitoring wells are scheduled to be drilled at site C-10 in the future.

Figure 6. Location of cluster site C-10, Allendale County.

Each of the deep, McQueen Branch aquifer wells (that is, those screened at the base of the Middendorf Formation) were sampled for water chemistry by WSRC during the period from November, 1988 to February, 1989 (Strom and Kaback, 1992).

Phase IV - No new funds were allocated for drilling operations during Phase IV of the project (August 1, 1989 to July 31, 1990); however, several well-completion tasks took place during this phase (Gellici, 1991). During grout emplacement at site C-10 (All-348), pump failure midway through the pressure-grout operation resulted in an incomplete grout seal. Subsequent efforts to tremie the grout down the annulus were unsuccessful. Sand bridging and/or clay swelling prevented the tremie line from reaching the estimated depth to where grout had initially been pumped. Cement-bond and pulse-echo geophysical logs were made by Halliburton Logging Services, Inc., in each of the two wells at site C-10 to check the integrity of the grout. A poorly grouted section in one well (ALL-348) necessitated a "perf-squeeze" operation in the interval from 1,045 to 1,174 ft lsd (land surface datum) to prevent hydraulic communication across confining beds of the McQueen Branch confining unit (Black Creek Formation). The casing was perforated in three zones from 1,060 to 1,075 ft, 1,100 to 1,115 ft, and 1,140 to 1,155 ft below land surface. The bottom of the well was filled with sand and the interval from 989 to 1,171 ft was filled with neat cement. Fresh water was pumped into the well and pressurized at the well head to 200 psi. On the following day, the cement and sand were drilled out.

On the basis of cement volume measured before and after the procedure, it was determined that very little cement had been squeezed into the annulus during the squeeze operation. It was concluded that clay of the Black Creek Formation had swelled around the casing forming a natural seal. No subsequent "perf-squeeze" operations were attempted.

Phase V - Phase V (August 1, 1990 to June 30, 1992) was extended 11 months owing to delays during Phase III that carried forward and to problems procuring land for subsequent cluster sites (Simones, 1992a). During this phase of the project, five monitoring wells were constructed at site C-3 and four at site C-5 (Table 1; Appendix 6). At site C-3, well AIK-845

was drilled to a depth of 526 ft (approximate depth to basement) to obtain a full suite of geophysical logs. Logs from the previous basement well (AIK-826) were unsatisfactory. The well was backfilled and screened in the McQueen Branch aquifer (Middendorf Formation). Wells AIK-846, AIK-847, and AIK-848 were completed in the Crouch Branch aquifer (Black Creek and Steel Creek Formations) and well AIK-849 was completed in the Steed Pond aquifer (Lang Syne/Sawdust Landing Formation).

At site C-5, well BRN-366 was drilled to a depth of 1,032 ft (approximate depth to basement) to obtain a full suite of geophysical logs. Logs from the previous basement well (BRN-357) were incomplete because the lower part of the borehole caved during logging. The new well was backfilled and completed in the upper part of the McQueen Branch aquifer (Black Creek Formation) (Table 1). Well BRN-365 was screened in the lower part of the Crouch Branch aquifer (Black Creek Formation); well BRN-368, in the upper part of the Crouch Branch aquifer (Steel Creek Formation); and well BRN-367, in the lower part of the Gordon aquifer (Congaree/Fourmile Formation).

To facilitate ground water sampling for chemical analyses, small submersible pumps (Table 2) were installed in each monitoring well during Phase V, with two exceptions: 1) well ALL-348 (site C-10) had been equipped with a pump during Phase III operations, and 2) well AIK-823 (site C-2) is a dry hole. Water-quality samples were collected from each well during the period from November 14 to 20, 1991 with two exceptions: 1) well AIK-849 (site C-3) was not sampled owing to mechanical problems with the pump, and 2) well AIK-823 (site C-2) is a dry hole. Water samples were analyzed for major cations and anions, trace elements, pH, conductivity, alkalinity, and total dissolved solids.

Phase VI - During Phase VI of the project (July 1, 1992 to June 30, 1993), work began on two new cluster sites, C-1 and C-7. Site C-1 is located half a mi northwest of the town of Jackson in Aiken County and 11 mi west-northwest of the center of SRS (Figs. 1 and 7). Land altitude at site C-1 is 235 ft (as determined from a topographic map). Site C-7 is located 4 mi northwest of the town of Martin in Allendale County and 12 mi east-southeast of the center of SRS (Figs. 1 and 8). Land altitude at site C-7 is approximately 252 ft (from a topographic map).

An exploratory well at site C-1 (AIK-902) was continuously cored from land surface to a depth of 576 ft (-341 ft msl). Core recovery was 455 ft, or 79 percent of the total cored interval. Top of saprolite was at a depth of 549 ft (-314 ft msl) and unweathered, crystalline basement rock at 560 ft (-325 ft msl). Basement rock at site C-1 is fine-grained chlorite schist with quartz veins. The core hole was completed as a monitoring well in the basal McQueen Branch aquifer (Middendorf Formation).

An exploratory well at site C-7 (ALL-357) was continuously cored from land surface to a depth of 1,417 ft (-1,167 ft msl). Core recovery was 1,084 ft, or 76 percent of the total cored interval. Top of saprolite was at a depth of 1,396 ft (-1,146 ft msl) and unweathered, crystalline basement at a depth of 1,415 ft (-1,165 ft msl). Basement at site C-7 is schist. The core hole at C-7 had been mistakenly drilled outside property lines owing to an inaccurate survey of the site. To avoid potential legal problems, the original core hole was cemented from basement to 5 ft below land surface. The remaining 5 ft was filled with sand. A new well was drilled (ALL-358) about 50 ft from the original borehole and completed in the McQueen Branch aquifer (Middendorf Formation).

In late January and early February 1993, each of the wells in the network was sampled for water-quality analysis. Wells at sites C-1 and C-7 were not sampled because pumps have not yet been installed in these wells.

Table 2. Specifications of submersible pumps at the well sites

Well site	County well number	Total depth of well (ft)	Depth to top of 4-inch lap pipe (ft, lsd)	Depth to top of screen (ft, lsd)	Depth to water level, (ft, lsd)	Pump setting from top of casing (ft)	Pump rating in gallons per min	Grundfos pump number and model number	Well volume (gal)	Minutes to pump three well volumes
C-2	AIK-823	168	93	153	** (dry hole)	—	—	—	—	—
C-2	AIK-825	231	186	216	179.2	210	5	*GENERAL PUMP MFG# 20X4P051-2	39	24
C-2	AIK-824	365	313	350	179.4	300	5	9119/7S05-11	230	138
C-2	AIK-818	425	368	410	180.5	260	12	9045/16S10-10	311	78
C-2	AIK-817	535	478	520	183.0	260	10	9110/16S10-10	470	141
C-3	AIK-849	97	41	82	49.1	60	N/A	*GENERAL PUMP MFG# 12X7P051-2	25	N/A
C-3	AIK-848	131	75	116	37.9	74	20	8812/16S05-5	91	14
C-3	AIK-847	193	135	178	29.4	120	25	9120/16S07-8	193	23
C-3	AIK-846	255	199	240	27.1	180	18	9120/16S07-8	289	48
C-3	AIK-845	356	299	341	25.6	200	21	9120/16S07-8	439	63
C-3	AIK-826	500	448	485	21.5	200	20	9102/16S07-8	660	99
C-5	BRN-360	140	92	125	18.0	80	19	9108/16S05-5	140	22
C-5	BRN-359	214	169	199	48.2	160	20	1920/16S07-8	207	31
C-5	BRN-367	285	206	270	45.8	200	16	9182/16S07-8	288	54
C-5	BRN-368	443	385	428	56.2	240	20	8918/16S10-10	521	78
C-5	BRN-365	539	482	524	53.1	240	19	9118/16S10-10	667	105
C-5	BRN-366	715	658	700	54.8	240	21	9110/16S10-10	923	132
C-5	BRN-358	847	801	832	52.4	240	19	9045/16S10-10	1,129	178
C-6	BRN-351	95	38	80	28.4	60	21	9108/16S07-8	51	7
C-6	BRN-350	170	113	155	28.9	150	20	9102/16S07-8	161	24
C-6	BRN-352	293	248	278	42.4	200	20	9109/16S07-8	331	50
C-6	BRN-354	411	372	396	42.7	200	20	9113/16S07-8	509	76
C-6	BRN-353	588	543	573	34.5	200	20	9046/16S07-8	776	116
C-6	BRN-355	701	654	686	35.4	500	7	9114/7S10-19	939	402
C-6	BRN-356	929	878	914	11.8	500	7	9112/7S10-19	1,305	559
C-6	BRN-349	1,045	988	1,030	11.8	200	21	9103/16S07-8	1,470	210
C-10	ALL-347	1,423	1,093	1,408	92.7	400	12	9115/10S10-15	1,901	475
C-10	ALL-348	1,605	1,532	1,575	83.5	800	2(?)	9103/16S07-8	2,171	3,257

*Not a Grundfos pump

**No pump installed

Figure 7. Location of cluster site C-1, Aiken County.

Phase VII - During Phase VII of the project (July 1, 1993 to June 30, 1994), three monitoring wells were completed at site C-1 and eight at site C-7 (Table 1; Appendix 6). At site C-1, one well (AIK-2380) was completed in the upper part of the McQueen Branch aquifer (Middendorf Formation?) and two wells (AIK-2378 and AIK-2379) in the upper and lower parts of the Crouch Branch aquifer, respectively (Black Creek Formation). A total of four wells are constructed at C-1; no additional wells are scheduled to be drilled at this site.

At site C-7, wells ALL-363 and ALL-364 were screened in the upper and lower parts of the Upper Three Runs aquifer, respectively (Dry Branch and Clinchfield Formations); wells ALL-365 and ALL-366 were completed in the upper and lower parts of the Gordon aquifer, respectively (Warley Hill, Congaree, and Congaree/Fourmile Formations); wells ALL-367, ALL-368, and ALL-369 were completed in the Crouch Branch aquifer (Steel Creek and Black Creek Formations); and well ALL-370 was completed in the upper part of the McQueen Branch aquifer (Black Creek Formation). A total of nine wells are constructed at site C-7; no additional wells are scheduled to be drilled at this site.

Figure 8. Location of cluster site C-7; Allendale County.

During Phases II and III of the project, automatic digital water-level recorders were installed by the USGS on 16 of the 17 monitoring wells that had been completed at that time. The exception was at well AIK-823 (site C-2), which is a dry hole. These wells were added to the statewide ground-water monitoring network maintained by the USGS. Recorders were disconnected in May and June 1991 to allow for the installation of submersible pumps. Evaluation of water level data collected up until that time revealed that several of the recorders had serious deficiencies. In some cases, no data at all would be recorded; in other cases, a flat, continuous water-level response occurred over a long period of time indicating that the floatation device was getting caught on a casing collar or that the recorder was malfunctioning. In light of these problems, the USGS considered switching to computerized, digital recorders that utilize pressure transducers in lieu of floatation devices. These recorders were thought to be less expensive, easier to maintain, and less prone to mechanical problems than the punch-tape, mechanical recorders. Installation was delayed until April 1993 owing to uncertainties about the type of recorder to purchase. It was decided by USGS and SCWRD personnel that the Unidata "Starlogger" would be installed at each site replacing the original "Stevens" recorder. As of April, 1993, 27 of the 41 wells in the network were being monitored. Wells at sites C-1 and C-7 will be connected in the near future and AIK-823 (site C-2) is a dry hole. Wells equipped with recorders are listed below.

WELLS EQUIPPED WITH AUTOMATIC WATER-LEVEL RECORDERS

<u>Cluster site</u>	<u>Well</u>	<u>Continuous record</u>
C-2	AIK-817	April 1988 to May 1991 and April 1993 to present
C-2	AIK-818	April 1988 to May 1991 and April 1993 to present
C-2	AIK-824	March 1989 to May 1991 and April 1993 to present
C-2	AIK-825	May 1989 to May 1991 and April 1993 to present
C-3	AIK-826	February 1989 to June 1991 and April 1993 to present
C-3	AIK-845	April 1993 to present
C-3	AIK-846	April 1993 to present
C-3	AIK-847	April 1993 to present
C-3	AIK-848	April 1993 to present
C-3	AIK-849	April 1993 to present
C-5	BRN-358	May 1989 to June 1991 and April 1993 to present
C-5	BRN-359	February 1989 to June 1991 and April 1993 to present
C-5	BRN-360	February 1989 to June 1991 and April 1993 to present
C-5	BRN-365	April 1993 to present
C-5	BRN-366	April 1993 to present
C-5	BRN-367	April 1993 to present
C-5	BRN-368	April 1993 to present
C-6	BRN-349	April 1988 to May 1991 and April 1993 to present
C-6	BRN-350	April 1988 to May 1991 and April 1993 to present
C-6	BRN-351	April 1988 to May 1991 and April 1993 to present
C-6	BRN-352	February 1989 to June 1991 and April 1993 to present
C-6	BRN-353	February 1989 to June 1991 and April 1993 to present
C-6	BRN-354	February 1989 to June 1991 and April 1993 to present
C-6	BRN-355	February 1989 to June 1991 and April 1993 to present
C-6	BRN-356	February 1989 to June 1991 and April 1993 to present
C-10	ALL-347	April 1993 to present
C-10	ALL-348	April 1993 to present

GEOLOGIC SETTING

The study area of Aiken, Allendale, and Barnwell Counties, S.C., is underlain by crystalline rock and sedimentary units that range in age from Precambrian(?) to Holocene. Crystalline basement is composed of metamorphic and igneous rocks that crop out to the northwest in the Piedmont province. Sandstone, siltstone, and mudstone of Triassic age fill a graben in the Savannah River Site area. Directly overlying the older rocks are sedimentary units of Late Cretaceous age. These sedimentary units consist of sand, silt, and clay that were deposited as transgressive or regressive sequences in predominantly deltaic and fluvial environments.

Overlying the Late Cretaceous units are Tertiary sediments consisting of sand, silt, clay, and limestone that become progressively more calcareous in a southeasterly (downdip) direction. Deposition occurred in deltaic or shallow-marine environments during a series of marine transgressions and regressions.

In the study area, all of the Cretaceous units strike in a northeasterly direction and dip to the southeast at a rate of 15 to 30 ft/mi (feet per mile). The Tertiary units also strike northeast and dip to the south and southeast, but with a gentler slope than the underlying sediments.

The geologic complexity of the region is characterized by coalescing deltas and alternating marine and nonmarine depositional features that create major lithostratigraphic and chronostratigraphic correlation problems. Formations have been partially to totally eroded in areas, streams have dissected the changing paleotopography through geologic time, and channels have been filled with sediments foreign to the original depositional environment. Situated close to the Fall Line in the northern portion of the study area, several formations terminate or "pinch out" in the subsurface. As the formations extend downdip, they grade laterally and vertically into different lithologic units. In addition, many of the formations are nonfossiliferous, making biostratigraphic and chronostratigraphic correlation difficult. With such problems, it is often difficult to trace the same unit over a distance of only a few miles. Although geophysical logs from several wells in the area are available, not all of them are useful in correlating formations. Some are of poor quality and others are from shallow wells, thereby limiting the amount of vertical data. Even those logs of good quality and depth are often of little help in correlation, as log signatures vary drastically in the same formation owing to facies and mineralogical changes and to changes in chemical characteristics of water in the formation. Wells with usable logs are generally widely scattered, leaving large areas with no geophysical data.

Utilizing high-quality lithological, geophysical, and paleontological data (Plates 1-7) acquired from sites C-3, C-5, C-6, and C-10 and geophysical logs from wells, BRN-386 in Barnwell and BRN-78 in Williston, a dip-oriented stratigraphic section was constructed east of SRS (Fig. 9; Plate 8; Table 3). Four Cretaceous formations were identified in the study area and include, in ascending order, the Cape Fear, Middendorf, Black Creek, and Steel Creek. Nine Tertiary formations were identified and include, in ascending order, the Lang Syne/Sawdust Landing, Snapp, Congaree/Fourmile, Warley Hill, Tinker, Santee, Clinchfield, Dry Branch, and Tobacco Road. The Upland unit, not yet classified as a formation, was also identified. The Lang Syne and Sawdust Landing Formations could not be differentiated and, therefore, will be referred to as the undifferentiated Land Syne/Sawdust Landing Formation. The Fourmile Formation could not be easily differentiated from the Congaree and, consequently, the two formations will be referred to as the undifferentiated Congaree/Fourmile Formation. The stratigraphic column used in this report is presented in Figure 10.

Figure 9. Location of stratigraphic/hydrostratigraphic section.

Table 3. Stratigraphic boundaries and thicknesses at each cluster site

C-1 Altitude Depth Thickness	C-2 Altitude Depth Thickness	C-3 Altitude Depth Thickness	C-5 Altitude Depth Thickness	C-6 Altitude Depth Thickness	C-7 Altitude Depth Thickness	C-10 Altitude Depth Thickness
Upland Unit						
Erod.	419 to 396 0 to 23 23	Erod.	Erod.	Erod.	Erod.	290 to 266 0 to 24 24
Tobacco Road Formation						
Undif.	396 to 346 23 to 73 50	Erod.	265 to 204 0 to 61 61	209 to 185 0 to 24 24	252 to 197 0 to 55 55	266 to 131 24 to 159 135
Dry Branch Formation						
Undif.	346 to 320 73 to 99 26	295 to 267 0 to 28 28	204 to 100 61 to 165 104	185 to 55 24 to 154 130	197 to 50 55 to 202 147	131 to -31 159 to 321 162
Clinchfield Formation						
Undif.	Undelin.	Undelin.	Undelin.	55 to 29 154 to 180 26	50 to 24 202 to 228 26	Undelin.
Tinker Formation and Santee Limestone						
Undif.	Undelin.	Undelin.	100 to 65 165 to 200 35	29 to -31 180 to 240 60	24 to -59 228 to 311 83	-31 to -150 321 to 440 119
Warley Hill Formation						
Undif.	Undelin.	Undelin.	Undelin.	-31 to -47 240 to 256 16	-59 to -72 311 to 324 13	-150 to -173 440 to 463 23
Congaree/Fourmile Formation						
Undif.	320 to 241 99 to 178 79	267 to 235 28 to 60 32	65 to -14 200 to 279 79	-47 to -181 256 to 390 134	-72 to -153 324 to 405 81	-173 to -272 463 to 562 99

Notes: Altitude is in feet above or below (-) mean sea level. Depth is in feet below land surface. Thickness is in feet.

Undelin., Formation is not delineated at this well site

Undif., Undifferentiated sediments

Erod., Formation has been eroded at this well site

Table 3. Continued

C-1 Altitude Depth Thickness	C-2 Altitude Depth Thickness	C-3 Altitude Depth Thickness	C-5 Altitude Depth Thickness	C-6 Altitude Depth Thickness	C-7 Altitude Depth Thickness	C-10 Altitude Depth Thickness
Snapp Formation						
Undif.	241 to 238 178 to 181 3	Undelin.	-14 to -30 279 to 295 16	-181 to -220 390 to 429 39	-153 to -194 405 to 446 41	-272 to -310 562 to 600 38
Lang Syne/Sawdust Landing Formation						
Undif.	238 to 232 181 to 187 6	235 to 195 60 to 100 40	-30 to -78 295 to 343 48	-220 to -299 429 to 508 79	-194 to -290 446 to 542 96	-310 to -413 600 to 703 103
Steel Creek Formation						
Undif.	Undelin.	195 to 157 100 to 138 38	-78 to -212 343 to 477 134	-299 to -463 508 to 672 164	-290 to -446 542 to 698 156	-413 to -591 703 to 881 178
Black Creek Formation						
131 to -68 119 to 318 199	232 to 24 187 to 395 208	157 to -45 138 to 340 202	-212 to -495 477 to 760 283	-463 to -778 672 to 987 315	-446 to -768 698 to 1,020 322	-591 to -948 881 to 1,238 357
Middendorf Formation						
-68 to -271 318 to 521 203	24 to -118 395 to 537 142	-45 to -209 340 to 504 164	-495 to -664 760 to 929 169	-778 to -959 987 to 1,168 181	-768 to -929 1,020 to 1,181 161	-948 to -1193 1,238 to 1,483 245
Cape Fear Formation						
-277 to -299 521 to 549 28	Undelin.	Undelin.	-664 to -765 929 to 1,030 101	-959 to -1118 1,168 to 1,327 159	-929 to -1131 1,181 to 1,383 202	-1,193 to -1,430 1,483 to 1,720 237

Notes: Altitude is in feet above or below (-) mean sea level. Depth is in feet below land surface. Thickness is in feet.

Undelin., Formation is not delineated at this well site

Undif., Undifferentiated sediments

Erod., Formation has been eroded at this well site

Stratigraphy					Hydrostratigraphy					
Age		Group	Formation		Updip (Northern region of SRS)		Middip (Central region of SRS)		Downdip (Southern region of SRS)	
Tertiary	?		Upland unit		Floridan-Midville aquifer system	Steed Pond aquifer unit	Floridan aquifer system	Upper Three Runs aquifer unit	Floridan aquifer system	Upper Three Runs aquifer unit
	Jacksonian	Barnwell	Tobacco Road							
			Dry Branch	Irwinton Mbr Twiggs Mbr Griffins Landing Mbr						
				Clinchfield						
	Claibornian	Orangeburg	Tinker/ Santee	Blue Bluff Mbr						
				Warley Hill						
			Congaree							
Sabinian	Black Mingo	Fourmile								
		Snapp								
Midwayan		Lang Syne/Sawdust Ld.		Crouch Branch confining unit		Meyers Branch confining system (Crouch Branch c.u.)		Meyers Branch confining system (Crouch Branch c.u.)		
Upper Cretaceous	Maestrichtian	Lumbee	Steel Creek		Crouch Branch aquifer unit	Dublin-Midville aquifer system	Crouch Branch aquifer unit	Dublin aquifer system (Crouch Branch a.u.)		
	Campanian		Black Creek		McQueen Branch c.u.		McQueen Branch c.u.	Allendale confining system (McQueen Branch c.u.)		
	Santonian		Middendorf		McQueen Branch aquifer unit		McQueen Branch aquifer unit	Midville aquifer system (McQueen Branch a.u.)		
	Coniacian		Cape Fear		Appleton confining system	Appleton confining system	Appleton confining system			

Figure 10. Stratigraphic column used in this report.

a.u., aquifer unit
c.u., confining unit

Cretaceous Formations

Cape Fear Formation - The Cape Fear Formation is the oldest outcropping unit in the Coastal Plain of the Carolinas. Stephenson (1907) named the unit for exposures along the Cape Fear River and its tributaries between Erwin and Rockfish Creek south of Fayetteville, N.C. Where exposed, the Cape Fear has channeled into the basement rock, leaving basal deposits of gravel and small boulders. Downstream, the gravel decreases in size and abundance and the Cape Fear consists of interbedded clay and sand. Clay beds range from a few inches to several feet in thickness and usually contain fine mica flakes and disseminated woody fragments. Sand beds also vary in thickness and are either massive or poorly cross-bedded. Generally, the sand ranges from fine to very coarse grained with scattered granules and pebbles. Overall, the sand is clayey and, therefore, poorly sorted.

At the C-well sites, the Cape Fear consists of variably colored, firm to indurated, bioturbated, poorly sorted, fine- to coarse-grained, clayey, feldspathic and quartzose sand and silty clay and clay. Pebbles typically occur at the base of the formation. A distinct contact between the Cape Fear and the overlying Middendorf Formation is marked by an abrupt lithologic change from the indurated clayey sand and clay of the Cape Fear to the unconsolidated sand and pebbly sand of the Middendorf and by an abrupt geophysical change from the low-resistivity Cape Fear sediments to the high-resistivity Middendorf sediments. The formation is 237 ft thick at site C-10 (downdip), 101 ft at site C-5, and is projected to pinch out just south of site C-3 (updip) where Cape Fear sediments are absent (Plate 8). The top of the formation dips approximately 30 ft/mi to the southeast.

In the study area, the formation commonly consists of alternating beds of indurated sand, clayey sand, and clay that are 10 to 20 ft thick (Plate 5). Thin, poorly consolidated sand beds, 5 to 10 ft thick, occur in the formation at site C-6 and thicken to 25 ft at site C-10. South of the study area, sand beds in the formation become increasingly unconsolidated owing to the absence of cristobalite cement (Clark and others, 1985).

Muscovite occurs throughout the formation, but in smaller quantities than in other Cretaceous units (Plates 4-7). Downdip, at site C-10, muscovite occurs in nearly all of the 1-ft core samples described, ranging from 0 to 10 percent and averaging 2 percent (based on visual estimates of core made at 1-ft intervals). Updip, at site C-5, muscovite ranges from 0 to 10 percent and averages 1 percent (Table 4).

Unlike the overlying Middendorf and Black Creek Formations, lignite is rare in the Cape Fear. At site C-10 it occurs in only two of the 159 1-ft core samples analyzed; at site C-5 it occurs in 9 of the 92 samples analyzed. Iron sulfide is also rare, with only minor amounts occurring at sites C-7 and C-10 (Table 4). Carbonate and glauconite are absent in the Cape Fear at all seven cluster sites.

Eleven samples from the Cape Fear were analyzed for clay and bulk mineralogy with x-ray diffraction techniques (Appendix 5). Kaolinite is the dominant clay mineral, ranging from 16 to 97 percent and averaging 50 percent. Feldspar is present in five of the 11 samples analyzed, ranging from 10 to 38 percent (see bulk mineralogy results, Appendix 5).

Very low to low resistivities (2 to 5 ohm-m, measured by the 64-inch normal resistivity tool) characterize the formation in the study area, owing to high clay content, compaction, and cristobalite cementation. Poorly to unconsolidated sand beds, however, have resistivity values approaching 20 ohm-m. These sand beds also have negative electric potential (Plates 4-7), opposite to that of sand beds in the overlying Middendorf Formation. Negative potential is

Table 4. Mineral composition of each formation as determined by core description

Formation	Well	Number of core samples analyzed	Average mineral percentage in formation				
			Range of mineral percentage in formation				
			Number of 1-ft core samples containing mineral				
			Carbonate	Muscovite	Lignite	Sulfide	Glauconite
Upland unit	C-2	4	0	0	0	0	0
			0	0	0	0	0
			0	0	0	0	0
	C-10	14	0	0	0	0	0
			0	0	0	0	0
			0	0	0	0	0
Tobacco Road	C-2	21	0	0	0	0	0
			0	0-0.1	0	0	0
			0	7	0	0	0
	C-5	60	0	4	0	0	0
			0	0-20	0	0	0
			0	42	0	0	0
	C-6	43	Core interval missing				
	C-7		0	7	0	0	0
			0	0.1-45	0	0	0
			0	43	0	0	0
	C-10	117	0	2	0	0	0
			0	0-10	0	0	0
0			101	0	0	0	
Dry Branch	C-2	25	0	0	0	0	0
			0	0-2	0	0	0
			0	13	0	0	0
	C-3	10	0	1	0	0	0
			0	0-5	0	0	0
			0	3	0	0	0
	C-5	82	0	0	0	0	0
			0	0-1	0	0	0
			0	3	0	0	0
	C-6	95	0	0	1	0	0
			0	0-0.1	0-25	0	0
			0	9	32	0	0
	C-7	128	1	0	0	0	0
			0-90	0-1	0-0.1	0	0
			3	6	6	0	0
	C-10	130	41	1	0	0	0
			0-90	0-3	0	0-2	0
			117	103	0	13	0

Table 4. Continued

Formation	Well	Number of core samples analyzed	Average mineral percentage in formation				
			Range of mineral percentage in formation				
			Number of 1-ft core samples containing mineral				
			Carbonate	Muscovite	Lignite	Sulfide	Glauconite
Clinchfield	C-6	8	67	0	0	0	23
			60-90	0	0	0	10-40
			8	0	0	0	8
	C-7	21	61	0	0	0	3
			0-95	0-3	0-3	0	0-15
			20	3	1	0	9
Tinker	C-5	27	0	1	0	0	0
			0	0-4	0	0	0
			0	22	0	0	0
Santee	C-6	48	87	0	0	0	12
			25-99	0-3	0-1	0	0-40
			48	5	3	0	29
	C-7	81	73	2	1	0	2
			15-98	0-15	0-15	0-0.1	0-7
			81	63	48	11	74
	C-10	112	84	0	0	0	2
			15-97	0-2	0-0.1	0-2	0-3
			112	24	3	51	110
Warley Hill	C-6	16	72	0	0	0	14
			35-97	0	0	0	0-35
			16	0	0	0	13
	C-7	11	58	0	0	0	0
			15-85	0	0	0	0-0.1
			11	0	0	0	4
	C-10	21	56	0	0	1	7
			15-85	0-2	0	0-2	3-20
			21	4	0	8	21
Congaree/ Fourmile	C-2	70	0	0	0	0	0
			0	0-3	0-0.1	0	0
			0	25	1	0	0
	C-3	20	0	2	0	0	1
			0	0-7	0	0	0-7
			0	14	0	0	2
	C-5	61	0	2	0	0	0
			0	0-5	0	0	0-0.1
			0	43	0	0	8
	C-6	101	22	1	0	0	5
			0-85	0-12	0-15	0	0-35
			58	18	9	0	32

Table 4. Continued

Formation	Well	Number of core samples analyzed	Average mineral percentage in formation				
			Range of mineral percentage in formation				
			Number of 1-ft core samples containing mineral				
			Carbonate	Muscovite	Lignite	Sulfide	Glaucinite
Congaree/ Fourmile	C-7	78	2	0	0	0	0
			0-40	0-0.1	0-0.1	0-0.1	0-4
			40	8	6	5	66
	C-10	89	49	1	0	1	13
			0-90	0-2	0	0-3	2-60
			76	61	0	63	89
Snapp	C-2	3	0	0	17	0	0
			0	0-0.1	0.1-45	0	0
			0	1	3	0	0
	C-5	16	0	9	0	0	0
			0	0.1-25	0-2	0-2	0-3
			0	16	2	3	3
	C-6	26	0	1	0	0	11
			0	0-3	0	0-0.1	0-30
			0	14	0	2	24
	C-7	39	0	4	0	0	3
			0-0.1	0-25	0-0.1	0-2	0-15
			5	30	3	12	18
	C-10	30	0	2	0	1	0
			0	1-3	0-3	0-5	0-2
			0	30	4	24	5
Lang Syne/ Sawdust Landing	C-2	6	0	8	30	0	0
			0	0-25	0-95	0	0
			0	4	4	0	0
	C-3	29	0	7	0	0	0
			0	0-20	0	0	0
			0	26	0	0	0
	C-5	48	0	3	1	0	1
			0	0-10	0-15	0-0.1	0-10
			0	46	12	1	15
	C-6	71	0	5	4	0	0
			0	0-30	0-35	0	0
			0	66	28	0	0
	C-7	77	0	2	1	0	1
			0-2	0-10	0-10	0-1	0-10
			14	65	50	12	35
	C-10	95	6	2	0	0	1
			0-40	0.1-3	0-1	0-2	0-35
			45	95	1	21	35

Table 4. Continued

Formation	Well	Number of core samples analyzed	Average mineral percentage in formation				
			Range of mineral percentage in formation				
			Number of 1-ft core samples containing mineral				
			Carbonate	Muscovite	Lignite	Sulfide	Glauconite
Steel Creek	C-3	30	0	5	0	2	0
			0	0-20	0	0-15	0
			0	21	0	6	0
	C-5	122	0	8	0	0	0
			0	0-25	0-10	0-5	0
			0	120	9	22	0
	C-6	143	0	6	1	0	0
			0	0-45	0-45	0-0.1	0
			0	111	21	3	0
	C-7	126	0	2	0	0	0
			0	0-10	0-10	0-5	0
			0	115	7	72	0
	C-10	160	0	5	0	0	0
			0	0-15	0-7	0-3	0
			0	156	6	28	0
Black Creek	C-1	171	0	11	0	0	0
			0	1-30	0	0	0
			0	171	0	0	0
	C-2	161	0	9	0	0	0
			0	0-30	0	0	0
			0	136	0	0	0
	C-3	185	0	14	0	0	0
			0	0-40	0	0	0
			0	156	0	0	0
	C-5	241	0	5	1	0	0
			0	0-25	0-20	0-5	0-0.1
			0	238	156	42	5
	C-6	302	8	15	1	0	0
			0-50	0-55	0-25	0-25	0-15
			98	298	47	33	16
	C-7	254	1	8	2	0	0
			0-10	0-35	0-90	0-5	0
			147	251	168	63	0
	C-10	330	2	7	1	1	0
			0-30	0-35	0-10	0-10	0-7
			135	328	150	221	54

Table 4. Continued

Formation	Well	Number of core samples analyzed	Average mineral percentage in formation				
			Range of mineral percentage in formation				
			Number of 1-ft core samples containing mineral				
			Carbonate	Muscovite	Lignite	Sulfide	Glauconite
Middendorf	C-1	177	0	6	0	0	0
			0	0-35	0	0	0
			0	168	0	0	0
	C-2	112	0	3	0	0	0
			0	0-30	0	0	0
			0	84	0	0	0
	C-3	134	0	9	1	0	0
			0	0-30	0-98	0-5	0
			0	115	2	5	0
	C-5	141	0	3	3	0	0
			0	0-15	0-95	0-2	0
			0	131	50	23	0
	C-6	159	0	8	4	1	0
			0	0-30	0-40	0-25	0
			0	146	61	55	0
	C-7	122	0	4	2	1	0
			0	0-15	0-99	0-7	0
			0	118	45	50	0
	C-10	193	0	5	3	2	0
			0	0-20	0-95	0-20	0
			0	193	116	142	0
Cape Fear	C-1	25	0	7	0	0	0
			0	0-20	0-1	0	0
			0	23	3	0	0
	C-5	92	0	1	0	0	0
			0	0-10	0-10	0	0
			0	77	9	0	0
	C-6	152	0	2	0	0	0
			0-0.1	0-20	0-5	0	0
			2	84	4	0	0
	C-7	171	0	4	0	0	0
			0	0-30	0-15	0-3	0
			0	154	6	9	0
	C-10	159	0	2	0	0	0
			0	0-10	0-5	0-5	0
			0	148	2	3	0

Table 5. Paleontologic and palynologic analyses and environmental interpretation

Well site	Altitude (ft, msl)	Depth (ft, fsd)	Analyst	Fossil type	Age interpretation	Zone	Paleo-environment	Stratigraphic formation	Comments
C-6	54.5	154.5	Zullo, 1988	Megafossils	Lower upper Jacksonian	NP17-18	Marine	Clinchfield or Dry Branch	
C-6	53.5	155.5	Zullo, 1988	Megafossils	Jacksonian	NP17-21	Marine	Clinchfield or Dry Branch	
C-6	52.2	156.8	Laws, 1988	Nannofossils	Upper middle to upper Eocene	NP16-20	Mid to inner shelf	Clinchfield or Santee	Poor preservation; nannos rare
C-6	51	158	Zullo, 1988	Megafossils	Jacksonian	NP17-21	Marine	Clinchfield or Dry Branch	
C-6	30.7	178.3	Zullo, 1988	Megafossils	Jacksonian	NP17-21	Marine	Clinchfield or Dry Branch	
C-6	30.7	178.3	Laws, 1988	Nannofossils	Upper middle to upper Eocene	NP-16	Mid to inner shelf	Clinchfield or Santee	
C-6	30.2	178.8	Laws, 1988	Nannofossils	Upper middle to upper Eocene	NP-16	Mid to inner shelf	Clinchfield or Santee	
C-6	21	188	Laws, 1988	Nannofossils	Upper middle to upper Eocene	NP-16	Mid to inner shelf	Santee	
C-6	21	188	Zullo, 1988	Megafossils	Upper Claibornian	NP-16	Marine	Santee	
C-6	19	190	Laws, 1988	Nannofossils	Upper middle to upper Eocene	NP-16	Mid to inner shelf	Santee	
C-6	15.3	193.7	Laws, 1988	Nannofossils	Upper middle to upper Eocene	NP-16	Mid to inner shelf	Santee	
C-6	1.2	207.8	Laws, 1988	Nannofossils	Upper middle to upper Eocene	NP-16	Mid to inner shelf	Santee	
C-6	-9	218	Zullo, 1988	Megafossils	Upper Claibornian	NP-16	Marine	Santee	
C-6	-9.3	218.3	Laws, 1988	Nannofossils	Upper middle to upper Eocene	NP-16	Mid to inner shelf	Santee	
C-6	-15	224	Laws, 1988	Nannofossils	Upper middle to upper Eocene	NP-16	Mid to inner shelf	Santee	
C-6	-18	227	Laws, 1988	Nannofossils	Upper middle to upper Eocene	NP-16	Mid to inner shelf	Santee	
C-6	-22.5	231.5	Laws, 1988	Nannofossils	Upper middle to upper Eocene	NP-16	Mid to inner shelf	Santee	
C-6	-30	239	Laws, 1988	Nannofossils	Upper middle to upper Eocene	NP-16	Mid to inner shelf	Santee	
C-6	-34.5	243.5	Laws, 1988	Nannofossils	Upper middle to upper Eocene	NP-16	Mid to inner shelf	Santee	
C-6	-36	245	Zullo, 1988	Megafossils	Lower Claibornian (?)	NP-15	Marine	Warley Hill	May correlate with Cubitostrea lisbonensis
C-6	-40 to -41	249 to 250	Zullo, 1988	Megafossils	Lower Claibornian (?)	NP-15	Marine	Warley Hill	May correlate with Cubitostrea lisbonensis
C-6	-52	261	Zullo, 1988	Megafossils	Lower Claibornian (?)	NP14-15	Marine	Congaree	
C-6	-61.5	270.5	Laws, 1988	Nannofossils	Lower middle Eocene	NP14-15	Mid to inner shelf	Congaree/Fourmile	
C-6	-62.5	271.5	Zullo, 1988	Megafossils	Lower Claibornian (?)	NP-15	Marine	Congaree	
C-6	-79.8	288.8	Laws, 1988	Nannofossils	Lower middle Eocene	NP14-15	Mid to inner shelf	Congaree/Fourmile	
C-6	-80	289	Zullo, 1988	Megafossils	Lower Claibornian (?)	NP14-15	Marine	Congaree	
C-6	-221.6	430.6	Lucas-Clark, 1989b	Dinoflagellates	Probably Late Cretaceous or early Paleocene	N/A	Marine	Lang Syne/Sawdust Landing	

Table 5. Continued

Well site	Altitude (ft. msl)	Depth (ft. fsd)	Analyst	Fossil type	Age interpretation	Zone	Paleo-environment	Stratigraphic formation	Comments
C-6	-258.8	467.8	Lucas-Clark, 1989b	Dinoflagellates	Probably Late Cretaceous or early Paleocene	N/A	Marine	Lang Syne/Sawdust Landing	
C-6	-514.7	723.7	Lucas-Clark, 1989b	Dinoflagellates	Late Cretaceous; possibly Santonian through Maastrichtian	N/A	Marine	Black Creek	
C-6	-586	795	Lucas-Clark, 1988	Dinoflagellates	Campanian through (probably) Early Maastrichtian	N/A	Marine	Black Creek	
C-6	-596	805	Lucas-Clark, 1988	Dinoflagellates	Late Campanian	N/A	Marine	Black Creek	
C-6	-606	815	Lucas-Clark, 1988	Dinoflagellates	Late Campanian	N/A	Marine	Black Creek	
C-6	-616	825	Lucas-Clark, 1988	Dinoflagellates	Late Campanian	N/A	Marine	Black Creek	
C-6	-626	835	Lucas-Clark, 1988	Dinoflagellates	Late Campanian through Maastrichtian	N/A	Marine	Black Creek	
C-6	-636	845	Lucas-Clark, 1988	Dinoflagellates	Coniacian through Maastrichtian	N/A	Marine	Black Creek	
C-6	-643.2	852.2	Laws, 1988	Diatoms	Upper Campanian	CC-22	N/A	Black Creek	
C-6	-646	855(?)	Lucas-Clark, 1988	Dinoflagellates	Campanian	N/A	Marine	Black Creek	
C-6	-656	865	Lucas-Clark, 1988	Dinoflagellates	Middle through Late Campanian	N/A	Marine	Black Creek	
C-6	-666	875	Lucas-Clark, 1988	Dinoflagellates	Coniacian through Earliest Maastrichtian	N/A	Marine	Black Creek	
C-6	-676	885	Lucas-Clark, 1988	Dinoflagellates	Santonian through Campanian	N/A	Marine	Black Creek	
C-6	-686	895	Lucas-Clark, 1988	Dinoflagellates	Santonian through Campanian, probably Campanian	N/A	Marine	Black Creek	
C-6	-693.2	902.2	Laws, 1988	Diatoms	Upper Campanian	CC-22	N/A	Black Creek	
C-7	232.8 to 232.6	19.2 to 19.4	Waanders, 1993	Spores/Pollen	Oligocene or younger	N/A	Nonmarine, fluvial/floodplain	Tobacco Road	
C-7	22.1 to 22.0	229.9 to 230.0	Waanders, 1993	Microplankton	Late Eocene (Bartonian or Jacksonian)	N/A	Marginal marine, beach or deltaic	Santee	
C-7	14.8 to 14.6	237.2 to 237.4	Waanders, 1993	Spores/Pollen	Late Eocene (Bartonian or Jacksonian)	N/A	Nearshore marginal marine, estuarine or lagoonal	Santee	
C-7	2.9 to 2.8	249.1 to 249.2	Waanders, 1993	Spores/Pollen	Late Eocene (Bartonian or Jacksonian)	N/A	Nearshore marginal marine, estuarine or lagoonal	Santee	
C-7	-7.2 to -7.3	259.2 to 259.3	Waanders, 1993	Spores/Pollen	Late Eocene (Bartonian or Jacksonian)	N/A	Nearshore open marine	Santee	
C-7	-18.2 to -18.3	270.2 to 270.3	Waanders, 1993	Spores/Pollen	Late Eocene (Bartonian or Jacksonian)	N/A	Nearshore open marine	Santee	
C-7	-28.2 to -28.3	280.2 to 280.3	Waanders, 1993	Spores/Pollen	Late Eocene (Bartonian or Jacksonian)	N/A	Nearshore open marine	Santee	
C-7	-38.3 to -38.4	290.3 to 290.4	Waanders, 1993	Spores/Pollen	Late Eocene (Bartonian or Jacksonian)	N/A	Nearshore open marine	Santee	
C-7	-48.2 to -48.3	300.2 to 300.3	Waanders, 1993	Spores/Pollen	Middle Eocene (Lutetian or Claibornian)	N/A	Open shelf marine	Santee	
C-7	-58.2 to -58.3	310.2 to 310.3	Waanders, 1993	Spores/Pollen	Middle Eocene (Lutetian or Claibornian)	N/A	Open shelf marine	Santee	
C-7	-83.2 to -83.3	335.2 to 335.3	Waanders, 1993	Spores/Pollen	Middle Eocene (Lutetian or Claibornian)	N/A	Nearshore open marine	Congaree	
C-7	-162.9 to -163	414.9 to 415.0	Waanders, 1993	Spores/Pollen	Late Paleocene (Thanetian or Early-Middle Sabinian)	N/A	Nearshore open marine, deltaic (?)	Snapp	

Table 5. Continued

Well site	Altitude (ft, msl)	Depth (ft, lsd)	Analyst	Fossil type	Age interpretation	Zone	Paleo-environment	Stratigraphic formation	Comments
C-7	-171 to -171.2	423.0 to 423.2	Waanders, 1993	Spores/Pollen	Late Paleocene (Thanetian or early-middle Sabinian)	N/A	Nearshore open marine, deltaic (?)	Snapp	
C-7	-212 to -212.2	464.0 to 464.2	Waanders, 1993	Spores/Pollen	Paleocene (Danian or early Midwayan)	N/A	Nearshore marine, lagoonal or deltaic	Lang Syne/Sawdust Landing	
C-7	-224 to -224.2	476.0 to 476.2	Waanders, 1993	Spores/Pollen	Paleocene (Danian or early Midwayan)	N/A	Nearshore marine, lagoonal or deltaic	Lang Syne/Sawdust Landing	
C-7	-288 to -288.2	540.0 to 540.2	Waanders, 1993	Spores/Pollen	Paleocene (Danian or early Midwayan)	N/A	Nearshore marine, lagoonal or deltaic	Lang Syne/Sawdust Landing	
C-7	-453.6 to -453.8	705.6 to 705.8	Waanders, 1993	Spores/Pollen	Maastrichtian	N/A	Nearshore marginal marine, estuarine or deltaic	Black Creek	
C-7	-569.5 to -569.7	821.5 to 821.7	Waanders, 1993	Spores/Pollen	Maastrichtian	N/A	Marginal marine, estuarine or deltaic	Black Creek	
C-7	-724 to -724.2	976.0 to 976.2	Waanders, 1993	Spores/Pollen	Probably Campanian	N/A	Marginal marine, estuarine or deltaic	Black Creek	
C-7	-822 to -822.2	1,074.0 to 1,074.2	Waanders, 1993	Spores/Pollen	Probably Campanian	N/A	Non-marine, fluvial or floodplain	Middendorf	
C-7	-1,047.8 to -1,048.0	1,299.8 to 1,300.0	Waanders, 1993	Mikroplankton	Late Cretaceous (undifferentiated)	N/A	Nearshore marginal marine, beach or deltaic	Cape Fear	
C-10	73	217	Fallow, 1988	Foraminifera	Late Eocene	N/A	Marine	Dry Branch	<i>Nonion rollshouseni</i>
C-10	71	219	Fallow, 1988	Foraminifera	Late Eocene	N/A	Marine	Dry Branch	<i>Nonion rollshouseni</i>
C-10	58	232	Fallow, 1988	Foraminifera	Late Eocene	N/A	Marine	Dry Branch	<i>Nonion rollshouseni</i>
C-10	50	240	Fallow, 1988	Foraminifera	Late Eocene	N/A	Marine	Dry Branch	<i>Nonion rollshouseni</i>
C-10	39	251	Fallow, 1988	Foraminifera	Late Eocene	N/A	Marine	Dry Branch	<i>Nonion rollshouseni</i>
C-10	34	256	Laws, 1989	Nannofossils	Upper Eocene	NP19-20	Marine	Dry Branch	
C-10	32	258	Fallow, 1988	Foraminifera	Late Eocene	N/A	Marine	Dry Branch	<i>Nonion rollshouseni</i>
C-10	28	262	Fallow, 1988	Foraminifera	Late Eocene	N/A	Marine	Dry Branch	<i>Nonion rollshouseni</i>
C-10	22	268	Laws, 1989	Nannofossils	Upper Eocene	NP19-20	Marine	Dry Branch	<i>Isthmolithus recurvus</i>
C-10	4	286	Laws, 1989	Nannofossils	Upper Eocene	NP19-20	Marine	Dry Branch	
C-10	0	290	Laws, 1989	Nannofossils	Upper Eocene	NP19-20	Marine	Dry Branch	
C-10	-2	292	Laws, 1989	Nannofossils	Upper Eocene	NP19-20	Marine	Dry Branch	<i>Isthmolithus recurvus</i>
C-10	-21	311	Lucas-Clark, 1993	Pollen and Dinoflagellates	Upper middle Eocene to lower upper Eocene	NP17-18	Marine, nearshore	Dry Branch	
C-10	-28	318	Lucas-Clark, 1993	Pollen and Dinoflagellates	Upper middle Eocene to lower upper Eocene	NP17-18	Marine, nearshore	Dry Branch	Very similar to assemblage at 311 ft.
C-10	-28.5	318.5	Lucas-Clark, 1989a	Dinoflagellates	Eocene	NP10-18	Marine	Dry Branch	
C-10	-30	320	Lucas-Clark, 1993	Pollen and Dinoflagellates	Upper middle Eocene to lower upper Eocene	NP17-18	Marine, relatively nearshore	Dry Branch	
C-10	-32	322	Laws, 1989	Nannofossils	Upper middle Eocene	NP16-17	Marine	Santee	
C-10	-38	328	Edwards, 1993	Dinocysts	Latest middle Eocene	NP-17	Marine, probably nearshore	Santee	

Table 5. Continued

Well site	Altitude (ft, msl)	Depth (ft, lsd)	Analyst	Fossil type	Age interpretation	Zone	Paleo-environment	Stratigraphic formation	Comments
C-10	-44	334	Laws, 1989	Nannofossils	Upper middle Eocene	NP16-17(?)	Marine	Santee	Nannos rare
C-10	-48	338	Lucas-Clark, 1993	Pollen and Dinoflagellates	Probably middle Eocene	N/A	Marine	Santee	
C-10	-53	343	Fallaw, 1988	Foraminifera	Middle Eocene	N/A	Marine	Santee	<i>Cibicides westi</i>
C-10	-107	397	Fallaw, 1988	Foraminifera	Middle Eocene	N/A	Marine	Santee	<i>Cibicides westi</i>
C-10	-110	400	Laws, 1989	Nannofossils	Upper middle Eocene	NP16-17	Marine	Santee	Nannos rare
C-10	-120	410	Lucas-Clark, 1993	Pollen and Dinoflagellates	Middle Eocene to lowermost Oligocene	NP15-21	Marine	Santee	
C-10	-136	426	Fallaw, 1988	Foraminifera	Middle Eocene	N/A	Marine	Santee	<i>Cibicides westi</i>
C-10	-143	433	Lucas-Clark, 1993	Pollen and Dinoflagellates	Middle Eocene	NP15-17	Marine	Santee	Probably NP15-16
C-10	-144	434	Edwards, 1993	Dinocysts	Late middle Eocene	NP16-17	Marine	Santee	
C-10	-148	438	Laws, 1989	Nannofossils	Upper middle Eocene	NP16-17	Marine	Santee	
C-10	-148	438	Lucas-Clark, 1993	Pollen and Dinoflagellates	Middle Eocene	NP-16	Marine	Santee	
C-10	-152	442	Fallaw, 1988	Foraminifera	Middle Eocene	N/A	Marine	Santee	<i>Cibicides westi</i>
C-10	-158	448	Lucas-Clark, 1993	Pollen and Dinoflagellates	Tertiary	N/A	N/A	Warley Hill	Only 2 taxa in this sample
C-10	-199	489	Lucas-Clark, 1993	Pollen and Dinoflagellates	Middle Eocene	NP15-17	Marine	Congaree	
C-10	-204.1	494.1	Edwards, 1993	Dinocysts	Early middle Eocene	NP14-16	Marine	Congaree/Fourmile	
C-10	-227	517	Lucas-Clark, 1993	Pollen and Dinoflagellates	Middle Eocene	NP14-15	Marine	Congaree/Fourmile	
C-10	-234	524	Edwards, 1993	Dinocysts	Early middle Eocene	NP14-15	Marine	Congaree/Fourmile	
C-10	-240	530	Lucas-Clark, 1993	Pollen and Dinoflagellates	Eocene, probably upper middle Eocene	NP14-15	Marine	Congaree/Fourmile	
C-10	-245	535	Laws, 1989	Nannofossils	Middle Eocene	NP15-16	Marine	Congaree/Fourmile	
C-10	-252	542	Edwards, 1993	Pollen, Dinocysts	Eocene	N/A	Marine	Congaree/Fourmile probably Fourmile	
C-10	-270	560	Lucas-Clark, 1993	Pollen and Dinoflagellates	Lower Eocene or lowermost middle Eocene	NP11-13	Marine	Fourmile	Probably early to late Ypresian
C-10	-277	567	Lucas-Clark, 1993	Pollen and Dinoflagellates	Paleogene	N/A	Marine (?)	Snapp	Only 2 taxa in this sample
C-10	-291	581	Lucas-Clark, 1993	Pollen and Dinoflagellates	Uppermost Paleocene to lower Eocene	NP9-12	Marine	Snapp	
C-10	-292	582	Lucas-Clark, 1993	Pollen and Dinoflagellates	Uppermost Paleocene; possibly lower Eocene; Sabinian	NP-9	Marine	Snapp	
C-10	-293.5	583.5	Edwards, 1993	Pollen, Dinocysts	Latest Paleocene	N/A	Marine	Snapp	
C-10	-318	608	Lucas-Clark, 1993	Pollen and Dinoflagellates	Tertiary	N/A	N/A	Lang Syne/Sawdust Landing	
C-10	-347	637	Lucas-Clark, 1993	Pollen and Dinoflagellates	Upper Paleocene; Sabinian	NP5-7/8	Marine	Lang Syne/Sawdust Landing	

Table 5. Continued

Well site	Altitude (ft. msl)	Depth (ft. fsd)	Analyst	Fossil type	Age interpretation	Zone	Paleo-environment	Stratigraphic formation	Comments
C-10	-349.5	639.5	Edwards, 1993	Pollen, Dinocysts	Late Paleocene	N/A	Marine	Lang Syne/Sawdust Landing	
C-10	-350	640	Lucas-Clark, 1993	Pollen and Dinoflagellates	Paleocene or early Eocene; Midwayan to Sabinian	N/A	Marine	Lang Syne/Sawdust Landing	
C-10	-362	652	Lucas-Clark, 1989a	Dinoflagellates	Probably Paleocene, although could be Late Cretaceous	N/A	Marine	Lang Syne/Sawdust Landing	
C-10	-362	652	Laws, 1989	Nannofossils	Upper Paleocene	NP8	Marine	Lang Syne/Sawdust Landing	
C-10	-362	652	Lucas-Clark, 1993	Pollen and Dinoflagellates	Upper Paleocene; upper Midwayan to lower Sabinian	NP4-7	N/A	Lang Syne/Sawdust Landing	
C-10	-371	661	Lucas-Clark, 1993	Pollen and Dinoflagellates	Paleocene; Midwayan to Sabinian	NP4-7	Marine	Lang Syne/Sawdust Landing	
C-10	-384	674	Lucas-Clark, 1989a	Dinoflagellates	Probably Paleocene, although could be Late Cretaceous	N/A	Marine	Lang Syne/Sawdust Landing	
C-10	-384	674	Lucas-Clark, 1993	Pollen and Dinoflagellates	Paleocene; Midwayan to Sabinian	NP4-7	Marine	Lang Syne/Sawdust Landing	
C-10	-396	686	Lucas-Clark, 1993	Pollen and Dinoflagellates	Paleocene; Midwayan to Sabinian	NP-2	Marine	Lang Syne/Sawdust Landing	NP-2 or younger.
C-10	-402	692	Lucas-Clark, 1989a	Dinoflagellates	Paleocene	N/A	Marine	Lang Syne/Sawdust Landing	
C-10	-402	692	Lucas-Clark, 1993	Pollen and Dinoflagellates	Paleocene; Midwayan to Sabinian	NP4-7/8	Marine	Lang Syne/Sawdust Landing	
C-10	-411	701	Lucas-Clark, 1993	Pollen and Dinoflagellates	Lower Paleocene; Midwayan; Danian (?)	NP1-5	Marine	Lang Syne/Sawdust Landing	
C-10	-566	856	Lucas-Clark, 1993	Pollen and Dinoflagellates	Upper Cretaceous; Maastrichtian	N/A	Non-marine	Steel Creek	
C-10	-591	881	Waanders, 1993	Spores/Pollen	Campanian to Maastrichtian (undifferentiated)	N/A	Non-marine, marsh or fluvial	Black Creek	
C-10	-591	881	Lucas-Clark, 1993	Pollen and Dinoflagellates	Upper Cretaceous; Campanian to Maastrichtian	N/A	Non-marine	Steel Creek	Probably Maastrichtian
C-10	-596	886	Lucas-Clark, 1993	Pollen and Dinoflagellates	Upper Cretaceous; Maastrichtian	MA1	Non-marine	Black Creek	
C-10	-610	900	Lucas-Clark, 1993	Pollen and Dinoflagellates	Upper Cretaceous; Maastrichtian	N/A	Marine	Black Creek	
C-10	-633	923	Lucas-Clark, 1993	Pollen and Dinoflagellates	Upper Cretaceous; probably Maastrichtian	N/A	Marine	Black Creek	
C-10	-659	949	Lucas-Clark, 1993	Pollen and Dinoflagellates	Upper Cretaceous; Upper Campanian to Lower Maastrichtian	N/A	Marine	Black Creek	
C-10	-664	954	Lucas-Clark, 1993	Pollen and Dinoflagellates	Upper Cretaceous; Campanian	N/A	Marine	Black Creek	
C-10	-672	962	Lucas-Clark, 1993	Pollen and Dinoflagellates	Upper Cretaceous; Upper Campanian	N/A	Marine	Black Creek	
C-10	-673	963	Lucas-Clark, 1989a	Dinoflagellates	Late Cretaceous; Santonian through Campanian	N/A	Marine	Black Creek	
C-10	-673	963	Lucas-Clark, 1993	Pollen and Dinoflagellates	Upper Cretaceous; Campanian	CA4-5	Marine	Black Creek	
C-10	-705	995	Lucas-Clark, 1989a	Dinoflagellates	Cretaceous; possible Albian/Cenomanian reworking	N/A	Marine	Black Creek	
C-10	-705	995	Lucas-Clark, 1993	Pollen and Dinoflagellates	Upper Cretaceous; Campanian; probably Upper Campanian	N/A	Marine	Black Creek	
C-10	-707	997	Lucas-Clark, 1993	Pollen and Dinoflagellates	Upper Cretaceous; Campanian; probably Upper Campanian	N/A	Marine	Black Creek	
C-10	-712	1,002	Lucas-Clark, 1993	Pollen and Dinoflagellates	Upper Cretaceous; Campanian; probably Upper Campanian	N/A	Marine	Black Creek	

Table 5. Continued

Well site	Altitude (ft. msl)	Depth (ft. lsd)	Analyst	Fossil type	Age interpretation	Zone	Paleo-environment	Stratigraphic formation	Comments
C-10	-745	1,035	Lucas-Clark, 1993	Pollen and Dinoflagellates	Upper Cretaceous; Campanian	CA-5	Marine	Black Creek	
C-10	-756	1,046	Lucas-Clark, 1993	Pollen and Dinoflagellates	Upper Cretaceous; Upper Campanian to Maastrichtian; probably Upper Campanian	N/A	Shallow marine	Black Creek	
C-10	-808	1,098	Lucas-Clark, 1993	Pollen and Dinoflagellates	Upper Cretaceous; Campanian; probably Upper Campanian	N/A	Marine	Black Creek	
C-10	-857	1,147	Lucas-Clark, 1993	Pollen and Dinoflagellates	Upper Cretaceous; Upper Campanian	N/A	Marine	Black Creek	
C-10	-891	1,181	Lucas-Clark, 1993	Pollen and Dinoflagellates	Upper Cretaceous; probably Campanian	N/A	Non-marine	Black Creek	
C-10	-966	1,256	Lucas-Clark, 1993	Pollen and Dinoflagellates	Upper Cretaceous; Campanian	CA4-5	Shallow marine; brackish (?)	Middendorf	
C-10	-969	1,259	Waanders, 1993	Spores/Pollen	Late Cretaceous (undifferentiated)	N/A	Restricted marginal marine, Estuarine	Middendorf	
C-10	-1,060	1,350	Lucas-Clark, 1993	Pollen and Dinoflagellates	Upper Cretaceous; Campanian	N/A	Non-marine (?)	Middendorf	
C-10	-1,086	1,376	Lucas-Clark, 1993	Pollen and Dinoflagellates	Upper Cretaceous; Lower Campanian	CA1-3	Shallow marine; probably brackish	Middendorf	
C-10	-1,161	1,451	Lucas-Clark, 1993	Pollen and Dinoflagellates	Upper Cretaceous; Coniacian-Campanian; probably Santonian	N/A	Non-marine	Middendorf	
C-10	-1,215	1,505	Lucas-Clark, 1988	Pollen and Dinoflagellates	Upper Cretaceous; Coniacian to Santonian	N/A	Non-marine	Cape Fear	

caused by comparatively high dissolved solids in water of the Cape Fear Formation (300 mg/L at site C-10) compared to that in the overlying Middendorf Formation (80 mg/L at site C-10).

SUMMARY STATISTICS OF CLAY MINERALOGY IN THE CAPE FEAR FORMATION										
	Illite (%)	Kaolinite (%)	Chlorite (%)	Illite/smectite (%)	Smectite (%)	Total clay (%)	Quartz (%)	Feldspar (%)	Calcite (%)	Total (%)
Mean	26.09	49.73	0.27	22.18	1.73	100.00	0.00	0.00	0.00	100.00
Median	28.00	48.00	0.00	25.00	1.00	100.00	0.00	0.00	0.00	100.00
Std. Dev.	14.45	22.66	0.65	12.30	2.00	0.00	0.00	0.00	0.00	0.00
Variance	208.89	513.42	0.42	151.36	4.02	0.00	0.00	0.00	0.00	0.00
Range	51.00	81.00	2.00	38.00	6.00	0.00	0.00	0.00	0.00	0.00
Minimum	3.00	16.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00	100.00
Maximum	54.00	97.00	2.00	38.00	6.00	100.00	0.00	0.00	0.00	100.00
Sum	287.00	547.00	3.00	244.00	19.00	1100.00	0.00	0.00	0.00	1100.00
Count	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00

Age-diagnostic fossils and pollen are rare in the Cape Fear Formation. Turonian, Coniacian, or Santonian age is indicated (Fallaw and Lawrence, 1992). One sample was diagnostic (Table 5). Lucas-Clark (1993), analyzing pollen and dinoflagellates from a sample at site C-10, indicated a Coniacian to Santonian age and a nonmarine origin.

Middendorf Formation - Sloan (1904 and 1908) used the term "Middendorf" for sediments near the Fall Line in South Carolina, applying it to sand, kaolinitic sand, kaolin, and gravel. Heron (1958) named the Middendorf for exposures along a railroad cut near Middendorf, S.C. The unit was described as consisting of intercalated, lensing, thick-bedded, light-colored, sand and clay (mudstone) with local concentrations of clay-clast conglomerates. The most common colors are light gray, white, and a variety of oxidation colors, although darker gray beds are locally present. At its type locality, the Middendorf is deeply weathered, causing difficulty in identifying the unit in areas removed from the type locale.

At the C-well sites, the Middendorf Formation consists of gray or tan, unconsolidated, lignitic, micaceous, poorly to moderately sorted, medium- to coarse-grained quartz sand and clayey sand, interbedded with sandy clay and clay. The formation is commonly capped by a 10- to 30-ft clay bed that is used to mark the top of the formation. Thickness of the formation ranges from 167 ft (site C-3) to 245 ft (site C-10). The top of the formation dips to the southeast at a rate of 26 ft/mi.

Muscovite occurs throughout the formation, composing 0 to 35 percent of the sediments (Table 4). At site C-10, muscovite is present in each 1-ft core sample described, ranging from 0 to 20 percent and averaging 5 percent. In extreme updip areas, as at site C-3, it ranges from 0 to 30 percent and averages 9 percent.

Lignite is common in the Middendorf at downdip sites (Plates 4-7). At C-10 it occurs in over half of the 1-ft core samples described, ranging from 0 to 95 percent and averaging 3 percent (Table 4). At updip sites C-1, C-2, and C-3, however, lignite is rare, occurring in only 2 of the 423 core samples described. Iron sulfide progressively increases downdip in the formation. Carbonate and glauconite are absent at all seven cluster sites.

Twenty-one samples from the Middendorf Formation were analyzed for clay and bulk mineralogy with x-ray diffraction techniques (Appendix 5). Kaolinite is the dominant clay mineral, ranging from 40 to 100 percent and averaging 75 percent. Trace amounts of quartz are also present.

SUMMARY STATISTICS OF CLAY MINERALOGY IN THE MIDDENDORF FORMATION										
	Illite (%)	Kaolinite (%)	Chlorite (%)	Illite/smectite (%)	Smectite (%)	Total clay (%)	Quartz (%)	Feldspar (%)	Calcite (%)	Total (%)
Mean	15.29	75.10	0.00	6.76	2.05	99.19	0.81	0.00	0.00	100.00
Median	13.00	78.00	0.00	5.00	1.00	100.00	0.00	0.00	0.00	100.00
Std. Dev.	13.18	19.81	0.00	6.49	2.38	2.06	2.06	0.00	0.00	0.00
Variance	173.71	392.29	0.00	42.09	5.65	4.26	4.26	0.00	0.00	0.00
Range	46.00	60.00	0.00	28.00	6.00	7.00	7.00	0.00	0.00	0.00
Minimum	0.00	40.00	0.00	0.00	0.00	93.00	0.00	0.00	0.00	100.00
Maximum	46.00	100.00	0.00	28.00	6.00	100.00	7.00	0.00	0.00	100.00
Sum	321.00	1577.00	0.00	142.00	43.00	2083.00	17.00	0.00	0.00	2100.00
Count	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00

The Middendorf is less consolidated and less clayey than the underlying Cape Fear Formation, resulting in an increased resistivity. At site C-10, for example, resistivity is one to two orders of magnitude greater than that in the underlying Cape Fear (Plate 7). Resistivity also increases updip owing to the low dissolved-solids content of water in these areas. At site C-3, resistivity is on the order of 1,000 ohm-m, as compared to 200 ohm-m at site C-10.

Age-diagnostic fossil and pollen assemblages are rare in the Middendorf Formation. The age indicated is Santonian to, perhaps, early Campanian (Fallaw and Lawrence, 1992). Six core samples from the "C" wells had age-diagnostic assemblages (Table 5). One indicates a Santonian age, four a Campanian age, and one an undifferentiated Late Cretaceous age. Three of the samples are interpreted as nonmarine and three as marine (Table 5).

Black Creek Formation - The term Black Creek Marl ("phase") was coined by Sloan (1907) for exposures along Black Creek, a tributary to the Pee Dee River near Darlington, S.C. The unit was redefined as the Black Creek Formation by Stephenson (1907) and characteristically consists of thin, interbedded black clay and light-colored sand. Owens (1989) raised the Black Creek to group status, dividing the unit into several formations. Revisions were made in the Carolinas by Owens and Sohl (1989) and Gohn (1992). At the present time, a lack of detailed palynology of the Black Creek sequence in the C-well cores prohibits accurately identifying and delineating the various formations of the group. Therefore, the sequence will be referred to as the Black Creek Formation in this report.

At the C-well sites, the Black Creek consists of brown or light-gray to black, unconsolidated, lignitic, micaceous, poorly to well-sorted, fine- to coarse-grained quartz sand and micritic, silty clay and clay. Lighter colors predominate in updip areas. The most commonly occurring (modal) sand size is medium. Over most of the study area, the upper and lower thirds of the formation consist of sand and clayey sand, and the middle third generally consists of fissile, silty clay (in updip areas) and fissile, micritic, silty clay (in downdip areas). The top of the formation is picked at the top of a clay bed, 10 to 25 ft thick, that caps the formation in the study area. Formation thickness ranges from 202 ft at site C-3 to 357 ft at site C-10. The formation dips 22 ft/mi to the southeast.

Muscovite is common in the Black Creek (Plates 1-7), occurring in 328 of the 330 core samples described at site C-10, where it composes from 0 to 35 percent of the unit and averages 7 percent (Table 4). In extreme updip areas, at site C-3, muscovite occurs in 156 of the 185 samples analyzed, ranging from 0 to 40 percent and averaging 14 percent.

Glauconite is absent in updip wells but increases downdip (Table 4). For example, at site C-5 the glauconite is present in only trace amounts and in only five of the 241 core samples described; at site C-6, it occurs in 16 of 302 samples, ranging from 0.1 to 15 percent;

and downdip, at site C-10, it occurs in 54 of 330 samples, ranging from 0.1 to 7 percent and averaging 0.4 percent. Mostly the glauconite is found in silty clay beds that compose the middle third of the formation (Plates 4, 5, and 7). Increases in glauconite reflect changing depositional systems and greater marine influences in the downdip section of the Coastal Plain sequence.

As in the Middendorf Formation, lignite is absent in the Black Creek at updip wells (Table 4). Downdip, however, at site C-10, lignite occurs in 150 of the 330 samples analyzed, making up 0 to 10 percent of the formation and averaging 1 percent. Iron sulfide is also absent in updip wells but increases downdip, occurring in 221 of the 330 samples described at C-10 and ranging from 0 to 10 percent with an average of 1 percent. Carbonate is absent in the Black Creek in updip wells. At sites C-6, C-7, and C-10, carbonate mud (micrite) occurs in the middle third of the formation (Table 4; Plates 5-7). Foraminifera and pelecypods are common.

Twenty-one core samples collected from the Black Creek were analyzed for clay and bulk mineralogy by x-ray diffraction techniques (Appendix 5). Kaolinite is the dominant clay mineral, ranging from 3 to 100 percent and averaging 48 percent. Traces of chlorite and quartz are also recorded. Feldspar occurs in three of the 21 samples analyzed, ranging from 4 to 7 percent (Appendix 5, bulk mineralogy results).

SUMMARY STATISTICS OF CLAY MINERALOGY IN THE BLACK CREEK FORMATION										
	Illite (%)	Kaolinite (%)	Chlorite (%)	Illite/smectite (%)	Smectite (%)	Total clay (%)	Quartz (%)	Feldspar (%)	Calcite (%)	Total (%)
Mean	33.05	47.52	0.14	15.81	2.81	99.62	0.38	0.00	0.00	100.00
Median	27.00	56.00	0.00	16.00	3.00	100.00	0.00	0.00	0.00	100.00
Std. Dev.	20.50	30.36	0.48	12.76	2.87	1.24	1.24	0.00	0.00	0.00
Variance	420.35	921.46	0.23	162.86	8.26	1.55	1.55	0.00	0.00	0.00
Range	70.00	97.00	2.00	48.00	11.00	5.00	5.00	0.00	0.00	0.00
Minimum	0.00	3.00	0.00	0.00	0.00	95.00	0.00	0.00	0.00	100.00
Maximum	70.00	100.00	2.00	48.00	11.00	100.00	5.00	0.00	0.00	100.00
Sum	694.00	998.00	3.00	332.00	59.00	2092.00	8.00	0.00	0.00	2100.00
Count	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00

Kaolinite increases in updip areas, averaging 63 percent of the formation at sites C-2 and C-3 (number of samples, $n = 6$). Here, illite averages only 21 percent, mixed-layer illite/smectite 11 percent, and smectite 1 percent. Downdip, however, illite is the most abundant clay mineral, averaging 43 percent at sites C-6 and C-10 ($n = 11$), approximately twice as abundant as in updip areas. Mixed-layer illite/smectite (20-percent) and smectite (2 percent) also increase downdip while kaolinite decreases (33 percent). Differences in the geographic distribution of clay minerals can be attributed to the degree of weathering that occurs in updip areas and/or to hydraulic sorting of clay-mineral species. During intense, deep weathering, as occurs in updip areas, illite is stripped of potassium ions, converting to smectite; smectite is further degraded to kaolinite. Hence, the relative abundance of kaolinite updip. In addition to the effects of chemical weathering, kaolinite is coarse grained relative to smectite. In nearly all studies of clay-mineral distributions in shallow-marine sediments, kaolinite is most abundant closest to shore (Blatt and others, 1980). Percent smectite generally increases offshore. This is due, in part, to hydraulic sorting of clay minerals. Fine-grained smectite is transported greater distances and deposited downdip in quiet-water environments. The distribution of clay minerals in the study area may, therefore, reflect changing depositional systems whereby offshore conditions prevailed downdip and nearshore to nonmarine conditions prevailed updip.

Geophysical signatures of the Black Creek are typical for unconsolidated sand and clay beds. Sand beds generally have resistivities ranging from 50 to 1,000 ohm-m whereas clay and silty-clay beds have resistivities from 2 to 10 ohm-m. In general, high radiation on the gamma-ray log occurs at the top of the middle third of the formation, marking the top of the thick, silty clay that persists throughout most of the study area (Plates 5-8).

A Campanian and early Maastrichtian age is suggested for the Black Creek Formation (Owens and Gohn, 1985 and Owens and Sohl, 1989 in Fallaw and Lawrence, 1992). A total of 34 samples contained age-diagnostic fossil assemblages from the Black Creek Formation at sites C-6, C-7, and C-10 (Table 5). Of the 17 samples analyzed at site C-10, four are interpreted as Maastrichtian and 13 as Campanian. The four Maastrichtian samples are from the uppermost part of the formation in the interval from -596 to -659 ft msl. A marine environment is indicated for the samples, with exceptions occurring at the very top of the formation (-596 ft msl) and at the top of the lower sand sequence (-891 ft msl) (Table 5). Samples analyzed from the thick, middle-clay interval are Campanian and marine in origin. For the most part, the 14 samples analyzed from site C-6 are either Campanian or Campanian to Maastrichtian in age. All are of marine origin.

Waanders (1993), analyzing spores and pollen from three samples at site C-7, indicated a Maastrichtian age for two upper samples near the top of the formation (-454 and -570 ft msl) and a "probable" Campanian age near the base of the formation (-724 ft msl). A marginal-marine (estuarine or deltaic) environment was interpreted for each sample (Table 5).

Steel Creek Formation - Cretaceous sediments overlying the Black Creek Formation are light-colored, quartz sand and mostly oxidized, kaolinitic clay (Fallaw and Price, 1995). The stratigraphic position and Maastrichtian age suggest that these sediments are correlative with the Peedee Formation in eastern South Carolina. The type-section for the Peedee Formation is located at Burches Ferry along the Pee Dee River in South Carolina (Ruffin, 1843). Here, the sediments are dark, calcareous, silty sand and silt with carbonate in the upper part in places. In these exposures, the basal unit incorporates phosphatic clasts consisting of subrounded cobbles and internal molds of mollusks. The unit is a predominantly dark-green to gray, slightly micaceous and glauconitic, argillaceous sand. Calcareous cemented concretions occur occasionally. Because lithologies at the type-section are so different than those found in the study area, Fallaw and Price (1995) have proposed naming the unit the "Steel Creek" Formation.

At the C-well sites, the Steel Creek Formation consists of brown or gray, unconsolidated, micaceous, poorly to moderately sorted, medium- to coarse-grained, pebbly sand and clayey sand interbedded with clay. Lithology of the Steel Creek varies in the study area. At site C-5 the formation is mainly a sand, with only minor amounts of clay. Of the 122 core samples analyzed, 101 (83 percent) are sand (mud < 25 percent). Ten miles downdip, at site C-6, only 9 percent of the formation is sand and 91 percent is clayey sand, sandy clay, or clay (mud > 25 percent). Farther downdip, at site C-10, the formation becomes sandy again with 63 percent classified as sand and 27 percent classified as clayey sand, sandy clay, or clay. These lithologic differences reflect changing depositional systems. Sand probably was deposited in meandering, distributary channels in a delta complex whereas clayey sediments were deposited in overbank areas, interdistributary bays, or in deep-water environments adjacent to the delta lobe(s).

Contact with the overlying Paleocene Lang Syne/Sawdust Landing Formation typically is marked by a lithologic change from the mottled, light-gray, clayey sand or clay of the Steel Creek Formation to the dark, fissile, lignitic clay and interbedded coarse sand of the Lang Syne/Sawdust Landing Formation. The upper part of the Steel Creek is often oxidized and

mottled. The formation ranges in thickness from 38 ft at site C-3 (updip) to 178 ft at site C-10 (downdip) and dips to the southeast at 20 ft/mi.

Muscovite is common in the Steel Creek (Plates 1-7), occurring in 156 of the 160 core samples described at site C-10 and ranging from 0 to 15 percent of the unit, with an average of 5 percent. At site C-5, muscovite occurs in 120 of the 122 core samples described, ranging from 0 to 25 percent and averaging 7 percent (Table 4).

In contrast to the underlying Black Creek and Middendorf Formations, lignite is rare in the Steel Creek Formation. At site C-10, for example, it occurs in only 6 of the 160 core samples described and at site C-5 it occurs in 9 of 122 samples. Iron sulfide is also sparse, occurring in only 28 of the 160 core samples analyzed at site C-10 and 22 of 122 samples at C-5. Glauconite and carbonate are absent in the formation at all seven cluster sites.

Ten samples were analyzed from the Steel Creek for clay and bulk mineralogy with x-ray diffraction techniques (Appendix 5). Kaolinite is the dominant clay mineral, ranging from 34 to 100 percent of the material and averaging 72 percent. Clay mineralogy of the Steel Creek is similar to that of the Middendorf, reflecting the generally nonmarine to marginal-marine depositional regimes of both formations in the study area.

SUMMARY STATISTICS OF CLAY MINERALOGY IN THE STEEL CREEK FORMATION										
	Illite (%)	Kaolinite (%)	Chlorite (%)	Illite/smectite (%)	Smectite (%)	Total clay (%)	Quartz (%)	Feldspar (%)	Calcite (%)	Total (%)
Mean	16.80	71.50	0.00	9.50	1.00	98.80	0.60	0.00	0.00	100.00
Median	17.50	75.50	0.00	7.00	0.00	100.00	0.00	0.00	0.00	100.00
Std. Dev.	11.19	22.48	0.00	11.54	2.00	2.53	1.90	0.00	0.00	0.00
Variance	125.29	505.39	0.00	133.17	4.00	6.40	3.60	0.00	0.00	0.00
Range	32.00	66.00	0.00	34.00	6.00	6.00	6.00	0.00	0.00	0.00
Minimum	0.00	34.00	0.00	0.00	0.00	94.00	0.00	0.00	0.00	100.00
Maximum	32.00	100.00	0.00	34.00	6.00	100.00	6.00	0.00	0.00	100.00
Sum	168.00	715.00	0.00	95.00	10.00	988.00	6.00	0.00	0.00	1000.00
Count	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00

High-radiation kicks on the gamma-ray log are characteristic of the Steel Creek (Plates 4, 5, and 7) and are associated with thin beds of very coarse to pebbly (gravelly) sediments. For example, the interval from -85 to -95 ft msl at site C-5 is marked by sharp and sudden increases in gamma radiation (Plate 4). This interval consists of pebbly sand, with pebbles ranging from 10 to 40 percent. Similar kicks on the log occur at -105 and -143 ft msl, where sediments are also gravelly, containing upward of 60 percent pebbles. Feldspars are commonly associated with gravelly deposits. The increased radiation is, therefore, probably due to the gamma-emitting potassium isotope (K^{40}) that occurs in feldspars.

Fossils from the Peedee Formation suggest a middle Maastrichtian age (Owens and Gohn, 1985 in Fallaw and Lawrence, 1992). Three samples had age-diagnostic fossil assemblages in the Steel Creek (Table 5). Waanders (1993), analyzing spores and pollen, indicated a Campanian to Maastrichtian age for a sample at the base of the formation at site C-10 (-591 ft msl). A nonmarine (marsh or fluvial) environment was suggested. Lucas-Clark (1993), analyzing pollen and dinoflagellates, suggested a Maastrichtian age for a sample near the base of the formation at site C-10 (-566 ft msl) and a Campanian to Maastrichtian age for a sample at the contact between the Steel Creek and Black Creek Formations at site C-10 (-591 ft msl). A nonmarine environment was interpreted for both samples.

Tertiary Formations

Lang Syne/Sawdust Landing Formation - Siple (1967) proposed the name "Ellenton Formation" for a subsurface lithologic unit penetrated in well 52-C at SRS. At the type well, these sediments consist of beds of dark, lignitic clay and coarse sand. Generally, the upper part of the formation contains a gray, silty to sandy, micaceous, lignitic clay. The lower part consists of clayey quartz sand of medium to coarse texture, sometimes gravelly. Fallaw and Price (1992) suggested that the Lang Syne and Sawdust Landing Members of Colquhoun and others (1983) be raised to formational status and replace the term Ellenton in the study area. Owing to an absence of detailed paleontologic data, the Lang Syne Formation and underlying Sawdust Landing Formation could not be differentiated. As such, the two are referred to as the Lang Syne/Sawdust Landing Formation in this report.

At the C-well sites, the Lang Syne/Sawdust Landing Formation consists of brown or gray to black, fissile, lignitic, micaceous clay and silty clay interbedded and interlaminated with green or tan to brown, glauconitic, micaceous, fine- to coarse-grained sand. Pyrite is occasionally present. Flaser to lenticular bedding structures are common. Percent clay increases downdip, grading into shelly, micritic clay and micritic clay at site C-10. A basal sand bed occurs at most of the sites. The formation thickens from 40 ft at site C-3 to 103 ft at site C-10.

Fine-grained muscovite and micaceous silt are common in clay beds of the Lang Syne/Sawdust Landing Formation. Muscovite increases in the sand and clayey sand beds. At site C-5, muscovite ranges from 0 to 10 percent and averages 3 percent. Downdip, at site C-10, where clay and micritic clay compose most of the formation, muscovite is present in every core sample analyzed ($n = 95$) but is no higher than 3 percent and averages 2 percent (Table 4).

Lignite exceeds 1 percent in the Lang Syne/Sawdust Landing only at cluster sites C-2 and C-6 (Table 4). The gray to black coloration of the formation, however, suggests that finely disseminated carbon is abundant in the unit. Glauconite is present in the formation at sites C-5, C-7, and C-10 (Plates 4, 6, and 7) but is absent at the remaining four sites. Most of the glauconite is concentrated in sand or clayey sand beds of the formation. At site C-5, glauconite occurs in a single 5-ft sand bed (-47 to -52 ft msl) where it ranges from 5 to 10 percent and averages 7 percent. At site C-7, an 8-ft clay and clayey sand bed (-259 to -267 ft msl) contains 0 to 10 percent glauconite and averages 6 percent. At site C-10, a 3-ft sand bed (-398 to -401 ft msl) is 35 percent glauconitic. Minor amounts (1 percent) of glauconite also occur in the micritic clay beds at site C-10 (-366 and -378 ft msl). Glauconite-rich zones may represent the basal unit of the Lang Syne Formation (Fallaw and Price, 1992) and may represent the contact boundary between the Lang Syne and Sawdust Landing Formations. The contact between the two, however, is difficult to determine where the basal glauconitic sand of the Lang Syne Formation is absent.

Carbonate is absent in the Lang Syne/Sawdust Landing at each cluster site, with the exception of C-7 and C-10 (downdip) where it occurs as shell fragments and carbonate mud (micrite). Shell fragments (oysters and pelecypods) occur in a 12-ft interval at C-10 (-353 to -364 ft msl) and compose 10 to 30 percent of the interval. Carbonate mud occurs throughout most of the middle third of the formation, ranging from 2 to 15 percent. Calcite cement is locally present.

Seven samples from the Lang Syne/Sawdust Landing Formation were analyzed for clay and bulk mineralogy (Appendix 5) with x-ray diffraction techniques. Illite is the dominant clay mineral ranging from 15 to 65 percent of the material and averaging 40 percent. Mixed-layer illite/smectite ranges from 7 to 39 percent and averages 25 percent. Traces of chlorite

are also noted. As in the Black Creek Formation, the predominance of illite and mixed-layer illite/smectite suggests deposition in low-energy, quiet-water environments subject to little chemical weathering.

SUMMARY STATISTICS OF CLAY MINERALOGY IN THE LANG SYNE/SAWDUST LANDING FORMATION										
	Illite (%)	Kaolinite (%)	Chlorite (%)	Illite/smectite (%)	Smectite (%)	Total clay (%)	Quartz (%)	Feldspar (%)	Calcite (%)	Total (%)
Mean	40.00	32.57	0.14	24.71	2.57	100.00	0.00	0.00	0.00	100.00
Median	46.00	31.00	0.00	24.00	4.00	100.00	0.00	0.00	0.00	100.00
Std. Dev.	18.85	26.92	0.38	9.53	2.44	0.00	0.00	0.00	0.00	0.00
Variance	355.33	724.95	0.14	90.90	5.95	0.00	0.00	0.00	0.00	0.00
Range	50.00	72.00	1.00	32.00	5.00	0.00	0.00	0.00	0.00	0.00
Minimum	15.00	6.00	0.00	7.00	0.00	100.00	0.00	0.00	0.00	100.00
Maximum	65.00	78.00	1.00	39.00	5.00	100.00	0.00	0.00	0.00	100.00
Sum	280.00	228.00	1.00	173.00	18.00	700.00	0.00	0.00	0.00	700.00
Count	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00

No distinguishing geophysical characteristics are noted in the Lang Syne/Sawdust Landing. In general, the formation is marked by low resistivities in downdip areas, where clay predominates, and by alternating high and low resistivities in updip areas, where the formation consists of interbedded sand and clay. A basal sand unit is commonly observed as a high-resistivity zone in downdip areas (Plates 5 and 7).

The Lang Syne/Sawdust Landing is considered early to late Paleocene. The lower part of the formation (Sawdust Landing equivalent) is assigned to nannoplankton zones NP3-4 (early Paleocene) of Martini (1971) and perhaps older (Fallaw and Price, 1992). The upper part (Lang Syne equivalent) is tentatively assigned to nannoplankton zones NP4-8 or NP5-8 (late Paleocene) (Fallaw and Price, 1992).

Nineteen samples from the Lang Syne/Sawdust Landing produced age-diagnostic fossil assemblages at sites C-6, C-7, and C-10 (Table 5). All are interpreted as Paleocene. Lucas-Clark (1993), analyzing pollen and dinoflagellates, indicated an upper Paleocene (NP4-8) age for samples in the interval from -347 to -402 ft msl at site C-10. A lower Paleocene date (NP1-5) was obtained from a sample at -411 ft msl, restricting the Lang Syne/Sawdust Landing contact to the interval between -402 and -411 ft msl. A highly glauconitic sand bed at site C-10 (35 percent glauconite) occurs in the interval from -398 to -402 ft msl. Assuming that the glauconitic sand bed represents the Lang Syne/Sawdust Landing contact, the contact would be very close to the base of the Paleocene section at site C-10 (the Cretaceous/Tertiary contact at site C-10 is at -413 ft msl).

Waanders (1993), analyzing spores and pollen, indicated an early Paleocene age (Danian or early Midwayan) for three samples in the interval from -212 to -288 ft msl at site C-7. The glauconitic zone at site C-7, however, occurs in the interval from -259 to -267 ft msl, above the early Paleocene date at -288 ft msl. Waanders (1993) indicated a nearshore marine (lagoonal or deltaic) environment for each of the three samples at site C-7.

Snapp Formation - Numerous investigators have carried the Williamsburg into the Savannah River Site area; however, the lithology at SRS is not similar to that at the type locality in eastern South Carolina (Sloan, 1908), where the unit consists of yellow or red sand. Because of lithologic differences of the sediments, Fallaw and Price (1992) proposed a new formation, the Snapp Formation, in the SRS area. The type section for the Snapp is described from core from well P-22TA at SRS. The sediments are light-gray, tan, orange, and yellow,

silty, micaceous, medium to coarse quartz sand and pebbly sand interbedded with kaolinitic clay.

At the C-well sites, the Snapp consists of brown, green, or off-white to gray, moderately to very poorly sorted, fine- to coarse-grained, glauconitic and micaceous quartz sand interbedded with gray to black clay and, infrequently, with orange to yellow oxidized clay. Granules, pebbles, and heavy minerals are common in the sand beds. The formation ranges in thickness from 41 ft at site C-7 to 16 ft at site C-5 and is projected to pinch out updip near the town of Williston, S.C.

Glaucinitic sand occurs near the top of the formation at sites C-6 and C-7. At site C-7, glauconite is in the upper 20 ft of the formation, making up 0 to 15 percent of the unit and averaging 3 percent (Table 4). The lower half of the formation consists of interbedded clayey sand and clay. At site C-6, which is oriented on-strike to C-7, glauconite occurs in 24 of the 26 samples analyzed, ranging from 0 to 30 percent and averaging 11 percent. The highest concentrations occur near the top of the formation. Minor amounts of glauconite also occur at sites C-5 and C-10. Glaucinitic sand beds in the Snapp are thought to represent transgressive deposits (Fallaw and Lawrence, 1992).

Muscovite occurs in varying amounts but is especially abundant in the sandy parts of the formation. At site C-5, muscovite occurs in each of the 16 core samples analyzed, ranging from 0.1 to 25 percent and averaging 9 percent. At site C-10, muscovite occurs in all 30 of the samples analyzed, ranging from 1 to 3 percent and averaging 2 percent. Carbonate sediments are absent in the Snapp at each of the C-well sites and lignite and iron sulfide occur in only minor amounts. No distinguishing, characteristic geophysical response is observed in the formation at the well sites.

Two samples were analyzed from the Snapp for clay and bulk mineralogy with x-ray diffraction techniques (Appendix 5).

SUMMARY STATISTICS OF CLAY MINERALOGY IN THE SNAPP FORMATION										
	Illite (%)	Kaolinite (%)	Chlorite (%)	Illite/smectite (%)	Smectite (%)	Total clay (%)	Quartz (%)	Feldspar (%)	Calcite (%)	Total (%)
Mean	53.00	19.00	0.00	27.00	0.50	99.50	0.50	0.00	0.00	100.00
Median	53.00	19.00	0.00	27.00	0.50	99.50	0.50	0.00	0.00	100.00
Std. Dev.	7.07	18.38	0.00	12.73	0.71	0.71	0.71	0.00	0.00	0.00
Variance	50.00	338.00	0.00	162.00	0.50	0.50	0.50	0.00	0.00	0.00
Range	10.00	26.00	0.00	18.00	1.00	1.00	1.00	0.00	0.00	0.00
Minimum	48.00	6.00	0.00	18.00	0.00	99.00	0.00	0.00	0.00	100.00
Maximum	58.00	32.00	0.00	36.00	1.00	100.00	1.00	0.00	0.00	100.00
Sum	106.00	38.00	0.00	54.00	1.00	199.00	1.00	0.00	0.00	200.00
Count	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00

The Snapp Formation is late Midwayan and early to middle Sabinian and correlates with nannoplankton zones NP-5 to NP-9 of Martini (1971) (Fallaw and Lawrence, 1992). Six samples had age-diagnostic fossil assemblages (Table 5). Waanders (1993), analyzing spores, pollen, and microplankton, indicated a late Paleocene age (Thanetian or early-middle Sabinian) for two sand(?) samples in the Snapp interval at site C-7. A nearshore, open-marine (deltaic?) depositional environment was suggested, which is consistent with the occurrence of glauconitic sand observed in the unit. Edwards and Frederiksen (1993), analyzing pollen and dinocysts, indicated a latest Paleocene age from a black clay bed (-293.5 ft msl) at site C-10. A marine environment was also inferred. Lucas-Clark (1993), analyzing pollen and

dinoflagellates, indicated an uppermost Paleocene to possibly lower Eocene age (NP9-12) and a marine environment for two samples at -291 and -292 ft msl at site C-10.

Congaree/Fourmile Formation - Sloan (1908) named the Congaree Formation for outcrops of shale, sand, and buhrstone occurring along the Congaree River in central South Carolina and also applied the term in the updip area of the Savannah River. Cooke (1936) divided Sloan's Congaree and assigned part to the Black Mingo Formation and part to the McBean Formation. Cooke and MacNeil (1952) reinstated the Congaree Formation as the stratigraphic equivalent of the Tallahatta Formation of Mississippi and Alabama. Pooser (1965) described the unit as "poorly sorted quartzose sands, interbedded sand and silty to arenaceous light-green clays, and hard, well-indurated siltstone and sandstone layers." In the SRS area, there appears to be a unit at the base of the Congaree correlative to the Fishburne Formation found in wells near the coast of South Carolina (Gohn and others, 1983). The type Fishburne is a finely crystalline limestone in Dorchester County, S.C. In the SRS region, Fallaw and Price (1992) have proposed the name Fourmile Formation for these sediments. At the type well, MWD-3A, in northwestern Barnwell County, S.C., the sediments are mostly orange, green, gray, yellow, and tan, moderately to well-sorted, fine- to coarse-grained quartz sand with green and gray clay beds a few feet thick present in the middle and at the top of the unit in places. It is difficult to distinguish the Congaree from the Fourmile in most places. In some areas the Congaree contains less glauconite at its base and an upper clay exists in the Fourmile. This is not always the case; therefore, the authors refer to these sediments as Congaree/Fourmile undifferentiated.

In updip regions of the study area, at sites C-3 and C-5, the Congaree/Fourmile Formation consists of gray or brown, slightly micaceous, poorly to moderately sorted, fine- to coarse-grained, smoky quartz sand and, occasionally, pebbly sand. Modal sand size is medium. Interstitial clay is low, generally less than 10 percent, and clay beds are rare. No calcareous sediments occur in the formation at updip sites (Table 4). Downdip, however, the unit grades into gray, brown, and green, glauconitic, calcareous sand, calcareous, micritic sand, sandy calcarenite, and calcarenite.

At site C-6, the formation is 134 ft thick and occurs between -47 and -181 ft msl (256 to 390 ft lsd). In the interval from -47 to -111 ft msl (upper half of the formation) the formation consists of glauconitic, calcareous sand. All of the 58 1-ft samples described from this interval are calcareous, with carbonate ranging from 15 to 85 percent and averaging 38 percent. Fossils include pelecypods, bryozoans, gastropods, sponge spicules, and ostracods. A glauconite-rich, calcareous sand bed near the base of this sequence (-97 and -107 ft msl) is expressed as an elevated radiation zone on the gamma-ray log (Plate 5). Glauconite in this zone ranges from 0.1 to 35 percent and averages 18 percent.

Below the calcareous sequence, from -124 to -181 ft msl (lower half of the formation), the unit consists of coarsening-upward, moderately to well-sorted, fine- to coarse-grained quartz sand and glauconitic sand; no carbonate occurs in this lower interval. Glauconite is again concentrated in a narrow zone, from -151 to -172 ft msl, where it ranges from 0 to 35 percent and averages 24 percent.

Downdip, at site C-10, the relative abundance of carbonate sediments increases and siliciclastic sediments decrease in the formation. Here, the upper three-fourths of the formation (-173 and -255 ft msl) consists of glauconitic calcarenite (carbonate > 75 percent) and glauconitic, sandy calcarenite (50 percent < carbonate < 75 percent). Carbonate occurs in all 76 samples analyzed, ranging from 3 to 90 percent and averaging 56 percent. Glauconite occurs throughout the interval, ranging from 2 to 60 percent and averaging 13 percent (Table 4); however, it is highly concentrated in two zones (-216 to -230 ft msl and -245 to -255 ft msl).

In the upper zone, glauconite ranges from 10 to 50 percent and averages 31 percent. In the lower zone, glauconite ranges from 5 to 60 percent and averages 23 percent.

Calcareous lithofacies in the upper three-fourths of the formation at site C-10 grade downward into siliciclastic facies near the base of the formation, similar to that observed at site C-6. In the interval between -256 and -272 ft msl (base of the formation), carbonate is absent and the zone consists of light-gray, moderately to poorly sorted, medium- to coarse-grained, quartz sand.

Lithofacies relationships between sites C-6 and C-10 (Fig. 11) suggest that the Congaree/Fourmile Formation was deposited as a long-term transgressive sequence during early Eocene to early middle Eocene time. Siliciclastic sediments in the lower part of the formation were deposited in a clastic shelf environment during low sea-level stands. Calcareous-sand deposits in the upper part of the formation were deposited in a mixed clastic/carbonate shelf environment during high sea-level stands. The source of carbonate sediments was the wave-eroded carbonate platform that was building south of the study area during early to middle Eocene time. Eroded carbonate sediments were subsequently reworked by wave action and deposited in a landward direction where they mixed with terrigenous sediments originating from coastal areas. As sea level rose, the platform migrated landward, increasing the amount of carbonate debris deposited on the clastic/carbonate shelf.

The lithologic break between the calcareous and siliciclastic sediments at site C-6 occurs about halfway through the formation and may represent the boundary contact between the Congaree and Fourmile Formations. At site C-10, however, this break is near the base of the sequence and, therefore, probably does not represent the contact. Lithofacies relationships between the two sites suggest that no break in deposition occurred through Congaree/Fourmile time, although it is generally believed that the Congaree unconformably overlies the Fourmile (Fallaw and others, 1989). Nystrom and others (1990) indicated that unless there is convincing evidence for strata equivalent to nannofossil zones NP10-11 (that is, the Fourmile Formation), the lower and upper early Eocene units of Fallaw (1990) (that is, the Congaree and Fourmile Formations) may constitute only one depositional sequence equivalent to the Congaree Formation.

The Congaree/Fourmile Formation appears to decrease in thickness in a downdip direction between sites C-6 and C-10 (Plate 8; Fig. 11). On the hand, the overlying Tinker/Santee Formation thickens rapidly between the two well sites. This suggests that marine scour of the Congaree/Fourmile may have occurred prior to deposition of the Tinker/Santee.

Geophysical response of the Congaree/Fourmile Formation is variable owing to lithologic changes that occur in the formation and to water chemistry changes that occur downdip. Resistivity of the formation generally decreases downdip due to an increase in water mineralization and an increase in clay content. At site C-5, for example, the resistivity of the formation ranges from about 200 to 300 ohm-m; at site C-6 from 100 to 150 ohm-m; and at site C-10 (downdip) from 40 to 80 ohm-m (measured by the 64-inch normal resistivity tool) (Plates 4, 5, and 7). Resistivity is subdued relative to Cretaceous sand beds, probably due to the finer-grained texture of Congaree/Fourmile sediments. Gamma radiation is generally very low, reflecting the relatively clean, clayfree nature of the sediments. In zones containing glauconite, however, gamma radiation increases. For example, the interval between -97 and -107 ft msl at site C-6 shows a sudden increase in gamma radiation. This zone contains as much as 35 percent glauconite. Glauconite contains potassium, a small percentage of which contains the gamma-emitting radioisotope K^{40} .

Four samples from the Congaree/Fourmile Formation were analyzed for clay and bulk mineralogy (Appendix 5). Illite is the dominant clay mineral, ranging from 33 to 61 percent and averaging 52 percent. Mixed-layer illite/smectite ranges from 15 to 32 percent and averages 25

Figure 11. Lithofacies relationships and hydrologic characteristics of units at sites C-6 and C-10.

percent. Of the four samples analyzed, two are from updip cores (one each from sites C-3 and C-5) and two from downdip cores (one each from sites C-6 and C-10). Updip samples contain a higher percentage of kaolinite, 41 percent at site C-3 and 31 percent at site C-5. Downdip samples contain only 4 and 9 percent kaolinite (C-6 and C-10, respectively). Downdip samples are dominated by illite and mixed-layer illite/smectite, which account for 92 and 91 percent of the clay suite at sites C-6 and C-10, respectively. These differences suggest that kaolinite, common in the updip Congaree Formation and equivalents (Huber Formation), was once illite and has been degraded to kaolinite by intense chemical weathering.

SUMMARY STATISTICS OF CLAY MINERALOGY IN THE CONGAREE/FOURMILE FORMATION										
	Illite (%)	Kaolinite (%)	Chlorite (%)	Illite/smectite (%)	Smectite (%)	Total clay (%)	Quartz (%)	Feldspar (%)	Calcite (%)	Total (%)
Mean	51.75	21.25	0.00	25.25	1.75	100.00	0.00	0.00	0.00	100.00
Median	56.50	20.00	0.00	27.00	1.50	100.00	0.00	0.00	0.00	100.00
Std. Dev.	12.84	17.63	0.00	7.93	2.06	0.00	0.00	0.00	0.00	0.00
Variance	164.92	310.92	0.00	62.92	4.25	0.00	0.00	0.00	0.00	0.00
Range	28.00	37.00	0.00	17.00	4.00	0.00	0.00	0.00	0.00	0.00
Minimum	33.00	4.00	0.00	15.00	0.00	100.00	0.00	0.00	0.00	100.00
Maximum	61.00	41.00	0.00	32.00	4.00	100.00	0.00	0.00	0.00	100.00
Sum	207.00	85.00	0.00	101.00	7.00	400.00	0.00	0.00	0.00	400.00
Count	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00

The Fourmile is early Eocene (Ypresian), assignable to zone NP-10 and perhaps NP-11 of Martini (1971) (Fallaw and Lawrence, 1992). The Congaree Formation is considered lower middle Eocene and includes nannoplankton zones NP12-14 of Martini (1971) (Fallaw and Lawrence, 1992). Laws (1990), however, has recovered calcareous nannofossil floras from the Congaree Formation which correlate to zones NP14-16. Nystrom and others (1990) indicated that the Congaree is correlative with the Tallahatta Formation in Georgia and includes nannoplankton zones NP12-14. They stated, however, that younger microfossil assemblages can be expected from the upper part of the formation.

Thirteen samples from the formation had age-diagnostic assemblages (Table 5). Zullo (1988), analyzing megafossils from the upper part of the formation at site C-6 (-52 to -80 ft msl), indicated a lower Claibornian (NP14-15) date and a marine environment. Laws (1988), analyzing nannofossils from the upper part of the section at site C-6 (-61.5 to -79.8 ft msl), also indicated a lower middle Eocene (NP14-15) age and a mid-inner shelf environment. Lucas-Clark (1993), analyzing pollen and dinoflagellates, indicated an early middle Eocene (NP14-15) to late middle Eocene (NP14-15 and NP-15) age for samples collected from the Congaree/Fourmile section at site C-10 in the interval from -199 to -240 ft msl. Edwards and Frederiksen (1993), analyzing dinocysts from samples collected between -204.1 and -252 ft msl at site C-10, indicated an early middle Eocene age (NP14-16). Waanders (1993) indicated a middle Eocene (Lutetian or Claibornian) date of a sample from site C-7 (-83.2 ft msl) and suggested a nearshore, open-marine environment for the Congaree/Fourmile Formation.

Warley Hill Formation - The term "Warley Hill Phase" was first used by Sloan in 1907. Cooke and MacNeil (1952) applied the name "Warley Hill Marl" to glauconitic beds occurring between the Congaree and McBean Formations. Pooser (1965) proposed that the name be changed to Warley Hill Formation because he concluded that the term "marl" was inappropriate to describe the overall lithology of the unit. He described the unit as "noncalcareous, glauconitic, quartzose sand which grades both seaward and upward into a

calcareous, glauconitic, quartzose sand, and finally into an arenaceous, glauconitic limestone prior to intertonguing with the essentially nonglauconitic Santee Limestone."

At site C-6, the Warley Hill Formation is 16 ft thick and occurs from -31 to -47 ft msl (240 to 256 ft lsd). Here, the formation consists of glauconitic, fossiliferous calcarenite or micrite. Carbonate occurs in all 16 samples analyzed, ranging from 35 to 97 percent and averaging 72 percent. It commonly occurs as very coarse-grained shell hash, ranging from 0 to 70 percent, or as carbonate mud, ranging from 15 to 95 percent. Glauconite ranges from 0 to 35 percent and averages 14 percent.

At site C-10, the Warley Hill Formation is 23 ft thick and occurs from -150 to -173 ft msl (440 to 463 ft lsd). Here, the unit consists mostly of lithified, glauconitic, shelly bimoldic limestone. Fossils include pelecypods, oysters, sponge spicules, and bryozoans. Carbonate occurs in all 21 samples analyzed, ranging from 15 to 85 percent and averaging 56 percent. Glauconite ranges from 3 to 20 percent and averages 7 percent. Large oysters occur in the sequence. Although the interval at site C-10 was sampled for fossils, no age-diagnostic assemblages were found.

The Warley Hill is correlative with nannoplankton zone NP-15 of Martini (1971) and corresponds to middle Eocene, early Lutetian, and middle Claibornian (Fallaw and Lawrence, 1992). Zullo (1988), analyzing megafossil assemblages, referred to the sequence at site C-6 as the "unnamed unit" and tentatively assigned it to lower Claibornian(?) and zone NP-15(?). He further indicated that the unit may correlate with *Cubitostrea lisbonensis* beds of the Santee Limestone and of the Lower Lisbon Formation in Alabama. Willoughby and Nystrom (1990) indicated that the mollusk *Cubitostrea lisbonensis* occurs in glauconitic strata below the Santee at Cave Hall in eastern Calhoun County. They suggested that the Warley Hill Formation, as described at its type section in eastern Calhoun County, where most of the formation is noncalcareous and nonfossiliferous, is an updip part of the depositional sequence in which *Cubitostrea lisbonensis* occurs. On the basis of these findings, the fossiliferous zone at sites C-6, C-7, and C-10 is included with the Warley Hill Formation. Green micrite, clayey, silty micrite, and micritic clay observed immediately above the fossiliferous interval, may also be correlative with the Warley Hill. Age dates, however, are ambiguous and the main author is including the micritic units with the overlying Blue Bluff Member of the Santee Limestone.

A single, sandy-calcarenite sample was analyzed for clay and bulk mineralogy (Appendix 5). Clay in the sample is 60 percent illite, 31 percent mixed-layer illite/smectite, and 9 percent quartz.

Tinker Formation and Santee Limestone - The term "Santee" was used in many variations by early investigators, but Cooke (1936) was the first to use the term Santee Limestone. He considered the name to be most appropriate because the formation's best and most fossiliferous exposures occur along or near the Santee River and in that area the formation is predominantly limestone. The formation consists of white, creamy yellow or light grayish-green fossiliferous, occasionally glauconitic, limestone. It contains numerous bryozoans, mollusks, and microfossils.

The Santee Limestone consists of three laterally gradational lithofacies: a clastic unit informally designated the Tims Branch Member, a carbonate mud and marl unit referred to as the Blue Bluff Member, and a shelly limestone unit referred the McBean Member. Fallaw and Price (1995) have proposed naming the clastic facies of the Santee Limestone (formerly the Tims Branch) the "Tinker" Formation. They suggest retaining the name "Blue Bluff" for the carbonate mud and marl member of the Santee. The term "McBean", however, has been applied to a variety of units including the overlying Dry Branch. The authors suggest discontinuing its usage in favor of Santee Limestone because Santee has priority.

Updip, at site C-5, the late middle Eocene section consists of the clastic Tinker Formation. Here, the formation is 35 ft thick and occurs in the interval from 100 to 65 ft msl (165 to 200 ft lsd). It consists of orange to brown and yellow to brown, slightly micaceous, poorly to moderately sorted, fine- to medium-grained quartz sand. Interstitial clay is very low, generally less than 5 percent. Muscovite is present in 22 of the 27 samples analyzed at site C-5, ranging from 0 to 4 percent and averaging 1 percent (Table 4). Carbonate, glauconite, sulfide, and lignite are absent in the interval at site C-5.

Downdip, at site C-6, the Santee consists of the Blue Bluff Member. Here, the formation is 60 ft thick and occurs from 29 to -31 ft msl (180 to 240 ft lsd). The unit consists of green, glauconitic, calcarenitic micrite or micrite (carbonate mud). Carbonate is present in each of the 48 samples analyzed, ranging from 25 to 99 percent and averaging 87 percent. Sand-size carbonate sediments (calcarenitic component) are present in the upper half of the formation, but are generally absent in the lower half, where carbonate mud dominates. In the upper half of the formation, from 29 to -5 ft msl, the formation consists of calcarenitic micrite with calcarenite ranging from 2 to 55 percent and averaging 31 percent of the carbonate fraction. Carbonate mud ranges from 45 to 98 percent and averages 68 percent of the carbonate fraction. In the lower half of the formation, calcarenite is virtually absent, averaging less than 1 percent. Here, carbonate mud is by far the dominant lithology, averaging about 95 percent of the carbonate fraction.

Farther downdip, at site C-10, the Santee is 119 ft thick and is present from -31 to -150 ft msl (321 to 440 ft lsd). Here, the unit consists of indurated, light- to medium-gray, shelly limestone and shelly, micritic limestone containing minor amounts (< 10 percent) of fine-grained quartz sand and terrigenous mud. Carbonate occurs in each of the 112 samples analyzed, ranging from 15 to 97 percent and averaging 84 percent (Table 4). Glauconite is also common, occurring in 110 to the 112 samples, ranging from 0 to 3 percent and averaging 2 percent. Grain size and carbonate content decrease in the lower part of the formation. The formation grades downward from a shelly limestone and shelly, micritic limestone to calcarenite (-111 to -127 ft msl), to micritic calcarenite (-127 to -136 ft msl), to silty micrite (-136 to -141 ft msl), and to micritic silt (-141 to -150 ft msl). The lowermost micritic silt contains from 15 to 30 percent carbonate, averaging 21 percent.

The lower half of the formation at site C-10 (-90 to -150 ft msl) is more clayey and less permeable and than the upper half (-31 to -90 ft msl). This is reflected on the gamma-ray log as a gradual increase in radiation, and on electric logs as a gradual decrease in resistance and resistivity (Plate 7). Pelecypods, bryozoans, and oysters are common in the upper part of the section but decrease downsection. On the other hand, forams are rare in the upper half but increase in the lower half of the formation.

Calcareous lithofacies relationships between sites C-6 and C-10 (Fig. 11) indicate a second, long-term transgressive sequence in the Eocene epoch, this occurring during Santee time (late middle Eocene). As sea level rose, platform carbonates migrated landward, eventually reaching site C-10 during a high sea-level stand. This resulted in deposition of shallow-shelf shoal deposits of the Santee Limestone in the upper part of the formation. The lower part of the unit observed at site C-10 (-136 to -150 ft msl, silty micrite and micritic silt) is the downdip equivalent of Blue Bluff lithologies that occurs throughout the Santee section at updip sites C-6 and C-7. These sediments were overridden by the transgressing carbonate platform at site C-10. Limestone, however, did not reach sites C-6 or C-7, resulting in the continued deposition of fine-grained carbonate sediments at these sites (micrites and marls of the Blue Bluff Member). Lithologies at the base of the Santee section at C-10 and in the lower half of the section at site C-6 (carbonate mud) represent deep-water shelf or restricted marine (lagoonal?) environments that occurred between the encroaching platform and the clastic coastline (that is, the Tinker Formation at updip site C-5). An increase in the percentage of

calcarenites in the upper half of the section at site C-6 further suggests that the carbonate source was migrating landward resulting in the deposition of the coarse-grained carbonate sediments (calcarenites) during the latter half of the depositional sequence. Additionally, a decrease in forams and an increase in bryozoans and oysters in the upper half of the section at site C-10 also suggest a migrating, shallowing-upward carbonate depositional sequence.

Four samples from the Santee Limestone and age-equivalents were analyzed for clay and bulk mineralogy with x-ray diffraction (Appendix 5). Each sample has a very similar clay suite. Illite is the dominant clay mineral, ranging from 58 to 69 percent and averaging 65 percent. Mixed-layer illite/smectite ranges from 25 to 27 percent and averages 26 percent; kaolinite ranges from 2 to 13 percent and averages 7 percent; and smectite ranges from 0 to 4 percent and averages 2 percent.

SUMMARY STATISTICS OF CLAY MINERALOGY IN THE SANTEE LIMESTONE										
	Illite (%)	Kaolinite (%)	Chlorite (%)	Illite/smectite (%)	Smectite (%)	Total clay (%)	Quartz (%)	Feldspar (%)	Calcite (%)	Total (%)
Mean	65.00	7.25	0.25	25.50	2.00	100.00	0.00	0.00	0.00	100.00
Median	66.50	7.00	0.00	25.00	2.00	100.00	0.00	0.00	0.00	100.00
Std. Dev.	4.83	4.57	0.50	1.00	1.83	0.00	0.00	0.00	0.00	0.00
Variance	23.33	20.92	0.25	1.00	3.33	0.00	0.00	0.00	0.00	0.00
Range	11.00	11.00	1.00	2.00	4.00	0.00	0.00	0.00	0.00	0.00
Minimum	58.00	2.00	0.00	25.00	0.00	100.00	0.00	0.00	0.00	100.00
Maximum	69.00	13.00	1.00	27.00	4.00	100.00	0.00	0.00	0.00	100.00
Sum	260.00	29.00	1.00	102.00	8.00	400.00	0.00	0.00	0.00	400.00
Count	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00

A late middle Eocene age is indicated for the Santee Limestone (Fallaw and Lawrence, 1992). Calcareous nannoplankton floras that correlate with nannoplankton zones NP15-17 have been recovered from the McBean and Blue Bluff Members (Laws, 1990). Age-diagnostic fossil assemblages are abundant in the calcareous section of the Santee Limestone, especially in the Blue Bluff section (Laws, 1990).

Fallaw (1988), analyzing foraminiferal faunas, determined a middle Eocene age for four samples between -53 and -152 ft msl at site C-10 (Table 5). Each of the samples contained *Cibicides westi*, an index to the middle Eocene in the area. Laws (1989), analyzing nannoplankton floras, indicated an upper middle Eocene age (NP16-17) for four samples recovered from -44 to -148 ft msl at site C-10. Fossils included *Dictyococcites bisectus*, *Reticulofenestra umbilica*, and *Reticulofenestra reticulata*, all diagnostic of the McBean Member (Laws, 1990). Edwards and Frederiksen (1993), analyzing dinocysts from site C-10, indicated a latest middle Eocene date (NP-17) for a sample near the top of the Santee (-38 ft msl), and a late middle Eocene date (NP16-17) for a sample near the base of the Santee (-144 ft msl). Laws (1988), analyzing nannoplankton, indicated an upper middle Eocene (NP-16) age for samples from 21 to -30 ft msl at site C-6. For a complete listing of dates from the sequence, the reader is referred to Table 5.

Clinchfield Formation - At its type locality in central Georgia, the Clinchfield consists mostly of quartz sand and clay, calcareous in places, and carbonate sediments (Pickering, 1970). Generally, the unit consists of medium-grained, well-sorted, poorly consolidated, massively bedded quartz sand; however, variations of this lithology occur and are considered as separate members (Huddlestun and Hetrick, 1979).

At site C-6, in the interval from 55 to 29 ft msl (154 to 180 ft lsd), an orange to yellow, sandy, glauconitic, fossiliferous limestone occurs that is interpreted as the Utley Limestone Member of the Clinchfield Formation. Ages, however, are equivocal. The Clinchfield is early upper Eocene (Jacksonian) corresponding to zone NP-17. Past age-determinations, however, may not be reliable and the unit may represent uppermost Claibornian (Fallaw and Lawrence, 1992). Zullo (1988), analyzing megafossil assemblages in the interval from 54.5 to 30.7 ft msl, indicated an upper Eocene (Jacksonian, NP17-21) age for the samples (Table 5). The lowermost sample collected at 30.7 ft msl contained the oyster *Crassostrea gigantissima*, which is prominent at the type-locality of the Griffins Landing Member in the overlying Dry Branch Formation. This species, however, can be used for stratigraphic correlation only on either extremely broad or very local scales (Huddlestun and Hetrick, 1986):

Nannofossil assemblages were analyzed by Laws (1988) from three samples in the interval from 52.2 to 30.2 ft msl at site C-6 (Table 5). Assemblages were interpreted as upper middle to upper Eocene (NP-16 and NP16-20), suggestive of a Santee age for the sediments. The unit, therefore, may represent the leading edge of the Santee Limestone in the study area. Lithologically, however, the unit differs from Santee sediments observed at site C-10, being less indurated and containing more glauconite and clastic sediments.

The Utley Limestone Member downcuts into the underlying Blue Bluff lithology at site C-6, consistent with the view that the Clinchfield was deposited in paleotopographic lows (Fallaw and Lawrence, 1992). A similar limestone is found overlying Blue Bluff sediments at site C-7 and is also interpreted as being correlative with the Utley Limestone Member. No age-diagnostic fossil assemblages, however, have been obtained from site C-7 in this interval.

No samples from the Clinchfield were analyzed for clay mineralogy. A high-resistivity zone marks the boundaries of the unit at site C-6 (Plate 5). A similar resistivity zone is noted on logs from a well in Barnwell (BRN-368) about five miles north of site C-6 (Plate 8). The unit is extended into Barnwell based on the geophysical interpretation.

Dry Branch Formation - The Dry Branch Formation includes three distinct lithofacies members: the Twiggs Clay, Irwinton Sand, and the Griffins Landing. The type locality for the Twiggs Clay is in central Georgia (Shearer, 1917) and the unit is dominant west of the Ocmulgee River. The Irwinton Sand is dominant from the Ocmulgee River eastward and the type locality is in central Georgia (LaMoreaux, 1946a and b). The type locality for the Griffins Landing is across the Savannah River from SRS (Huddlestun and Hetrick, 1986). The Dry Branch Formation has been correlated in outcrop from its type locality in central Georgia (Huddlestun and Hetrick, 1986) to the Savannah River Site.

At the C-well sites, the Dry Branch Formation includes the Griffins Landing Member, which consists of calcareous sand, clay, and carbonate sediments, and the Irwinton Sand Member, which consists of poorly- to well-sorted sand with interbedded tan and gray clay near the base (Twiggs? lithology). Huddlestun and Hetrick (1986, in Fallaw and Lawrence, 1992) note that "...the Twiggs lithofacies represents a transgressive, offshore deposit; the Griffins Landing lithofacies appears to represent a maximum transgression; and the Irwinton, being nonfossiliferous, is regressive over the Griffins Landing...and represents the most restricted marginal marine environment in the Dry Branch Formation...".

The Dry Branch is 28 ft thick at site C-3, where the top of the formation is eroded, and 162 ft at site C-10. With the exception of site C-10, the Dry Branch consists of yellow or tan, moderately sorted, fine- to medium- and occasionally coarse-grained, nearly pure quartz sand with only minor amounts of interstitial clay and clay laminae (Irwinton Sand Member). Of the 212, 1-ft core samples described at sites C-2, C-3, C-5, and C-6, no carbonate, glauconite, or

iron sulfide were noted in the formation. Muscovite, common in other formations, occurs in only 28 of the 212 core samples, usually in trace amounts (0.1 percent).

At downdip site C-10, the Dry Branch Formation consists of a lower calcareous (Griffins Landing Member?) and an upper clastic sequence (Twiggs? lithology). The calcareous sequence from 79 to -31 ft msl consists of medium-tan, moderately sorted, fine-grained, calcareous sand and infrequently, micritic, calcareous sand. Carbonate averages 46 percent and clastics 54 percent in this interval. The calcareous section grades upwards (113 to 79 ft msl) into a lithified, whitish-tan, sandy, shelly limestone (Ocala equivalent?) with solution-enlarged porosity. (During drilling of site C-10, mud circulation was repeatedly lost in this interval.) Percent carbonate is much higher than it is in the underlying calcareous sand, averaging 76 percent. Fossils in the limestone include brachiopods, bryozoans, and pelecypods. Overlying the limestone, in the interval from 131 to 113 ft msl, is tan to orange, poorly to moderately sorted, fine- to coarse-grained, clayey, quartz sand capped by a mottled tan and greenish-gray, interlaminated silt and clay sequence (131 to 121 ft msl), suggestive of the Twiggs lithology.

The lower calcareous sand sequence at site C-10 is well-dated (Table 5). Laws (1989), analyzing nannoplankton assemblages from five samples in the interval from 34 to -2 ft msl, indicated an upper Eocene age (NP19-20). *Isthmolithus recurvus*, a key diagnostic fossil for the Dry Branch (Laws, 1990), was identified in two of the five samples. Fallaw (1988), analyzing foraminifera assemblages from seven samples in the interval from 73 to 28 ft msl, indicated a late Eocene age. *Nonion rollshouseni*, a late Eocene marker, was identified in each sample. Lucas-Clark (1993 and 1989a), analyzing pollen and dinoflagellates, indicated an Eocene to lower upper Eocene age for four samples in the interval from -21 to -30 ft msl.

Ocala-equivalent limestone that caps the carbonate sequence was sampled for fossils but no diagnostic assemblages were recovered from the interval. The overlying clay (Twiggs? lithology) was barren, as were samples analyzed for fossils in the clastic section of the Dry Branch.

Calcareous sediments do not occur in the formation at site C-6. Here, the Dry Branch consists of a thick (130 ft) quartz sand sequence that is texturally similar to the thick (110 ft) calcareous sand sequence at site C-10; both are homogenous, moderately sorted, fine- to medium-grained sequences. No fossils were collected at site C-6; however, on the basis of their stratigraphic positions and on their textural likeness, it is believed that these two units are age-equivalents and that the calcareous sand sequence at site C-10 is a downdip, lateral-facies equivalent of the updip, quartz sand sequence at site C-6. Lateral and vertical facies relationships observed at and between the two sites (Fig. 11) strongly suggest a third major Eocene transgressive sequence, this occurring during upper Eocene time (Jacksonian). The sand sequence at site C-6 was deposited in a clastic shelf environment and the age-equivalent, calcareous sand sequence at site C-10 was deposited in a mixed clastic/carbonate shelf environment closer to the offshore carbonate source. Calcareous sand at C-10 grades upward into sandy limestone (Ocala equivalent?) that caps the carbonate section and that represents the maximum transgressive lithology during the landward advancement of the carbonate platform that was developing south of the study area during Jacksonian time. The depositional scenario is similar to that observed in the upper middle Eocene interval (Santee time).

Seven samples from the Dry Branch Formation were analyzed for clay and bulk mineralogy with x-ray diffraction techniques (Appendix 5). Kaolinite is slightly more abundant than illite, averaging about 39 percent, as compared to illite, which averages 36 percent. Kaolinite increases updip (Irwinton Sand Member) at sites C-3, C-5, and C-6. Here, it ranges from 12 to 84 percent and averages 49 percent. One sample was obtained from the Twiggs

lithology at site C-10 (122 ft msl). This sample consists of 60 percent kaolinite, 21 percent mixed-layer illite/smectite, and 19 percent illite. Two samples from the basal part of the calcareous Griffins Landing Member at site C-10 (micritic clay sample at -3 ft msl and calcareous sand sample at -23 ft msl) are dominated by illite, which averages 62 percent.

SUMMARY STATISTICS OF CLAY MINERALOGY IN THE DRY BRANCH FORMATION										
	Illite (%)	Kaolinite (%)	Chlorite (%)	Illite/smectite (%)	Smectite (%)	Total clay (%)	Quartz (%)	Feldspar (%)	Calcite (%)	Total (%)
Mean	36.43	38.71	0.00	23.57	0.71	99.43	0.57	0.00	0.00	100.00
Median	33.00	38.00	0.00	27.00	0.00	100.00	0.00	0.00	0.00	100.00
Std. Dev.	21.84	30.27	0.00	10.18	1.25	0.98	0.98	0.00	0.00	0.00
Variance	476.95	916.24	0.00	103.62	1.57	0.95	0.95	0.00	0.00	0.00
Range	56.00	76.00	0.00	30.00	3.00	2.00	2.00	0.00	0.00	0.00
Minimum	8.00	8.00	0.00	6.00	0.00	98.00	0.00	0.00	0.00	100.00
Maximum	64.00	84.00	0.00	36.00	3.00	100.00	2.00	0.00	0.00	100.00
Sum	255.00	271.00	0.00	165.00	5.00	696.00	4.00	0.00	0.00	700.00
Count	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00

Tobacco Road Formation - The Tobacco Road Formation consists of moderately to poorly sorted, red, brown, tan, purple, and orange, silty, clayey quartz sand and quartz sand (Fallaw and Price, 1992). The unit has been traced in outcrop from its type locality in Richmond County, Ga. to SRS (Huddleston and Hetrick, 1978 and 1986; Nystrom and Willoughby, 1982). In general, sand of the Tobacco Road is muddier, more micaceous, and more highly colored than that in the Dry Branch. A quartz pebble zone typically marks the base of the formation in many areas.

At the C-well sites, the Tobacco Road Formation consists of mottled, off-white to pink or purple to red, micaceous, very poorly sorted, fine- to very coarse-grained, clayey sand and pebbly, clayey sand. Pebbles commonly occur at the base of the formation, such as at sites C-5 and C-7. The basal pebble zone is marked on geophysical logs by an increase in radiation on the gamma-ray log, which probably is due to an increase in potassium feldspar that is often associated with gravelly sediments. The formation ranges in thickness from 24 ft at site C-6, where the upper part of the formation is eroded, to 135 ft at site C-10. Very little core was recovered from the interval at site C-6 and the pick is based strictly on the gamma-ray response, which shows a marked increase in radiation similar to that observed in the basal pebble zone at updip site C-5.

Muscovite is more common in the Tobacco Road than in the Dry Branch in the study area (Table 4). At site C-5, muscovite occurs in 42 of the 60 samples analyzed, ranging from 0.1 to 20 percent and averaging 4 percent. At downdip site C-10, muscovite occurs in 101 of the 117 samples analyzed, ranging from 0.1 to 10 percent and averaging 2 percent. No carbonate, lignite, sulfide, or glauconite are present in the formation.

Clay content is significantly higher in the Tobacco Road Formation than in the underlying Irwinton Sand Member of the Dry Branch Formation. In the Tobacco Road, clay ranges from 10 to 45 percent at site C-5 and averages 25 percent. At site C-7, clay ranges from 12 to 65 percent and averages 31 percent. In the Irwinton Sand Member of the Dry Branch Formation, clay ranges from 1 to 75 percent and averages 11 percent at site C-5, and from 1 to 90 percent, averaging 13 percent at site C-7.

Seven samples from the Tobacco Road Formation were analyzed for clay and bulk mineralogy with x-ray diffraction techniques (Appendix 5). Kaolinite is clearly the dominant clay

mineral, ranging from 41 to 100 percent and averaging 81 percent. Quartz was noted in one sample (28 percent).

SUMMARY STATISTICS OF CLAY MINERALOGY IN THE TOBACCO ROAD FORMATION										
	Illite (%)	Kaolinite (%)	Chlorite (%)	Illite/smectite (%)	Smectite (%)	Total clay (%)	Quartz (%)	Feldspar (%)	Calcite (%)	Total (%)
Mean	10.71	80.57	0.00	4.57	0.14	96.00	4.00	0.00	0.00	100.00
Median	11.00	89.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00	100.00
Std. Dev.	10.67	23.96	0.00	10.06	0.38	10.58	10.58	0.00	0.00	0.00
Variance	113.90	573.95	0.00	101.29	0.14	112.00	112.00	0.00	0.00	0.00
Range	31.00	59.00	0.00	27.00	1.00	28.00	28.00	0.00	0.00	0.00
Minimum	0.00	41.00	0.00	0.00	0.00	72.00	0.00	0.00	0.00	100.00
Maximum	31.00	100.00	0.00	27.00	1.00	100.00	28.00	0.00	0.00	100.00
Sum	75.00	564.00	0.00	32.00	1.00	672.00	28.00	0.00	0.00	700.00
Count	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00

The Tobacco Road Formation is considered upper Eocene (Jacksonian) (Fallaw and Lawrence, 1992). Samples analyzed for fossil assemblages were barren, with one exception. Waanders (1988), analyzing spores and pollen, indicated an "Oligocene or younger" date for a sample from site C-7 (Table 5). Lithologically, this sample is similar to the Tobacco Road, consisting of pink, poorly sorted, very fine- to coarse-grained, clayey sand. Waanders also indicated a nonmarine, fluvial environment based on fossil assemblages identified in the sample. This is in contrast to convincing evidence (for example, oysters) that the Tobacco Road is marginal marine (Huddleston and Hetrick, 1986). Analysis of this single sample suggests either 1) that the sample has been contaminated or misinterpreted, 2) that the upper part of the Tobacco Road Formation is Oligocene, or 3) that the formation is not Tobacco Road but is, instead, Upland unit (the Upland unit is considered nonmarine and fluvial) or an unnamed unit. On the basis of the lithology of the sample and on the consistency of this same lithology throughout the interval at C-7, it is believed that the sample is Tobacco Road and that either the sample has been contaminated or misinterpreted, or that the upper part of the Tobacco Road Formation is Oligocene in age.

Upland unit - This is an informal name applied to sediments that occur at high altitudes in many places throughout the southwestern South Carolina Coastal Plain (Nystrom and Willoughby, 1982; Nystrom and others, 1986; Logan and Euler, 1989). Kite (1984) described the unit as "very coarse, commonly pebbly sand, poorly sorted with abundant clay, mostly interstitial clay, and tiny white flakes or sand-sized grains which give the unit a distinctive speckled appearance". The unit is an extension of the Altamaha Formation of Georgia (Nystrom and Willoughby, 1992). The type locality for the Altamaha is in southeastern Georgia (Dall and Harris, 1892; Huddleston, 1988).

At site C-2, a distinctive coarse-grained unit exists which is interpreted as Upland unit. The unit is 23 ft thick and occurs from 419 to 396(?) ft msl. It consists of brown to red, poorly sorted, pebbly sand and clayey sand. Land surface at site C-2 is littered with small to large pebbles, characteristic of the unit. Core recovery was poor in the upper 33 ft at site C-2 and, therefore, the lower boundary of the unit may not be accurate.

At site C-10 (downdip), the Upland unit is 24 ft thick and occurs from 290 to 266(?) ft msl. It consists of orange to tan, poorly sorted, clayey sand and pebbly clayey sand. Medium to large pebbles are noted. Below this lithology is mottled, purple and gray, poorly sorted, clayey sand of the Tobacco Road Formation. The boundary between the two units, however, is

problematic because the upper part of the Tobacco Road Formation is texturally similar to the Upland unit. No age dates have been determined from the Upland unit at C-well sites.

One sample from the unit was analyzed for clay and bulk mineralogy using x-ray diffraction techniques (Appendix 5). The clay fraction in the sample consists of 60 percent kaolinite, 7 percent illite, and 3 percent mixed illite/smectite. Thirty percent quartz is also noted.

AQUIFER CLASSIFICATION

Explanation of system

Aquifer nomenclature used in this report and the classification of hydrologic units as systems, units, and zones is adopted from Aadland and others (in press) and adheres to guidelines established by the United States Geological Survey (Laney and Davidson, 1986) and the South Carolina Hydrostratigraphic Subcommittee (Burt, 1987a and b). Aquifers and confining units are defined on the basis of relative differences in hydraulic properties (hydraulic conductivity, porosity, and leakance) of the sediments and rocks that constitute the sedimentary section; mapped on the basis of lithologies that define the hydrologic units at type-well locations; classified on the basis of the lateral and vertical hydraulic continuity and the hydraulic characteristics of the hydrologic units; and named on the basis of physiographic and geographic features located near the type well or well cluster.

Hydrostratigraphic Nomenclature

Proposed South Carolina Hydrostratigraphic Units (after Laney and Davidson, 1986)

<u>Level</u>	
1	Hydrogeologic province
2	Aquifer system/ Confining system
3	Aquifer unit/ Confining unit
4	Aquifer zone/ Confining zone (informal)

Hydrogeologic provinces (Level 1) are major regional rock and/or sediment packages that have fundamental hydrologic characteristics and flow systems significantly different from adjacent rocks. For example, ground water in the Southeastern Coastal Plain hydrogeologic province flows mainly through intergranular, primary porosity of the unconsolidated sediments that compose the province, producing regional ground-water flow patterns through the interconnected pore systems of Coastal Plain sediments. On the other hand, ground water in the Piedmont hydrogeologic province flows mainly through secondary, fracture porosity that is much lower and more discontinuous than that found in Coastal Plain sediments, thus producing only localized flow patterns through the disconnected pore systems of the Piedmont rocks.

Aquifer systems (Level 2) consist of one or more aquifers that function regionally as a single hydrologic system that is hydraulically isolated from adjacent systems. Confining systems consist of one or more confining units that regionally isolate adjacent aquifer systems by effectively impeding vertical ground water flow. System boundaries are delineated where thick, regionally extensive confining beds systematically separate and hydraulically isolate adjacent aquifers. Aquifer systems coalesce updip where confining beds thin and/or become discontinuous, leakance coefficients increase, head differences across confining beds are minimal, and ground-water flow patterns converge.

The building blocks of the classification scheme are aquifer and confining units (Level 3). As defined by the South Carolina Hydrostratigraphic Subcommittee (Burt, 1987a), an aquifer is a mappable ($> 400 \text{ mi}^2$) body of rock or sediments that is sufficiently permeable to conduct ground water in significant quantities to wells and springs (Bates and Jackson, 1980). A confining unit, on the other hand, is a mappable ($> 400 \text{ mi}^2$) body of rock or sediments of significantly lower hydraulic conductivity that impedes vertical ground water flow into or out of an aquifer (Lohman and others, 1972).

Aquifer and confining zones (Level 4) are locally ($< 400 \text{ mi}^2$) defined where hydraulic characteristics of an aquifer or confining unit differ significantly from the rest of the unit and are important enough at site-specific studies to warrant classification. For example, a part of an aquifer that is significantly more permeable than the rest of the aquifer can be locally mapped as a "high-permeability" zone. A sand lens in a confining unit can be locally mapped as a "high-leakance" zone if deemed useful for site-specific studies.

The hydrostratigraphic classification scheme implemented by Aadland and others (in press) for west-central South Carolina accounts for and accommodates the updip thinning of the sedimentary wedge and the lateral variation in lithofacies observed in the study area. In addition, the hierarchical ranking of the hydrologic units into provinces, systems, units, and zones makes the classification flexible enough to be useful and applicable to the full range of hydrogeologic settings and scales. It can be made as detailed as the complexity of the local hydrologic regime demands, resulting in a unified and consistent hydrostratigraphic classification amenable to future hydrogeological studies and reports.

HYDROGEOLOGIC SETTING

Sediments of the Southeastern Coastal Plain hydrogeologic province were deposited during the past 90 m.y. (million years) in fluvial, deltaic, littoral, and offshore depositional systems, resulting in a sedimentary sequence composed of a wide-ranging continuum of grain sizes, lithologies, and interfingering lithofacies that have different capabilities for transmitting ground water. In general, coarse-grained, high-permeability sediments were deposited in fluvial, littoral, and deltaic environments; fine-grained, low-permeability sediments were deposited in marshes, lagoons, interdistributary bays, and offshore environments. Post-depositional processes, such as compaction, clay authigenesis, cementation, and dissolution, were important secondary factors affecting the hydraulic characteristics of the sediments. For example, the highly permeable offshore carbonate platforms owe much of their porosity to calcite dissolution. On the other hand, the low permeability of the Cape Fear Formation is mostly the result of clay authigenesis, cristobalite cementation, and compaction. Extensive bioturbation, occurring penecontemporaneously, may have also effectively reduced porosity and permeability in the Cape Fear by mixing and redistributing mud- and sand-sized particles throughout the formation (Simones, 1992b).

Hydraulic conductivity (K) is a measure of the ability of sediments to transmit water. In the study area, clay and marl are the least permeable lithologies, having hydraulic conductivities ranging from 10^{-5} to 10^{-3} ft/d; clayey sand is slightly more permeable with hydraulic conductivities ranging from 1 to 10^{-3} ft/d; and sand, limestone, and gravel are the most permeable with hydraulic conductivities ranging from 1 to 3×10^2 ft/d. The full range of hydraulic conductivity in sediments of the Coastal Plain encompasses nearly eight (10^8) orders of magnitude.

The thickness and lateral continuity of sediment types determine the geographic and vertical extents of the hydrologic units and the ability of these units to transmit or impede ground water movement. In the study area, aquifers range in thickness from 10 to 400 ft; confining units range from 5 to 250 ft. Transmissivity (T), a measure of the ability of an aquifer to transmit water, is the product of aquifer thickness (b) and hydraulic conductivity. Transmissivity ranges from 500 to 50,000 ft²/d across the study area. Leakance, a measure a confining unit's ability to impede the vertical movement of water, is the quotient of vertical hydraulic conductivity and thickness of the confining unit. Leakance ranges from 10^{-6} to 10^{-3} ft/d/ft across the study area.

Detailed subsurface mapping of hydrologic units in west-central South Carolina (Aadland and others, in press) has demonstrated that chronostratigraphic and lithostratigraphic boundaries do not conform to hydrostratigraphic boundaries. In some cases, a single lithostratigraphic unit consists of parts of two or more hydrostratigraphic units; in other cases, a single hydrostratigraphic unit consists of parts of two or more lithostratigraphic units. The Black Creek Formation, for example, includes parts of three different hydrologic units (Fig. 12). Silty clay and clay beds of the middle one-third of the formation form the McQueen Branch confining unit. The upper third of the formation and part of the overlying Steel Creek Formation compose the Crouch Branch aquifer. The lower third of the Black Creek Formation, the entire Middendorf Formation and, locally, the upper part of the Cape Fear Formation, compose the McQueen Branch aquifer. Similar boundary inconsistencies occur between hydrologic and geologic units throughout the Tertiary section (Fig. 12). Because hydrostratigraphic units are not coincidental with stratigraphic units, they should be named independently of each other (Laney and Davidson, 1986).

Aquifers and confining units delineated and described for this report were defined at a type-well location (Aadland and others, in press) where the hydrogeologic characteristics typical of the unit were measured, and they were named for geographic features near the type wells. In ascending order, aquifer systems in the study area include the Midville, Dublin, and Floridan (Fig. 13). In ascending order, confining systems are the Appleton, Allendale, and Meyers Branch. Where confining beds of the Allendale confining system thin, and leakance coefficients increase, the confining system no longer regionally separates the Dublin and Midville aquifer systems and the Dublin-Midville aquifer system is defined (Figs. 13 and 14). Likewise, where the Meyers Branch confining system thins, the overlying Floridan aquifer system and underlying Dublin aquifer system coalesce and the Floridan-Dublin aquifer system is defined. In regions where confining beds in the Allendale and Meyers Branch confining systems thin and where corresponding leakance values increase, the entire sedimentary section from the top of the basal Appleton confining system to the water table is hydraulically connected and the Floridan-Midville aquifer system is defined. The approximate updip limit of each confining system is shown on Figure 14.

As defined, aquifer and confining systems can consist of one or more aquifer and/or confining unit. In the study area, which is located at the updip edge of the Southeastern Coastal Plain hydrogeologic province, the Midville and Dublin aquifer systems consist, each, of a single aquifer, the McQueen Branch and Crouch Branch, respectively (Fig. 13). The Floridan aquifer system, on the other hand, consists of two aquifers, the Gordon and the Upper Three Runs, separated by the Gordori confining unit. The Gordon and Upper Three Runs coalesce into a single aquifer, the Steed Pond, northward across the study area.

The Allendale and Meyers Branch confining systems consist, each, of a single confining unit in the study area, the McQueen Branch and Crouch Branch, respectively (Fig. 13). The basal Appleton confining system is thought to consist of a single confining unit in the study area but has not been formally designated owing to sparse data. A dip-oriented hydrostratigraphic section (Plate 9; Table 6), incorporating the same wells used to construct the lithostratigraphic section, illustrates the nomenclature and the limits of the hydrologic units immediately east of SRS.

Aquifer Systems

Floridan - Carbonate rocks of the Floridan aquifer system are used extensively in the southeastern part of the Coastal Plain as an aquifer. In the study area, the updip clastic-facies equivalents of the carbonate rocks (Barnwell and Orangeburg Groups) are hydraulically connected with them and are part of a single regional flow system. For example, at the southern fringe of the study area, immediately south of site C-10, clastic sediments interfinger with calcareous sediments, grading downdip into limestone that forms the prolific aquifers of the Floridan aquifer system near the coast. This lithologic transition between clastic and calcareous sediments of the system does not represent a hydrologic boundary because the two lithofacies are in direct hydrologic communication. Thus, the clastic and carbonate sequences of the Floridan aquifer system are treated as a single hydrologic unit because there are no regionally significant water-level differences between them and there is little evidence of an intervening confining unit (Aucott and Speiran, 1985b).

Predominately clastic sediments of the Floridan aquifer system, also referred to as the Tertiary sand aquifer (Aucott and Speiran, 1985a), overlie the Meyers Branch confining system throughout the lower two-thirds of the study area and include all Tertiary sediments from the water table to the confining beds in the Paleocene Black Mingo Group (Figs. 10 and 13). Towards the northern part of SRS, the Meyers Branch confining system thins, becomes

Figure 13. Hydrostratigraphic nomenclature for west-central South Carolina (modified from Aadland and others, in press).

Figure 14. Updip limits of confining systems (after Aadland and others, 1995).

Table 6. Hydrostratigraphic boundaries and unit thicknesses at the cluster sites

Well	Ground altitude	Hydrologic system	Top depth	Base depth	Top altitude	Unit thickness	Clay thickness	Confining carbonate thickness	Transmissive carbonate thickness	Number of carbonate beds >5'	Number of sand beds >5'	Total sand thickness	Total % sand	Total transmissive thickness	Total % trans.
Steed Pond aquifer															
BRN-78	340(T)		Undelin.	Undelin.	--	--	--	--	--	--	--	--	--	--	--
BRN-386	181(T)		Undelin.	Undelin.	--	--	--	--	--	--	--	--	--	--	--
C-1	235(T)	F	WT	103	235	103	8	0	0	0	2	95	92%	95	92%
C-2*	418.8	F	Undelin.	Undelin.	--	--	--	--	--	--	--	--	--	--	--
C-3	295.2	F-M	42.5	90	253	48	8	0	0	0	2	40	83%	40	83%
C-5	265.6		Undelin.	Undelin.	--	--	--	--	--	--	--	--	--	--	--
C-6	208.7		Undelin.	Undelin.	--	--	--	--	--	--	--	--	--	--	--
C-7	252(T)		Undelin.	Undelin.	--	--	--	--	--	--	--	--	--	--	--
C-10	289.6		Undelin.	Undelin.	--	--	--	--	--	--	--	--	--	--	--
Upper Three Runs aquifer															
BRN-78	340(T)	F-M	WT	142	340	142	--	--	--	--	--	--	--	--	--
BRN-386	181(T)	F	WT	119	181	119	--	--	--	--	--	--	--	--	--
C-1	235(T)		Undelin.	Undelin.	--	--	--	--	--	--	--	--	--	--	--
C-2	418.8		Undelin.	Undelin.	--	--	--	--	--	--	--	--	--	--	--
C-3	295.2		Undelin.	Undelin.	--	--	--	--	--	--	--	--	--	--	--
C-5	265.6	F-D	17.8	162	248	144	0	0	0	0	1	144	100%	144	100%
C-6	208.7	F	28.3	173	180	145	0	0	0	0	1	145	100%	145	100%
C-7	252(T)	F	WT	227	252	227	16	4	21	1	3	186	82%	207	91%
C-10	289.6	F	WT	380	290	380	23	0	78	2	6	279	73%	357	94%
Gordon aquifer															
BRN-78	340(T)	F-M	180	306	160	126	7	0	0	0	2	119	94%	119	94%
BRN-386	181(T)	F	160	262	21	102	7	0	0	0	3	95	93%	95	93%
C-1	235(T)		Undelin.	Undelin.	--	--	--	--	--	--	--	--	--	--	--
C-2	418.8		Undelin.	Undelin.	--	--	--	--	--	--	--	--	--	--	--
C-3	295.2		Undelin.	Undelin.	--	--	--	--	--	--	--	--	--	--	--
C-5	265.6	F-D	172	280	94	108	3	0	0	0	2	105	97%	105	97%
C-6	208.7	F	241	426	-32	185	0	0	0	0	1	185	100%	185	100%
C-7	252(T)	F	313	407	-61	94	0	0	12	1	1	82	87%	94	100%
C-10	289.6	F	445	600	-155	155	6	0	75	2	3	74	48%	149	96%

* Water table below the projected base of the Steed Pond aquifer.

All depths and altitudes are in feet. Values in italic are estimated. Undelin., hydrostratigraphic unit not delineated at this well. WT, water table. F, Floridan aquifer system. F-D, Floridan-Dublin aquifer system. F-M, Floridan-Midville aquifer system. T, measured from a topographic map.

Table 6. Continued

Well	Ground altitude	Hydrologic system	Top depth	Base depth	Top altitude	Unit thickness	Clay thickness	Confining carbonate thickness	Transmissive carbonate thickness	Number of carbonate beds >5'	Number of sand beds >5'	Total sand thickness	Total % sand	Total transmissive thickness	Total % trans.
Crouch Branch aquifer															
BRN-78	340(T)	F-M	318	576	22	258	52	0	0	0	4	206	80%	206	80%
BRN-386	181(T)	D	406	586	-225	180	26	0	0	0	6	154	86%	154	86%
C-1	235(T)	D-M	160	274	75	114	0	0	0	0	1	114	100%	114	100%
C-2	418.8	F-M	187	382	232	195	22	0	0	0	2	173	89%	173	89%
C-3	295.2	F-M	106	270	189	164	14	0	0	0	2	150	91%	150	91%
C-5	265.6	F-D	316	560	-50	244	14	0	0	0	2	230	94%	230	94%
C-6	208.7	D	571	758	-362	187	63	0	0	0	4	124	66%	124	66%
C-7	252(T)	D	522	806	-270	284	77	0	0	0	9	207	73%	207	73%
C-10	289.6	D	747	988	-457	241	30	0	0	0	5	211	88%	211	88%
McQueen Branch aquifer															
BRN-78	340(T)	F-M	592	832	-252	240	--	--	--	--	--	--	--	--	--
BRN-386	181(T)		Not pnt.	Not pnt.	--	--	--	--	--	--	--	--	--	--	--
C-1	235(T)	D-M	350	521	-115	171	0	0	0	0	1	171	100%	171	100%
C-2	418.8	F-M	404	538	15	134	11	0	0	0	3	123	92%	123	92%
C-3	295.2	F-M	314	504	-19	190	19	0	0	0	5	171	90%	171	90%
C-5	265.6	M	625	930	-359	305	45	0	0	0	5	260	85%	260	85%
C-6	208.7	M	918	1213	-709	295	63	0	0	0	6	232	79%	232	79%
C-7	252(T)	M	938	1185	-686	247	34	0	0	0	6	213	86%	213	86%
C-10	289.6	M	1150	1489	-860	339	42	0	0	0	9	297	88%	297	88%

All depths and altitudes are in feet. Values in *italic* are estimated. Not pnt., hydrostratigraphic unit not penetrated in this well. T, measured from a topographic map.

D, Dublin aquifer system. D-M, Dublin-Midville aquifer system. F-D, Floridan-Dublin aquifer system. F-M, Floridan-Midville aquifer system. M, Midville aquifer system.

Table 6. Continued

Well	Ground altitude	Hydrologic system	Top depth	Base depth	Top altitude	Unit thickness	Clay thickness	Number of clay beds >2	Clayey-sand thickness	Number of clayey-sand beds >2	Confining carbonate thickness	Number of confining carbonate beds >2	Total confining thickness	Leakance ft/d/ft	Total % confining beds
Gordon confining unit															
BRN-78	340(T)	F-M	142	180	198	38	--	--	--	--	--	--	38	--	100%
BRN-386	181(T)	F	119	160	62	41	10	1	0	0	31	1	41	4.07E-06	100%
C-1	235(T)		Undelin.	Undelin.	--	--	--	--	--	--	--	--	--	--	--
C-2	418.8		Undelin.	Undelin.	--	--	--	--	--	--	--	--	--	--	--
C-3	295.2		Erod.	Erod.	--	--	--	--	--	--	--	--	--	--	--
C-5	265.6	F-D	162	172	104	10	7	2	3	1	0	0	10	2.37E-05	100%
C-6	208.7	F	173	241	36	68	0	0	0	0	68	1	68	2.46E-06	100%
C-7	252(T)	F	227	313	25	86	28	1	0	0	58	1	86	1.94E-06	100%
C-10	289.6	F	380	445	-90	65	0	0	0	0	65	1	65	2.57E-06	100%
Crouch Branch confining unit															
BRN-78	340(T)	F-M	306	318	34	12	12	1	0	0	0	0	12	1.39E-05	100%
BRN-386	181(T)	MB	262	406	-81	144	70	5	0	0	0	0	70	2.39E-06	49%
C-1	235(T)	MB	103	160	132	57	46	3	11	2	0	0	57	3.61E-06	81%
C-2	418.8	F-M	176	187	243	11	11	1	0	0	0	0	11	1.52E-05	100%
C-3	295.2	F-M	90	106	205	16	16	1	0	0	0	0	16	1.04E-05	100%
C-5	265.6	F-D	280	316	-14	36	11	3	8	1	0	0	19	1.50E-05	31%
C-6	208.7	MB	426	571	-217	145	106	3	40	2	0	0	146	1.56E-06	73%
C-7	252(T)	MB	407	522	-155	115	97	3	11	2	0	0	108	1.72E-06	84%
C-10	289.6	MB	600	747	-310	147	101	3	0	0	0	0	101	1.65E-06	69%
McQueen Branch confining unit															
BRN-78	340(T)	F-M	576	592	-236	16	16	1	0	0	0	0	16	1.04E-05	100%
BRN-386	181(T)	AL	586	Not pnt.	-405	--	--	--	--	--	--	--	--	--	--
C-1	235(T)	D-M	274	350	-39	76	69	2	0	0	0	0	69	2.42E-06	91%
C-2	418.8	F-M	382	404	37	22	22	1	0	0	0	0	22	7.59E-06	100%
C-3	295.2	F-M	270	314	25	44	39	2	0	0	0	0	39	4.28E-06	89%
C-5	265.6	AL	560	625	-294	65	31	3	17	2	0	0	48	5.33E-06	48%
C-6	208.7	AL	758	918	-549	160	160	1	0	0	0	0	160	1.04E-06	100%
C-7	252(T)	AL	806	938	-554	132	132	1	0	0	0	0	132	1.27E-06	100%
C-10	289.6	AL	988	1150	-698	162	158	2	4	1	0	0	162	1.06E-06	98%

All depths and altitudes are in feet. Values in italic are estimated. Undelin., hydrostratigraphic unit not delineated in this well. Not pnt., hydrostratigraphic unit not penetrated.

D-M, Dublin-Midville aquifer system. F, Floridan aquifer system. F-D, Floridan-Dublin aquifer system. F-M, Floridan-Midville aquifer system.

MB, Meyers Branch confining system. AL, Allendale confining system. T, measured from topographic map.

Table 6. Continued

Well	Ground altitude	Hydrologic system	Top depth	Base depth	Top altitude	Unit thickness	Clay thickness	Number of clay beds >2	Clayey-sand thickness	Number of clayey-sand beds >2	Confining carbonate thickness	Number of confining carbonate beds >2	Total confining thickness	Leakance ft/d/ft	Total % confining beds
Appleton confining system															
BRN-78	340(T)		Not pnt.	Not pnt.	--	--	--	--	--	--	--	--	--	--	--
BRN-386	181(T)		Not pnt.	Not pnt.	--	--	--	--	--	--	--	--	--	--	--
C-1	235(T)	AP	521	567	-286	46	--	--	--	--	--	--	--	--	--
C-2	418.8	AP	538	553	-119	15	--	--	--	--	--	--	--	--	--
C-3	295.2	AP	504	523	-209	19	--	--	--	--	--	--	--	--	--
C-5	265.6	AP	930	1073	-664	143	--	--	--	--	--	--	--	--	--
C-6	208.7	AP	1213	1374	-1004	161	83	4	--	--	--	--	--	--	--
C-7	252(T)	AP	1185	1416	-933	231	86	8	--	--	--	--	--	--	--
C-10	289.6	AP	1489	1726	-1199	237	51	9	--	--	--	--	--	--	--
Piedmont Hydrogeologic Province (Pre-Cretaceous Basement)															
BRN-78	340(T)		Not pnt.	--	Not pnt.										
BRN-386	181(T)		Not pnt.	--	Not pnt.										
C-1	235(T)		567	--	-332										
C-2	418.8		553	--	-134										
C-3	295.2		523	--	-228										
C-5	265.6		1073	--	-807										
C-6	208.7		1374	--	-1165										
C-7	252(T)		1416	--	-1164										
C-10	289.6		1726	--	-1436										

All depths and altitudes are in feet. Values in italic are estimated. Not pnt., hydrostratigraphic unit not penetrated in this well.

AP, Appleton confining system. T, measured from topographic map.

intermittent, and the entire Floridan aquifer system coalesces with the Dublin-Midville aquifer system to form the Floridan-Midville aquifer system (Figs. 13 and 14; Plate 9).

Aucott and Speiran (1985a and b) combined all of the Eocene sandy units (Barnwell and Orangeburg Groups) into the Tertiary sand aquifer because "they act hydraulically as a single aquifer in most of the State." In the study area, confining beds in these formations support a substantial head difference between overlying and underlying units. Thus, two aquifers are defined, the Gordon overlain by the Upper Three Runs. The aquifers are separated by the Gordon confining unit. In the northwest region of SRS (Fig. 13) the Gordon confining unit pinches out, and the Gordon and Upper Three Runs aquifers coalesce to form the Steed Pond aquifer.

Dublin - The Dublin aquifer system is present in the southeastern half of the study area and consists of one aquifer, the Crouch Branch (Plate 9; Fig. 13). It is underlain by the Allendale confining system and overlain by the Meyers Branch confining system. The Dublin aquifer system was defined and named by Clarke and others (1985) for sediments penetrated by well 21U4 drilled near the town of Dublin in Laurens County, Ga. and is correlative with the upper portion of the Chattahoochee River aquifer of Miller and Renken (1988). The updip limit of the Dublin aquifer system corresponds to the updip limit of the Allendale confining system. North of this line, the Dublin-Midville aquifer system is defined (Fig. 14).

Sediments typical of the Dublin aquifer system are penetrated in reference well P-22 located at the south end of SRS (Aadland and others, in press). The system consists of lignitic, micaceous, sand and clayey sand of the Black Creek Formation, and medium to coarse, moderately sorted sand and interbedded clay of the Steel Creek Formation.

Midville - The Midville aquifer system is also present in the southeastern half of the study area and consists of one aquifer, the McQueen Branch (Fig. 13; Plate 9). It overlies the basal Appleton confining system and is separated from the Dublin by the Allendale confining system. The Midville was defined and named by Clarke and others (1985) for the hydrogeologic properties of sediments penetrated in well 28X1, near the town of Midville in Burke County, Ga. It is comparable to the lower portion of the Chattahoochee River aquifer of Miller and Renken (1988) and correlative with the Middendorf aquifer of Aucott and Sperian (1985a). The system extends north to the updip limit of the Allendale confining system (Fig. 14) where clay beds in the Allendale thin and no longer regionally separate the Midville from the overlying Dublin.

Sediments penetrated in reference well P-24 are typical of the Midville aquifer system in the study area (Aadland and others, in press). Here, the Midville consists of the medium to very coarse-grained sand of the Middendorf Formation and fine-grained, often clayey, sand of the lower third of the Black Creek Formation. The two formations are locally separated by interbedded sand and variegated clay that caps the Middendorf Formation.

Floridan-Dublin - Over most of the study area, the Meyers Branch confining system extends north of the Allendale confining system, hydraulically isolating the Floridan from the underlying Dublin and Dublin-Midville systems (Aadland and others, in press). In a small region in the eastern part of the study area (Fig. 14), however, clay beds of the Meyers Branch confining system thin dramatically, leakage values increase, and the Floridan and Dublin aquifer systems are in hydraulic communication. In this region, the Floridan and Dublin aquifer systems coalesce to form the Floridan-Dublin aquifer system. Thick, continuous clay beds in the underlying Allendale confining system continue to hydraulically isolate the Midville and Floridan-Dublin aquifer systems.

The Floridan-Dublin aquifer system is divided into three aquifers in the study area. In descending order these include the Upper Three Runs, Gordon, and Crouch Branch aquifers separated by the Gordon and Crouch Branch confining units. The system is defined by hydrogeologic properties of sediments penetrated in well C-5. Here, the system is 560 ft thick and extends from the water table to the top of the McQueen Branch confining unit. It includes all Tertiary sediments, the Steel Creek Formation, and the upper-third of the Black Creek Formation.

Dublin-Midville - The Dublin-Midville aquifer system underlies the central part of SRS (Fig. 13) and includes all sediments of the Cretaceous Lumbee Group from the Middendorf Formation to sand in the lower part of the Steel Creek Formation. It is overlain by the Meyers Branch confining system and underlain by the Appleton confining system. Where clay beds of the overlying Meyers Branch confining system thin and become intermittent the Dublin-Midville coalesces with the overlying Floridan aquifer system forming the Floridan-Midville aquifer system (Fig. 14). The Dublin-Midville and the updip Floridan-Midville aquifer systems were referred to as the Tuscaloosa aquifer by Siple (1967). The aquifer system is the equivalent of the Chattahoochee River aquifer of Miller and Renken (1988), and the Dublin-Midville aquifer system as defined by Clarke and others (1985) in west-central Georgia.

The Dublin-Midville aquifer system includes two aquifer units, the McQueen Branch aquifer and the Crouch Branch aquifer, separated by the McQueen Branch confining unit (Fig. 13; Plate 9). The two aquifers can be traced northward where they continue to be an integral part of the Floridan-Midville aquifer system and southward where they constitute the aquifer units of the Midville and Dublin aquifer systems, respectively.

The Dublin-Midville aquifer system is defined for the hydrogeologic properties exhibited by the sediments penetrated in reference well P-27 (Aadland and others, in press). The unit consists of the medium- to very coarse-grained, typically angular, slightly silty sand of the Middendorf Formation and the clayey, micaceous, poorly to moderately well sorted, fine to medium sand and silty clay beds of the Black Creek Formation. The system includes a thick clay bed that constitutes the McQueen Branch confining unit.

Floridan-Midville - Northwest of Upper Three Runs Creek, permeable beds that correspond to the Floridan and Dublin-Midville aquifer systems are often in hydraulic communication, owing to the thin and laterally discontinuous character of the intervening clay and silty clay beds (Aadland and others, in press). Here, the Floridan and Dublin-Midville systems coalesce to form the Floridan-Midville aquifer system (Figs. 13 and 14; Plate 9).

The Floridan-Midville aquifer system is divided into three aquifers: in descending order, the Steed Pond, Crouch Branch, and McQueen Branch separated by the Crouch Branch and McQueen Branch confining units. The Crouch Branch and McQueen Branch aquifers extend to the northwest from the southern part of the study area where they are an integral part of the Dublin-Midville aquifer system. The Steed Pond aquifer on the other hand, is the updip hydrostratigraphic equivalent of the Gordon and Upper Three Runs aquifers of the Floridan aquifer system.

Aquifer Units

Upper Three Runs - The Upper Three Runs aquifer occurs between the water table and the Gordon confining unit. In updip areas it includes all strata above the Warley Hill Formation (middle Eocene) (Fig 10). In downdip areas it includes all strata above the Blue Bluff Member of the Santee Limestone (upper middle Eocene). The aquifer consists mainly of quartz sand but

locally contains calcareous sediments of the Santee Limestone. The aquifer is the updip clastic-facies equivalent of the Upper Floridan aquifer of Miller (1986) and Clarke and others (1990) in the carbonate phase of the Floridan aquifer system.

The Upper Three Runs aquifer is defined for hydrogeologic properties of sediments penetrated in well P-27 near the center of SRS (Aadland and others, in press). Here, the aquifer is 132 ft thick and consists mainly of yellow or tan, unconsolidated, moderately sorted, lower coarse- to medium-grained, quartz sand and clayey sand of the Santee Limestone; varicolored, poorly to well-sorted sand and interbedded tan or gray clay of the Dry Branch Formation; and varicolored, poorly sorted, fine to coarse, clayey sand and pebbly sand of the Tobacco Road Formation. Calcareous sand and clay, and limestone are also locally present in the Santee near the type-well location.

Downdip, at the C-10 reference well, the Upper Three Runs aquifer is 380 ft thick and consists of unconsolidated, poorly to moderately sorted, clayey sand and sand of the Tobacco Road and of the upper part of the Dry Branch Formations; white to tan, sandy, shelly limestone (Ocala equivalent) and calcareous sand of the lower part of the Dry Branch Formation; and sandy, shelly limestone and micritic limestone of the Santee Limestone.

A thin-section study of six sand samples from the aquifer in updip areas shows that they are quartzarenites containing trace amounts of potassium feldspar, detrital kaolinite, and metamorphic rock fragments (Thayer, personal communication). Sediments contain variable amounts of detrital matrix, ranging from less than 5 percent to 27 percent. Downdip, in the C-10 well, the Upper Three Runs aquifer contains glauconite and 10 to 35 percent skeletal grains, including forams, echinoderms, bryozoans, pelecypods, and broken skeletal debris.

X-ray diffraction of clay samples from the aquifer at C-well sites indicates that kaolinite is the dominant clay mineral, averaging 58 percent of the clay fraction. Kaolinite is the most abundant clay mineral in each aquifer in the study area, except for the Gordon.

SUMMARY STATISTICS OF CLAY MINERALOGY IN THE UPPER THREE RUNS AQUIFER										
	Illite (%)	Kaolinite (%)	Chlorite (%)	Illite/smectite (%)	Smectite (%)	Total clay (%)	Quartz (%)	Feldspar (%)	Calcite (%)	Total (%)
Mean	25.58	58.25	0.00	15.50	0.33	99.67	0.33	0.00	0.00	100.00
Median	20.00	60.00	0.00	18.50	0.00	100.00	0.00	0.00	0.00	100.00
Std. Dev.	22.35	36.18	0.00	14.53	0.89	0.78	0.78	0.00	0.00	0.00
Variance	499.54	1308.93	0.00	211.00	0.79	0.61	0.61	0.00	0.00	0.00
Range	64.00	92.00	0.00	36.00	3.00	2.00	2.00	0.00	0.00	0.00
Minimum	0.00	8.00	0.00	0.00	0.00	98.00	0.00	0.00	0.00	100.00
Maximum	64.00	100.00	0.00	36.00	3.00	100.00	2.00	0.00	0.00	100.00
Sum	307.00	699.00	0.00	186.00	4.00	1196.00	4.00	0.00	0.00	1200.00
Count	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00

Sieve analyses of 36 sand samples from the aquifer (Appendix 3) indicate that mean grain size ranges from lower fine to upper coarse (2.62 to 0.47 ϕ) and averages lower medium (1.68 ϕ). Grain size is slightly skewed towards the coarse-grained end of the distribution (Fig. 15a). The most frequently occurring grain size (modal) is lower medium. Sand in the aquifer is very well to very poorly sorted (0.33 to 2.41 ϕ). Gravel averages 3 percent, sand 88 percent, and mud 9 percent. Permeability and porosity were estimated from median grain size and sorting by the empirical method of Beard and Weyl (1973). Average porosity is 35 percent and the geometric mean permeability is 57 ft/d.

SUMMARY OF SIEVE ANALYSES IN THE UPPER THREE RUNS AQUIFER											
	Folk and Ward		Trask			Gravel (%)	Sand (%)	Mud (%)	Porosity (%)	Permeability	
	Mean (phi)	Sorting (phi)	Median (phi)	Sorting (phi)	Sorting (mm)					(Darcy)	(ft/d)
Mean	1.68	1.16	1.50	0.65	1.63	3	88	9	35	38	92
Geometric mean	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	57
Standard error	0.09	0.09	0.11	0.06	0.08	1	2	1	1	5	12
Median	1.69	0.98	1.54	0.55	1.46	0	92	7	35	38	92
Mode	--	--	--	0.40	1.32	0	--	--	33	38	92
Std. Dev.	0.54	0.52	0.69	0.36	0.51	7	11	6	3	28	69
Variance	0.29	0.27	0.47	0.13	0.26	45	123	38	12	806	4774
Kurtosis	-0.09	-0.59	0.36	2.94	6.84	7	3	-1	0	5	5
Skewness	-0.26	0.64	-0.55	1.65	2.44	3	-2	1	0	2	2
Range	2.14	2.08	2.79	1.59	2.42	25	45	21	13	142	346
Minimum	0.47	0.33	-0.18	0.27	1.21	0	53	2	27	4	10
Maximum	2.62	2.41	2.61	1.86	3.63	25	98	23	40	146	355
Sum	60.43	41.90	54.15	23.47	58.60	99	3170	331	1252	1365	3321
Count	36	36	36	36	36	36	36	36	36	36	36

The upper part of the aquifer corresponding to the Tobacco Road Formation contains a higher mud content than the lower part, which corresponds to the Dry Branch Formation and Santee Limestone. At site C-5, for example, mud averages 25 percent in the upper part and 11 percent in the lower part (based on visual estimates made at 1-ft intervals). Mud content derived from sieve analyses (Appendix 6) averages 16 percent in the upper part and 8 percent in the lower part.

Percent mud in the Upper Three Runs aquifer derived from:					
		Core Description		Sieve Analyses	
		Range	Mean	Range	Mean
C-5	upper part	10-45	25	11-21	16
	lower part	1-75	11	4-14	8
C-6	upper part	Eroded	Eroded	Eroded	Eroded
	lower part	3-30	15	2-10	4
C-7	upper part	12-65	31	Not available	
	lower part	1-90	13	3-8	5

At sites C-6 and C-7, which are oriented on a line parallel to depositional strike, the lower part of the Upper Three Runs aquifer consists of a calcareous unit (Plates 8 and 9) thought to be correlative with the Utley Limestone Member of the Clinchfield Formation. At site C-6, this unit occurs from 55 to 36 ft msl and consists of glauconitic, sandy, micritic limestone and sandy calcarenite. At site C-7, it occurs from 50 to 25 ft msl and consists of shelly limestone and shelly, micritic sand. Age-diagnostic fossil assemblages from the unit, however, are ambiguous and the unit may actually represent the leading edge of the Santee Limestone. Immediately below the limestone is a thick marl sequence that is correlative with the Blue Bluff Member of the Santee Limestone and that constitutes a large part of the underlying Gordon confining unit (Plate 9). The Gordon confining unit separates the Upper Three Runs aquifer from the Gordon aquifer.

Figure 15a. Grain-size distributions of sand samples from three aquifers in the study area (UVC, upper very coarse; LVC, lower very coarse; UC, upper coarse; LC, lower coarse; UM, upper medium; LM, lower medium; UF, upper fine; LF, lower fine; UVF, upper very fine; LVF, lower very fine).

Figure 15b. Grain-size distributions of sand samples from two aquifers in the study area (UVC, upper very coarse; LVC, lower very coarse; UC, upper coarse; LC, lower coarse; UM, upper medium; LM, lower medium; UF, upper fine; LF, lower fine; UVF, upper very fine; LVF, lower very fine).

Four monitoring wells are screened in the Upper Three Runs aquifer at sites C-6 and C-7, two at each site (Plates 5 and 6). One well is screened in the clastic section of the aquifer (Dry Branch Formation) and one in the calcareous section (Utley Limestone Member). At site C-6, a very small (0.4 ft) vertical hydraulic head difference exists between the wells, indicating vertical hydraulic continuity in the aquifer and a slight downward gradient (Plate 5). A head difference of 2.5 ft occurs between wells at C-7, also with a downward gradient. Altitudes of individual wells at site C-7, however, have not been accurately surveyed, so the head difference noted between the well pair may merely reflect altitude differences and not hydrologic conditions.

Water-chemistry differences are significant between the two wells screened in the Upper Three Runs aquifer at site C-6, reflecting mineralogical differences in the sediments and rocks that compose the aquifer. Water from well BRN-351, screened in the clastic section of the aquifer, has a total dissolved solids concentration of 19 mg/L and a pH of 6.7. Water from well BRN-350, screened in the calcareous section of the aquifer, is more mineralized, with a dissolved solids concentration of 89 mg/L, and more alkaline, with a pH of 8.5. Because the

vertical hydraulic gradient at the site is small (0.4 ft), little mixing of water occurs between the upper and lower parts of the aquifer.

The ionic-activity product was calculated for water in well BRN-350 and compared with the solubility product of calcite (see Fetter, 1980, p. 320-321). The analysis indicates an ionic activity product of $10^{-7.80}$. The solubility product for calcite is $10^{-8.35}$. The ratio between the two is 3.55, indicating that the water is supersaturated with respect to calcite. A thin-section study of the Utley Limestone at C-6 indicates a series of freshwater diagenetic events, the last event being sparry calcite cementation (Thayer, 1989). The analysis of the water chemistry implies that precipitation of the sparry calcite may have occurred in recent times.

Water from well BRN-360, which is completed in the Upper Three Runs aquifer at site C-5, has a pH of 8.1 and a dissolved solids concentration of 56 mg/L. Dissolved solids in the water may be elevated, however, due to leaching of grout. In consideration that no calcareous sediments are present in the sedimentary section at site C-5, the water is abnormally high in calcium (19 mg/L), bicarbonate (61 mg/L), and hardness (49 mg/L). These high concentrations are thought to be caused by leaching of grout along the annulus of the well.

Hourly water-level measurements were obtained from each of the two wells at site C-6 between April 1988 and May 1991. Water levels were averaged over each day and plotted as a function of depth below land surface and of altitude above sea level (Appendix 7). A Pearson's product-moment correlation coefficient (r) was calculated, using the daily water-level measurements from the two wells (Appendix 8). This coefficient measures the closeness of a linear relationship between two variables. If one variable can be expressed exactly as a linear function of another variable, then the correlation is 1 or -1, depending on whether the two variables are positively or inversely related. A correlation of zero between the two variables indicates that each variable has no linear relationship with the other. Water-level fluctuations in the two wells at C-6 are very strongly and positively correlated ($r = 0.9996$) indicating that water-level changes in the wells are nearly identical and that a high degree of vertical hydraulic continuity exists in the aquifer.

The Upper Three Runs is the surficial, water-table aquifer in the study area and is, therefore, strongly influenced by local recharge and discharge events; consequently, the range in water-level fluctuation is greater than occurs in the deeper, confined aquifers of the area. Water levels in the aquifer at site C-6 fluctuated 5.5 ft over the recorded time interval, representing the greatest range at the site (Fig. 16). Water levels in the lowermost aquifer (McQueen Branch) fluctuated only 3.5 ft.

Monthly precipitation data obtained from station number 380764 in Blackville (located 13 mi north of site C-6) are overlaid on a hydrograph of the Upper Three Runs at C-6 but show only moderate correlation with water-level changes in the aquifer (Fig. 16). Departures from normal precipitation (Fig. 17), however, are more strongly related to water levels. Below-normal rainfall occurred throughout 1988, with minor exceptions during the months of April, June, August, and September. This resulted in a lowering of the water table at C-6 (Fig. 16). Below-normal rainfall from October 1988 to March 1989 (Fig. 17) caused steady water-level declines during this period. Water levels rebounded during the growing season (May to October 1989) and continued to rise throughout the winter months (November 1989 to March 1990) owing to the above-normal precipitation that occurred from April 1989 through December 1989. Rainfall deficits throughout most of 1990, coupled with the effects of evapotranspiration, resulted in a water-level decline starting in April 1990 and continuing through September 1990. Nearly 15 inches of rain in October 1990 reversed the trend and, in general, the water table rose from October 1990 through May 1991.

At site C-6, ground water discharges from the Upper Three Runs aquifer to the flood plain of the Salkehatchie River and to surrounding tributaries, Parker Branch and Hurricane Creek. The altitude of the water table at site C-6 is 175 ft msl, about 15 ft above the flood plain

Figure 16. Overlay of water levels at site C-6 with precipitation and discharge in the Salkehatchie River.

of the Salkehatchie. Monthly minimum flow rates (ft^3/s , cubic ft per second) of the river obtained from a USGS stream-flow station in Miley, S.C. (located 22 mi southeast of site C-6) are overlaid on the hydrograph of the Upper Three Runs aquifer (Fig. 16). Minimum flow rates occur in June and July and generally correspond to low water levels in the aquifer. Maximum flow rates occur in February and April and correspond with high water levels.

Figure 17. Departures from normal precipitation at station 380764 in Blackville, S.C. (Jan. 1988 to Dec. 1991).

One well (BRN-360) is completed in the Upper Three Runs aquifer at site C-5, which is located 10 miles updip of site C-6. A hydrograph of this well (Fig. 18) shows a good correlation ($r = 0.75$) between water levels in the aquifer at the two sites (between wells BRN-360 and BRN-350). Examination of the hydrograph indicates a low water level in February 1989 and a high in April 1991 (Fig. 18), each occurring approximately one month earlier than those at site C-6 (Fig. 16). In fact, throughout most of the recorded time interval there is a one-month time lag in water-level fluctuation between the two sites. This probably is due to differences in the thickness of the unsaturated zone and to differences in local relief at the well sites. If a 30-day lag is artificially introduced into the data the correlation coefficient increases to 0.82. Water levels fluctuated about 12 ft at site C-5, approximately twice the difference than occurred at site C-6 (5.5 ft).

Water-level recorders were not operational between July 1991 and March 1993 and, therefore, no continuous water level data are available for this period. Recorders were reconnected in April 1993. Hydrographs were constructed for the period from April 1993 to November 1993 for each of the wells screened in the Upper Three Runs aquifer at sites C-6 and C-5 (Figs. 19 and 20; Appendix 7). Effects of the drought of 1993 are evident on the

Figure 18. Hydrograph of the Upper Three Runs aquifer at site C-5 (Feb. 1989 to Jun. 1991).

Figure 19. Hydrograph of the Upper Three Runs aquifer at site C-6 (Apr. 1993 to Nov. 1993).

Figure 20. Hydrograph of the Upper Three Runs aquifer at site C-5 (Apr. 1993 to Nov. 1993).

graphs. Water levels at site C-6 show a steady decline from May 1993 through November 1993. Although precipitation was above normal in September and October (Fig. 21), the water table continued to drop through November. It should be noted, however, that the water table does remain high relative to its position during the period 1988-91 (see Fig. 16).

Updip, at site C-5, a steady water-level decline occurred in the Upper Three Runs aquifer during the drought of 1993 (Fig. 20), similar to that observed at site C-6. The decline, however, levels off at the end of August (on August 22 and 23, 1.49 inches of rain is recorded). Water levels begin to recover in mid to late September, decline slightly in October, and level off again in November. In general, most of the aquifers in the region displayed a similar pattern during the summer of 1993, with declines occurring throughout the summer months before leveling off in late August or early September. An exception to this is the basal McQueen Branch aquifer that showed only slight, if any, decline during the drought (see discussion below for details).

Figure 21. Departures from normal precipitation at station 380764 in Blackville, S.C. (Apr. 1993 to Nov. 1993).

In the northern and central regions of the study area, the Upper Three Runs aquifer does not yield large quantities of water owing to the presence of interstitial silt and clay and poorly sorted sediments that combine to significantly reduce permeability (Aadland and others, in press). Local lenses of relatively clean, permeable sand may, however, yield sufficient quantities for domestic use. In the General Separations Area (GSA), located on SRS near the central part of the study area, 110 low-discharge, short-duration, single-well pumping tests were made of the Upper Three Runs aquifer (Parizek and Root, 1986; Evans and Parizek, 1991). Hydraulic conductivity averaged 3.4 ft/d. Hydraulic conductivity determined from 363 slug tests

averaged 5.6 ft/d and that from seven long-duration pumping tests averaged 6.6 ft/d (Aadland and others, in press). Ground water modeling of the aquifer (GeoTrans, 1992) in the GSA used a calibrated hydraulic-conductivity value of 6.0 ft/d for the lower part of the aquifer, and 3.4 ft/d for the upper part. These low hydraulic-conductivity values determined from the various field tests and modeling efforts reflect the clayey nature of sediments that compose the Upper Three Runs aquifer in the northern and central regions of the study area.

At the south end of the study area (near well C-10), in an area of transition between the clastic and carbonate phases of the Floridan aquifer system, hydraulic conductivity and well yields generally increase. An aquifer zone in the Upper Three Runs aquifer in Allendale County is very productive and is tapped for municipal supplies by the towns of Allendale, Ulmer, and Fairfax. The zone occurs between 30 and 90 ft msl at site C-10 and consists of limestone that is correlative with the Santee. North of C-10, at wells C-6 and C-7, the limestone is absent and the sequence consists of fine-grained marl and clay deposited in a deep-water shelf environment. Here, municipalities (such as the town of Barnwell) must tap the underlying Gordon aquifer for sufficient public water supplies (Fig. 11).

Pumping tests of aquifers made in the study area were analyzed and compiled by Newcome (1993) and are provided in Table 7. Well locations are shown on Fig. 22. In the town of Allendale, three public-supply wells completed in this limestone aquifer zone have yields ranging from 375 to 550 gal/min (gallons per minute). Pumping tests made from two of the three wells (ALL-310 and ALL-353; Fig. 19) had transmissivities of 25,000 and 29,000 gal/d/ft (gallons per day per foot) or 3,300 and 3,900 ft²/d (feet squared per day). Specific capacities of 7.4 and 13 gal/min/ft (gallons per minute per foot) were calculated for the wells (Table 7). In Allendale, the zone is about 60 ft thick and hydraulic conductivities calculated from the pumping tests are 56 and 65 ft/d for the two wells.

Ulmer, S.C., has two wells completed in this limestone zone (ALL-48 and BRN-295; Fig. 19). Transmissivities of 30,000 and 47,000 gal/d/ft (4,000 and 6,300 ft²/d) and specific capacities of 14 and 4.7 gal/min/ft, respectively, were calculated for the wells (Table 7). Geophysical logs indicate a thickness of 60 ft. Hydraulic conductivities of 67 ft/d and 105 ft/d were calculated. All wells completed in this zone at the south end of the study area are gravel-packed and screened to filter out a very fine-grained sand that occurs in the limestone. South of the study area, however, indurated, pure limestone dominates the section and wells are constructed without screens.

Gordon - The Gordon aquifer consists of all saturated strata between the overlying Gordon underlying Crouch Branch confining units. The aquifer is semiconfined (leaky), with a downward potential from the overlying Upper Three Runs aquifer in interfluvial areas and an upward potential along the tributaries of the Savannah River where the Upper Three Runs aquifer is incised (Aadland and others, in press).

The Gordon aquifer is defined by hydrogeologic properties of sediments penetrated in reference well P-27 near the center of SRS (Aadland and others, in press). Here, the unit is 77 ft thick and is correlative with the sandy parts of the Snapp Formation and the overlying Congaree/Fourmile Formation. It consists of yellow, orange, tan, moderately to poorly sorted, subangular, fine- to coarse-grained, unconsolidated quartz sand with pebbly zones (Robertson, 1990). Clay beds and stringers are present in the aquifer but they are too thin and discontinuous to be more than local confining zones.

At site C-10, quartz sand of the Gordon aquifer grades into glauconitic, calcareous sand, especially in the upper half of the formation. Dominant allochems in the carbonate-rich rocks include forams, pelecypods, echinoderms, bryozoans, intraclasts, and unidentifiable skeletal debris. Other constituents include detrital quartz, terrigenous clay,

Table 7. Pumping test data from aquifers in the study area (modified from Newcome, 1993)

AIKEN COUNTY											
County number	Grid number	Owner's number	Latitude	Longitude	Altitude (ft)	Location	Date of test	Duration (dd/recov in hrs)	Electric log	Well depth (ft)	Water level (ft)
AIK-419	41V-k1	--	332730	815050	2547	Beech Island	1/4/67	6/1.5	--	457	219
AIK-432	41U-a2	--	333459	815050	450	Graniteville (Greenfield well)	11/17/78	24/2	--	235	173
AIK-440	41U-u4	--	333059	815053	270	Burnettown	5/22/69	24/3	--	205	104
AIK-447	38X-n1	905-80H	331750	813820	290	Savannah River Site	8/9/76	12/	--	862	125
AIK-452	39W-x1	905-82A	332015	814358	375	Savannah River Site	7/7/77	12/2	X	695	180
AIK-460	39U-p1	--	333121	814440	380	Houndslake Country Club	7/13/78	2.5/	X	283	84
AIK-474	42U-u1	--	333051	815515	430	Clearwater	4/26/78	24/3	--	269	176
AIK-476	41U-v2	--	333058	815115	150	Burnettown	6/5/69	24/2.5	--	174	72
AIK-478	39U-k2	--	333220	814040	480	Aiken, 3 mi SE	6/29/82	13/	--	200	150
AIK-483	37V-c1	--	--	--	--	Aiken	8/4/78	24/4	X	380	138
AIK-508	40Y-l3	905-85G	331328	814609	105	Savannah River Site	4/21/77	4/	--	186	18+
AIK-516	39X-k6	905-101F	331714	814028	318	Savannah River Site	9/3/82	24/5	X	855	148
AIK-532	39X-u5	905-21F	331719	814027	314	Savannah River Site	8/17/64	24/	--	764	137
AIK-538	38X-n2	905-43H	331713	813828	301	Savannah River Site	2/23/52	12/	--	860	111
AIK-544	38X-n6	905-66H	331712	813835	303	Savannah River Site	11/27/67	24/1	--	860	118
AIK-550	40Y-k4	905-96G	331243	814543	--	Savannah River Site	4/28/80	24/	--	419	4+
AIK-552	39X-l2	905-100F	331658	814023	289	Savannah River Site	9/9/81	21/5	--	850	121
AIK-589	38X-n15	905-108H	331710	813807	280	Savannah River Site	3/28/84	24/6	--	860	118
AIK-648	38X-g2	95-1780-101	331803	813835	264	Savannah River Site	10/30/84	24/	--	417	100
AIK-821	36U-f1	--	333312	812950	280	Aiken State Park (Campground)	4/14/86	24/	--	182	Flow
AIK-822	39T-b1	--	333920	814110	470	Aiken, 6 1/2 mi NNE	11/20/84	5/1.5	X	180	--
AIK-830	39U-y1	--	333030	814421	500	Aiken (Woodside well)	12/11/86	23/3	--	473	189
AIK-831	39U-y2	--	333036	814421	505	Aiken (Silverbluff Road well)	3/16/87	48/13	X	485	204
AIK-832	39U-r4	--	333158	814225	480	Aiken (Pinelogs Road well)	5/25/87	48/2	X	450	159
AIK-841	41U-a5	--	333412	815047	481	Graniteville, 2 mi W	2/5/92	24/	X	300	185
AIK-899	38X-n71	905-119H	331710	813840	297	Savannah River Site	10/5/88	25/5	--	849	135
AIK-900	41U-r2	--	3331--	8151--	--	Burnettown, 1 mi NW	1/27/92	24/	--	240	155
AIK-901	39X-k37	905-102F	331706	814026	300	Savannah River Site	9/15/86	24/2	--	797	121
AIK-907	39W-w9	905-112G	332024	814225	--	Savannah River Site	6/5/85	23/	--	694	138
AIK-907	39W-w9	905-112G	332024	814225	--	Savannah River Site	6/7/85	6/4	--	694	--
AIK-911	40X-j2	905-116G	331826	814545	--	Savannah River Site	10/16/90	12/1	--	141	33
AIK-916	39X-n64	905-67B	331713	814322	269	Savannah River Site	10/17/63	20/4	--	730	101
AIK-918	38X-n75	905-87H	331701	813825	301	Savannah River Site	3/27/78	24/5	--	820	121
AIK-919	38X-n76	905-88H	331712	813821	300	Savannah River Site	5/20/80	24/	--	875	119
AIK-2376	39X-k145	905-103F	--	--	--	Savannah River Site	10/26/88	24/	--	--	145
AIK-2376	39X-k145	905-103F	--	--	--	Savannah River Site	9/14/91	12/	--	--	138

Table 7. Continued

ALLENDALE COUNTY											
County number	Grid number	Owner's number	Latitude	Longitude	Altitude (ft)	Location	Date of test	Duration (dd/recov in hrs)	Electric log	Well depth (ft)	Water level (ft)
ALL-27	36AA-o1	--	330307	812910	186	Martin (Sandoz Plant)	11/29/77	72/3	X	794	5+
ALL-48	33Z-y1	--	330520	811420	200	Ulmer	1/12/79	24/1	--	310	22
ALL-66	37Z-q3	--	330655	813356	210	Martin (Creek Plantation)	2/12/79	24/4	X	720	36
ALL-310	34AA-q2	--	330108	811807	210	Allendale	5/29/80	24/3	--	329	22
ALL-326	33BB-p1	--	325631	811420	120	Fairfax	5/4/83	24/2	X	344	8
ALL-353	34AA-y5	--	330027	811914	200	Allendale	1/23/79	24/2	X	343	47
ALL-362	36AA-n2	--	330214	812852	155	Martin (Sandoz Plant)	10/25/89	24/9	--	812	39
BARNWELL COUNTY											
County number	Grid number	Owner's number	Latitude	Longitude	Altitude (ft)	Location	Date of test	Duration (dd/recov in hrs)	Electric log	Well depth (ft)	Water level (ft)
BRN-57	35Y-c4	TW #10	331410	812245	190	Barnwell (Clinton Street)	7/25/62	24/5	--	320	29
BRN-60	35Y-b8	TW #1	331407	812159	150	Barnwell (Burlington Mills)	/68	12/	--	327	66
BRN-61	35Y-c7	Well #10	331400	812230	160	Barnwell (Burlington Mills)	68	12/	--	315	60
BRN-72	36Y-e1	P-1	331458	812932	258	Barnwell Nuclear Fuel Plant	11/26/71	1,440/368	X	768	57
BRN-75	34W-s4	--	332142	811631	290	Blackville (water tank)	9/2/75	24/3	X	470	62
BRN-79	35W-f1	--	332348	812407	360	Williston (West and Elko Streets)	1/27/78	17/6	X	685	129
BRN-253	38Y-o4	905-95K	331239	813941	281	Savannah River Site	4/28/80	24/	X	585	104
BRN-268	37Y-f2	905-30P	331327	813447	325	Savannah River Site	11/3/51	24/8	--	605	131
BRN-269	38Y-o1	905-33K	331239	813927	279	Savannah River Site	12/14/52	--	--	605	92
BRN-284	38Y-m9	905-104L	331249	813724	250	Savannah River Site	2/8/82	24/44	--	590	79
BRN-285	38Y-m10	905-105L	331245	813721	260	Savannah River Site	4/5/82	24/4	--	602	81
BRN-295	33Z-n1	--	330737	811345	195	Ulmer, 3 mi NW	12/12/84	3.5/26	X	200	54
BRN-310	38Y-d1	905-83G	331452	813852	294	Savannah River Site	10/12/77	12/	--	585	109
BRN-363	36W-b1	--	332411	812622	350	Williston (Halford Street)	2/19/91	48/2.5	--	455	121
BRN-369	35X-a1	--	331940	812015	270	Blackville, 4 mi SW	9/ /89	24/2	X	450	76
BRN-465	37Y-g3	905-26G	331320	813307	260	Savannah River Site	7/2/91	2/	--	374	81
BRN-466	37Y-g2	905-107G	331319	813306	262	Savannah River Site	7/2/84	24/	--	335	82
BRN-469	37W-x1	905-108G	--	--	280	Savannah River Site	9/4/85	24/6	--	200	80
BRN-810	37X-w1	905-131G	331558	813236	216	Savannah River Site	8/19/91	24/4	--	213	16
BRN-811	38Y-h6	--	--	--	300	Savannah River Site	8/10/90	26/2.5	--	--	122
BRN-812	38Y-o36	905-106K	331239	813933	--	Savannah River Site	3/20/89	24/2	--	616	95
BRN-812	38Y-o36	905-106K	331239	813933	--	Savannah River Site	1/3/90	24/2	--	616	108

Table 7. Continued

AIKEN COUNTY (cont.)								
County number	Screen spread (ft below land surface)	Aquifer name/ Thickness (ft)	Pumping rate (gpm)	Transmissivity (gal/d/ft)	Storage coef- ficient	Specific capacity (gal/min/ft)	Well efficiency (%)	Hydro- logic bound- ary
AIK-419	290-320	MBAU	311	13,000	--	5.4	85	--
AIK-432	195-225	MBAU?	250	11,000	--	7.2	95?	R?
AIK-440	160-170; 180-200	MBAU	197	95,000	--	11	25	--
AIK-447	719-734; 750-811; 824-850	MBAU	1,615	220,000?	--	39	45	--
AIK-452	445-450; 496-506; 511-521; 534-544; 560-570; 585-600; 610-615; 620-630; 638-648; 655-665; 680-690	CBAU, MBAU/200	2,005	70,000	--	31	90	--
AIK-460	180-190; 210-225; 245-255; 265-280	CBAU/100	120	> 26,000	--	22	--	D?
AIK-474	209-239	CBAU	115	8,200	--	1.8	45	--
AIK-476	126-136; 149-169	MBAU/50	197	120,000	--	10	20?	--
AIK-478	180-200	CBAU	77	2,400	--	3.0	100	D
AIK-483	300-310; 328-348; 360-370	--	402	85,000	--	12	30	--
AIK-508	155-176	CBAU	30	7,200	--	.3	10	--
AIK-516	600-630; 670-720; 830-850	MBAU/110	1,005	95,000	--	14	35	--
AIK-532	--	--	1,550	48,000	--	21	90	--
AIK-538	425-815	MBAU	560	200,000	--	60	60	--
AIK-544	660-854	MBAU	1,530	135,000-220,000	--	39	40-65	--
AIK-550	280-310; 340-370	--	760	74,000-290,000	--	5?	--	--
AIK-552	600-640; 690-710; 800-840	MBAU	1,491	130,000	--	17	30	--
AIK-589	540-590; 750-840	CBAU, MBAU	1,507	400,000	--	36	20	--
AIK-648	337-342; 347-352; 355-370; 382-387; 393-412	CBAU	374	160,000	--	32	40	--
AIK-821	162-172	CBAU	88	5,200	--	< .8	< 30	--
AIK-822	140-180	MBAU	450	54,000	--	15	65	--
AIK-830	327-342; 354-364; 370-420; 425-430; 438-468	CBAU, MBAU/400	1,005	150,000	--	43	60	--
AIK-831	318-362; 370-380; 398-430; 448-468; 470-480	CBAU, MBAU/400	1,001	230,000	0.002	37	35	R
AIK-832	212-20; 233-50; 260-80; 304-09; 322-34; 347-83; 396-422; 430-40	CBAU, MBAU/280	1,507	120,000	--	33	90	D
AIK-841	200-300	MBAU?	450	14,000	--	6.4	90	--
AIK-899	652-849?	MBAU/200	1,507	210,000	--	42	45	--
AIK-900	160-240	--	600	100,000	--	14	25	D
AIK-901	624-634; 642-652; 670-680; 698-708; 722-732; 742-792	MBAU	1,500	200,000	--	56	65	--
AIK-907	365-457; 531-582; 612-683	--	2,200	97,000-170,000	--	20	25-45	--
AIK-907	365-457; 531-582; 612-683	--	2,200	160,000	0.002	--	--	R
AIK-911	111-121; 126-136	--	11	11,000	--	5.7	100	--
AIK-916	615-620; 630-725	MBAU	2,200	120,000	--	25	45	--
AIK-918	530-590; 750-800	CBAU, MBAU	1,500	320,000	--	75	50	R?
AIK-919	535-540; 780-870	CBAU, MBAU	1,500	230,000	--	45	45	--
AIK-2376	--	--	1,500	210,000	--	37	40	--
AIK-2376	--	--	1,000	230,000	--	42	40	--

CBAU, Crouch Branch aquifer unit; MBAU, McQueen Branch aquifer unit.

Table 7. Continued

ALLENDALE COUNTY (cont.)								
County number	Screen spread (ft below land surface)	Aquifer name/ Thickness (ft)	Pumping rate (gpm)	Transmissivity (gal/d/ft)	Storage coef- ficient	Specific capacity (gal/min/ft)	Well efficiency (%)	Hydro- logic bound- ary
ALL-27	550-585; 631-651; 674-694; 714-744; 764-784	CBAU/165	2,150	68,000	--	18	50	--
ALL-48	180-200; 214-224; 235-245; 290-300	UTR	700	30,000	--	14	95	--
ALL-66	390-410; 518-523; 595-626; 635-680; 690-716	CBAU,MBAU/200	1,500	50,000	--	16	65	--
ALL-310	241-328	UTR/130	752	25,000	--	7.4	70	--
ALL-326	257-262; 270-280; 295-300; 319-339	UTR/100	298	3,800	--	1.3	70	--
ALL-353	290-340	UTR	550	29,000	--	13	90	--
ALL-362	537-47; 560-65; 603-13; 624-34; 674-89; 698-723; 746-56; 760-65; 772-802	CBAU	1,507	63,000	--	15	45	--
BARNWELL COUNTY (cont.)								
County number	Screen spread (ft below land surface)	Aquifer name/ Thickness (ft)	Pumping rate (gpm)	Transmissivity (gal/d/ft)	Storage coef- ficient	Specific capacity (gal/min/ft)	Well efficiency (%)	Hydro- logic bound- ary
BRN-57	180-185; 210-215; 225-235; 275-295	GAU/145	536	35,000	--	8.2	45	--
BRN-60	218-222; 228-232; 238-242; 247-255; 261-265; 270-278; 284-293; 306-310; 316-320	GAU,CBCU/125	495	82,000	--	16	40	--
BRN-61	220-28; 236-40; 246-54; 262-66; 272-80; 288-92; 300-08	GAU,CBCU/145	530	44,000	--	15	70	--
BRN-72	520-570; 680-768	CBAU,MBAU/380	2,000	140,000	0.0002	32	50	--
BRN-75	240-250; 265-270; 292-307; 333-344; 357-362	GAU,CBCU/150	703	31,000	--	6.9	45	--
BRN-79	490-540; 590-600; 640-680	CBAU,MBAU/300	1,404	110,000	--	11	20	--
BRN-253	475-527; 535-580	CBAU	754	66,000	--	19	60	--
BRN-268	360-370; 380-415; 475-485; 505-565; 590-600	CBCU,CBAU/160	540	50,000	--	25	100	--
BRN-269	385-390; 430-600	CBAU/130	567	110,000	--	38	75	--
BRN-284	447-462; 480-505; 510-550	CBAU	750	79,000	--	27	70	R
BRN-285	430-470; 484-504; 552-592	CBAU	751	76,000	--	19	50	R
BRN-295	175-200	UTR/100	80	47,000	--	4.7	20	--
BRN-310	285-290; 512-532; 538-558; 566-576	CBCU,CBAU	754	72,000	--	13	40	--
BRN-363	370-450	CBAU	408	67,000	--	12	35	--
BRN-369	425-445	CBAU/40	170	24,000	--	6.1	50	--
BRN-465	237-241; 263-369	GAU,CBCU	128	11,000	--	4.2	75	--
BRN-466	262-297; 310-330	GAU	115	8,400	--	2.4	55	R
BRN-469	175-195	GCU,GAU	46	15,000	--	0.5	<10	--
BRN-810	182-207	GAU	50	15,000	0.0003	1.1	10-15	D
BRN-811	260-270	GAU	25	1,300	--	0.5	75	--
BRN-812	--	--	775	130,000	0.0005	16	25	R
BRN-812	--	--	500	160,000	--	29	40	--

CBAU, Crouch Branch aquifer unit; CBCU, Crouch Branch confining unit; MBAU, McQueen Branch aquifer unit;
UTR, Upper Three Runs aquifer; GAU, Gordon aquifer unit; GCU, Gordon confining unit.

collophane, heavy and opaque minerals, and organic debris. Authigenic minerals include sparry calcite as a pore-filling cement and replacement, pyrite cubes, framboids, clinoptilolite, and fibrous chalcedony. Thin-section porosity of the limestone ranges from 5 to 30 percent and is mostly moldic and vuggy (Thayer, 1989 and personal communication). South of C-10, the aquifer grades into platform limestone of the Lower Floridan aquifer of the carbonate phase of the Floridan aquifer system.

Clay mineralogy of the Gordon aquifer is summarized below. Unlike other aquifers in the study area, in which kaolinite is the most abundant clay mineral, illite and mixed-layer illite/smectite are the most abundant in the Gordon aquifer, combining for 87 percent of the total clay fraction.

SUMMARY STATISTICS OF CLAY MINERALOGY IN THE GORDON AQUIFER										
	Illite (%)	Kaolinite (%)	Chlorite (%)	Illite/smectite (%)	Smectite (%)	Total clay (%)	Quartz (%)	Feldspar (%)	Calcite (%)	Total (%)
Mean	58.40	11.80	0.00	29.00	0.80	100.00	0.00	0.00	0.00	100.00
Median	59.00	9.00	0.00	31.00	0.00	100.00	0.00	0.00	0.00	100.00
Std. Dev.	2.70	10.94	0.00	8.09	1.79	0.00	0.00	0.00	0.00	0.00
Variance	7.30	119.70	0.00	65.50	3.20	0.00	0.00	0.00	0.00	0.00
Range	7.00	27.00	0.00	21.00	4.00	0.00	0.00	0.00	0.00	0.00
Minimum	54.00	4.00	0.00	15.00	0.00	100.00	0.00	0.00	0.00	100.00
Maximum	61.00	31.00	0.00	36.00	4.00	100.00	0.00	0.00	0.00	100.00
Sum	292.00	59.00	0.00	145.00	4.00	500.00	0.00	0.00	0.00	500.00
Count	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00

Sieve analyses of 38 sand samples from the Gordon aquifer (Appendix 3) indicate that grain size ranges from upper very fine to upper coarse (3.12 to 0.25 ϕ) and averages lower medium (1.61 ϕ). Modal grain size is also lower medium (Fig. 15). Sand in the aquifer is moderately well to poorly sorted (0.61 to 1.49 ϕ). Gravel averages 1 percent, sand 93 percent, and mud 6 percent. Porosity and permeability, estimated from the sieve data (Beard and Weyl, 1973), average 35 percent and 73 ft/d (geometric average), respectively.

Six wells are completed in the Gordon aquifer at sites C-5, C-6, and C-7, two at each site (Plates 4, 5, and 6). One well is completed in the upper part of the aquifer and one in the lower part. Minimal head differences exist between the well pairs at each site indicating vertical hydraulic continuity in the aquifer. Hydrographs constructed for each of the two wells at site C-6 during the period from February 1989 to June 1991 (Appendix 7) are very strongly correlated ($r = 0.997$) (Appendix 8), indicating that water-level fluctuations in the two wells are nearly identical.

Water levels in the aquifer at C-6 fluctuated about 5 ft over the recorded time interval (Fig. 23). Low levels occurred in June 1989 and August 1990; high levels occurred in April 1990 and May 1991. A seasonal cycle is noted on the graphs, with decreases in water level occurring during the growing season and increases occurring during the winter and spring months. A sharp increase during October 1990 is due to the nearly 12-inch above-normal rainfall that occurred during the month. Water levels rise steadily from October 1990 to May 1991 owing to the above-normal precipitation that occurred during this period. Water-level fluctuations in the Gordon aquifer at site C-5 (BRN-359) are very strongly correlated with those at site C-6 ($r > 0.95$), indicating lateral continuity in the aquifer.

Figure 23. Hydrograph of the Gordon aquifer at site C-6 (Feb. 1989 to Jun. 1991).

SUMMARY STATISTICS OF SIEVE ANALYSES IN THE GORDON AQUIFER											
	Folk and Ward		Trask			Gravel (%)	Sand (%)	Mud (%)	Porosity (%)	Permeability	
	Mean (phi)	Sorting (phi)	Median (phi)	Sorting (phi)	Sorting (mm)					(Darcy)	(ft/d)
Mean	1.61	1.00	1.53	0.60	1.52	1	93	6	35	46	113
Geometric mean	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	73
Standard error	0.12	0.04	0.12	0.02	0.03	0	1	1	0	7	17
Median	1.65	0.97	1.58	0.57	1.49	0	93	5	35	30	72
Mode	1.83	—	—	0.54	1.45	0	97	—	35	41	100
Std. Dev.	0.72	0.22	0.71	0.15	0.16	2	5	5	2	44	107
Variance	0.51	0.05	0.50	0.02	0.03	3	22	22	3	1937	11469
Kurtosis	-0.41	-0.04	-0.33	-0.07	0.17	16	1	1	1	2	2
Skewness	0.18	0.56	0.15	0.46	0.71	4	-1	1	0	2	2
Range	2.87	0.88	3.09	0.59	0.65	10	21	21	9	169	411
Minimum	0.25	0.61	0.00	0.34	1.27	0	78	1	30	3	7
Maximum	3.12	1.49	3.09	0.94	1.91	10	99	22	39	172	419
Sum	61.05	37.86	58.06	22.62	57.72	29	3527	244	1314	1765	4295
Count	38	38	38	38	38	38	38	38	38	38	38

Hydrographs of the Gordon aquifer during the drought of 1993 show water-level declines of about 2.8 ft at site C-5 and 3.4 ft at site C-6 (Figs. 24 and 25). These declines, however, are no greater than those observed in previous years (between 1988 and 1991). Steady water-level declines occur throughout the spring and summer months before leveling off in September and October. At site C-6, the aquifer shows signs of recovering, with slight rises occurring in September and November 1993.

Hydraulic properties of the Gordon aquifer are especially consistent in the central regions of the study area (Table 8), reflecting the relatively clay-free and homogeneous quality of the aquifer. Hydraulic conductivity calculated from eight large-scale pumping tests ranges from 24 to 41 ft/d and averages 35 ft/d (Table 8). Transmissivity is more variable, ranging from 1,124 to 5,880 ft²/d and averaging 3,275 ft²/d. It is significantly higher outside SRS, near the towns of Barnwell and Blackville, than at SRS, owing to an increase in aquifer thickness. At SRS, for example, transmissivity averages 2,058 ft²/d, compared to 4,900 ft²/d east of the site. Storage coefficients determined from the tests range from 2.0×10^{-4} to 8.8×10^{-4} and average 3.3×10^{-4} .

A 24-hour, multiple-well pumping test of well BRN-810 (Fig. 19) was made in the vicinity of Par Pond at SRS. Results indicate a transmissivity of 2,145 ft²/d (Table 8). Using a sand thickness of 60 ft, a hydraulic conductivity of 35 ft/d is calculated. South of Par Pond, however, transmissivity and hydraulic conductivity of the aquifer decrease. Two single-well pumping tests made south of Par Pond (BRN-465 and BRN-466; Fig. 19) produced transmissivities of 11,000 and 8,400 gal/d/ft, respectively (1,500 and 1,100 ft²/d) (Table 7). At well P-24, which is located about one mile west of the pumping test, the Gordon is 91 ft thick. Assuming a comparable thickness at the two test wells, hydraulic conductivities of 16 and 12 ft/d are calculated. These values are low relative to those obtained from tests in the central regions of the study area and in the northern regions of Par Pond, suggesting that grain size, sorting, and interstitial clay are beginning to effectively reduce porosity and permeability in the aquifer. South of SRS, in the vicinity of site C-10, sieve analyses suggest that hydraulic conductivity is reduced even further owing to a continued downdip increase in percent mud, a decrease in mean grain size, and poorer sorting (Robertson and Thayer, 1990).

Figure 24. Hydrograph of the Gordon aquifer at site C-5 (Apr. 1993 to Nov. 1993).

SITE: C-6

AQUIFER: GORDON

WELL: BRN-352

LAND SURFACE ELEVATION: 207.151 FEET

Figure 25. Hydrograph of the Gordon aquifer at site C-6 (Apr. 1993 to Nov. 1993).

Table 8. Summary of pumping tests of the Gordon aquifer (modified from Aadland and others, in press)

Source	Area	Pumped well	Monitored well	Transmissivity (ft ² /d)	Storage coefficient	Leakance (ft/d/ft)	Hydraulic conductivity (ft/d)
Albenesius and others (1990) Test 1	H-Area	HSB-84A	HSB-68A	2,009	2.2×10^{-4}	—	31
	H-Area	HSB-84A	HSB-86A	2,055	2.7×10^{-4}	—	38
	H-Area	HSB-84A	HSB-118A	2,102	3.0×10^{-4}	—	—
	H-Area	HSB-84A	HSB-139A	1,644	3.1×10^{-4}	—	—
	H-Area	HSB-84A	HSB-83A	2,253	2.3×10^{-4}	—	24
	H-Area	HSB-84A	HSB-69A	1,292	3.6×10^{-4}	4.83×10^{-4}	—
Albenesius and others (1990) Test 2	H-Area	HSB-84A	HSB-68A	2,202	2.0×10^{-4}	—	34
	H-Area	HSB-84A	HSB-86A	2,226	2.7×10^{-4}	—	41
	H-Area	HSB-84A	HSB-118A	2,543	2.6×10^{-4}	—	—
	H-Area	HSB-84A	HSB-139A	1,812	2.9×10^{-4}	—	—
	H-Area	HSB-84A	HSB-83A	2,562	2.2×10^{-4}	—	27
	H-Area	HSB-84A	HSB-69A	1,124	2.9×10^{-4}	—	—
CH ₂ M Hill (1989)	H-Area	HPT-1A	HPT-2A	2,290	2.3×10^{-4}	5.72×10^{-5}	37.5
	H-Area	HPT-1A	DRB-6WW	2,000	8.8×10^{-4}	2.94×10^{-5}	—
Snipes (written com.)	MWD	—	—	—	—	—	29
Sirrine (1991)	Par Pond	905-131G	905-18G	2,116	2.8×10^{-4}	—	35
Newcome (1993)	Barnwell	BRN-57	BRN-57	4,680	—	—	32
	Barnwell	BRN-61	BRN-61	5,880	—	—	41
	Blackville	BRN-75	BRN-75	4,140	—	—	41

Steed Pond - North of Upper Three Runs Creek, where the Floridan-Midville aquifer system is defined, permeable beds that correspond to the Gordon and Upper Three Runs aquifers of the Floridan are only locally separated. Here, the aquifers coalesce to form the Steed Pond aquifer (Fig. 13; Plate 9). The aquifer occurs from the water table to the clay and clayey sand beds of the Crouch Branch confining unit.

The Steed Pond aquifer is defined by hydrogeologic properties of sediments penetrated in well MSB-42, located in the northwest corner of SRS (Aadland and others, in press). Here, the aquifer is 97 ft thick and includes sand and clayey sand of the Congaree/Fourmile Formation and of the lower part of the Dry Branch Formation. The aquifer consists mainly of subangular, medium- and coarse-grained, slightly gravelly, quartz sand and clayey sand.

Petrographic analysis of five Steed Pond sand samples from well C-2 indicates that they are quartzarenites composed of monocrystalline quartz with accessory polycrystalline quartz and minor sedimentary rock fragments, heavy and opaque minerals, muscovite, and detrital grains of kaolinite (Thayer, 1989). Clay matrix ranges from 1.8 to 2.6 percent and consists of silt-sized angular quartz, ground-up micas, and allogenic clay. Clay mineralogy of the Steed Pond aquifer at C-well sites is summarized below. Like other aquifers in the study, kaolinite is the dominant clay mineral, averaging 54 percent.

Sieve analyses of 25 sand samples from the Steed Pond aquifer at sites C-1, C-2, and C-3 (Appendix 3) indicate that mean grain size ranges from upper very fine to lower very coarse (3.16 to -0.25 ϕ) and averages lower medium (1.61 ϕ). The samples are skewed toward the coarse-grained sizes (Fig. 15). Modal and median grain size are upper medium. Sand in the

SUMMARY STATISTICS OF CLAY MINERALOGY IN THE STEED POND AQUIFER										
	Illite (%)	Kaolinite (%)	Chlorite (%)	Illite/smectite (%)	Smectite (%)	Total clay (%)	Quartz (%)	Feldspar (%)	Calcite (%)	Total (%)
Mean	20.00	54.40	0.00	12.20	1.80	88.40	11.60	0.00	0.00	100.00
Median	15.00	52.00	0.00	6.00	2.00	100.00	0.00	0.00	0.00	100.00
Std. Dev.	14.11	19.17	0.00	10.38	1.79	15.90	15.90	0.00	0.00	0.00
Variance	199.00	367.30	0.00	107.70	3.20	252.80	252.80	0.00	0.00	0.00
Range	30.00	49.00	0.00	21.00	4.00	30.00	30.00	0.00	0.00	0.00
Minimum	7.00	35.00	0.00	3.00	0.00	70.00	0.00	0.00	0.00	100.00
Maximum	37.00	84.00	0.00	24.00	4.00	100.00	30.00	0.00	0.00	100.00
Sum	100.00	272.00	0.00	61.00	9.00	442.00	58.00	0.00	0.00	500.00
Count	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00

SUMMARY OF SIEVE ANALYSES IN THE STEED POND AQUIFER											
	Folk and Ward		Trask			Gravel (%)	Sand (%)	Mud (%)	Porosity (%)	Permeability	
	Mean (phi)	Sorting (phi)	Median (phi)	Sorting (phi)	Sorting (mm)					(Darcy)	(ft/d)
Mean	1.61	1.14	1.48	0.70	1.66	4	89	7	34	45	109
Geometric mean	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	66
Standard error	0.16	0.07	0.16	0.05	0.08	2	2	1	1	13	32
Median	1.46	1.15	1.42	0.65	1.56	0	91	6	34	23	56
Mode	--	--	--	--	--	0	--	--	34	18	44
Std. Dev.	0.81	0.33	0.81	0.27	0.38	9	8	5	3	65	159
Variance	0.65	0.11	0.66	0.07	0.14	76	68	26	7	4276	25316
Kurtosis	0.34	-0.40	0.52	4.75	7.89	6	1	-1	1	14	14
Skewness	-0.41	0.41	-0.29	1.94	2.60	3	-1	1	-1	4	4
Range	3.41	1.21	3.48	1.27	1.79	32	32	18	11	318	774
Minimum	-0.25	0.60	-0.30	0.35	1.27	0	66	1	28	3	7
Maximum	3.16	1.80	3.17	1.61	3.06	32	98	19	39	321	781
Sum	40.17	28.39	37.03	17.62	41.54	95	2222	183	847	1117	2718
Count	25	25	25	25	25	25	25	25	25	25	25

aquifer is moderately well to poorly sorted (0.60 to 1.80 ϕ). Gravel averages 4 percent, sand 89 percent, and mud 7 percent. Porosity and permeability were estimated from the sieve analyses using the empirical method of Beard and Weyl (1973). Porosity averages 34 percent and permeability has a geometric mean of 66 ft/d.

Very few hydraulic data are available for the Steed Pond aquifer. Four multiple-well, long-duration pumping tests of the aquifer were made from fully-penetrating wells in the northern part of A-M Area at SRS (Geraghty and Miller, 1986). Transmissivity ranged from 18,909 gal/d/ft (2,528 ft²/d) to 37,882 gal/d/ft (5,064 ft²/d) and averaged 25,826 gal/d/ft (3,453 ft²/d) (Table 9). Hydraulic conductivity ranged from 31.6 to 63.1 ft/d and averaged 43.0 ft/d.

Table 9. Summary of pumping tests of the Steed Pond aquifer (modified from Geraghty and Miller, 1986)

Pumped well	Monitored well	Well separation (ft)	Transmissivity (gal/d/ft) (ft ² /d)		Storage coefficient	Leakance (ft/d/ft)	Hydraulic conductivity (ft/d)
RWM-6	RWM-7	720	21,366	2,856	6.0×10^{-4}	5.0×10^{-4}	35.7
RWM-7	RWM-6	760	18,909	2,528	6.3×10^{-4}	1.3×10^{-3}	31.6
RWM-8	RWM-10	870	25,148	3,362	9.0×10^{-4}	3.6×10^{-4}	42.0
RWM-11	RWM-5	720	37,882	5,064	5.0×10^{-5}	5.7×10^{-4}	63.1

Crouch Branch - The Crouch Branch aquifer persists throughout the study area. It is defined by the hydrogeologic properties of sediments penetrated in well P-27 near the center of SRS (Aadland and others, in press). Here, the aquifer is 247 ft thick and includes sand beds in the upper third of the Black Creek Formation and interbedded sand and clay of the Steel Creek Formation.

The Crouch Branch aquifer thins in the eastern part of the study area, near site C-6, where clay beds of the adjacent McQueen Branch and Crouch Branch confining units thicken at the expense of Crouch Branch sand (Plate 5). Clay beds in the aquifer itself also thicken in this area. These significant increases in clay content suggest that the eastern flank of a delta complex is located along a line extending from Williston to Allendale, S.C. East of the line, shelf clay dominates the section.

Thin sections of sand samples from updip sites C-2 and C-3 indicate that they are quartzarenites (Folk, 1980 classification) consisting of monocrystalline and polycrystalline quartz with subordinate muscovite (Thayer, 1989 and 1994). Accessory constituents include K-feldspar, plagioclase, detrital "books" of kaolinite, and heavy and opaque minerals. Authigenic kaolinite and pyrite are rare. Thin sections from downdip sites C-5 and C-10 (Thayer, personal communication) show they are also quartzarenites consisting of monocrystalline quartz. The matrix consists of silt-size grains of angular quartz, muscovite, and clay minerals. Authigenic kaolinite and pyrite are common. Measured thin-section porosity of the samples ranges from 20 to 25.5 percent.

Clay mineralogy of the aquifer at the C-well sites is summarized below. Kaolinite is the dominant clay mineral in the aquifer, averaging 65 percent.

Sieve analyses of 163 sand samples (Appendix 3) indicate that mean grain size ranges from upper very fine to upper coarse (3.27 to 0.06 ϕ) and averages upper medium (1.46 ϕ). Modal grain size is also upper medium (Fig. 15). Sand in the aquifer is moderately well sorted to very poorly sorted (0.65 to 2.24 ϕ). Gravel averages 3 percent, sand 85 percent, and mud 12 percent. Porosity and permeability were estimated from the sieve analyses. Porosity averages 33 percent and the geometric mean permeability is 94.1 ft/d.

Hydrographs were constructed for wells BRN-353 and BRN-355, which are screened in the Crouch Branch aquifer at site C-6 (Appendix 7). Well BRN-353 is completed near the top of the aquifer and BRN-355 near the base. The Pearson's correlation coefficient between the two

wells is 0.997 (Appendix 8), indicating a nearly identical water level response between the two wells.

SUMMARY STATISTICS OF CLAY MINERALOGY IN THE CROUCH BRANCH AQUIFER										
	Illite (%)	Kaolinite (%)	Chlorite (%)	Illite/smectite (%)	Smectite (%)	Total clay (%)	Quartz (%)	Feldspar (%)	Calcite (%)	Total (%)
Mean	22.33	64.60	0.00	9.73	2.33	99.40	0.20	0.00	0.00	100.00
Median	19.00	60.00	0.00	7.00	0.00	100.00	0.00	0.00	0.00	100.00
Std. Dev.	15.10	23.04	0.00	9.39	3.33	1.68	0.77	0.00	0.00	0.00
Variance	227.95	530.97	0.00	88.21	11.10	2.83	0.60	0.00	0.00	0.00
Range	56.00	85.00	0.00	29.00	11.00	6.00	3.00	0.00	0.00	0.00
Minimum	0.00	15.00	0.00	0.00	0.00	94.00	0.00	0.00	0.00	100.00
Maximum	56.00	100.00	0.00	29.00	11.00	100.00	3.00	0.00	0.00	100.00
Sum	335.00	969.00	0.00	146.00	35.00	1491.00	3.00	0.00	0.00	1500.00
Count	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00

SUMMARY STATISTICS OF SIEVE ANALYSES IN THE CROUCH BRANCH AQUIFER											
	Folk and Ward		Trask			Gravel (%)	Sand (%)	Mud (%)	Porosity (%)	Permeability	
	Mean (phi)	Sorting (phi)	Median (phi)	Sorting (phi)	Sorting (mm)					(Darcy)	(ft/d)
Mean	1.46	1.42	1.20	0.78	1.74	3	85	12	33	57	139
Geometric Mean	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	94
Standard Error	0.05	0.03	0.06	0.02	0.02	0	1	0	0	4	9
Median	1.42	1.42	1.15	0.75	1.68	1	87	12	33	40	97
Mode	1.47	1.29	0.17	0.75	1.68	0	—	12	34	39	95
Std. Dev.	0.69	0.33	0.75	0.24	0.31	5	7	5	2	49	118
Variance	0.47	0.11	0.56	0.06	0.10	24	48	26	6	2372	14040
Kurtosis	-0.19	-0.16	0.15	0.55	2.00	12	3	6	0	1	1
Skewness	0.43	0.01	0.54	0.75	1.27	3	-1	1	0	1	1
Range	3.21	1.59	3.65	1.26	1.74	29	39	39	11	219	533
Minimum	0.06	0.65	-0.39	0.33	1.26	0	59	1	28	1	3
Maximum	3.27	2.24	3.26	1.59	3.00	29	98	41	39	220	535
Sum	238.73	232.17	195.52	127.43	284.35	457	13898	1946	5366	9329	22699
Count	163	163	163	163	163	163	163	163	163	163	163

Correlations between hydrographs of the Crouch Branch and those of the Gordon are also very high ($r > 0.80$) (Appendix 8), indicating similar water-level patterns between the two aquifers. Seasonal cycles are evident in the Crouch Branch. Water levels are highest in April and May, decline during late spring and throughout the summer months, begin to recover in early fall, and steadily rise during the winter months (Fig. 26). This is the same seasonal pattern noted in the Gordon aquifer (Fig. 23). Water-level change, however, is greater in the Gordon than in the Crouch Branch. Water levels in the Gordon fluctuated about 5 ft over the recorded time interval whereas those in the Crouch Branch fluctuated only 3 ft. These differences may be caused by pumping in the town of Barnwell, which is located 5 mi northwest of site C-6. Barnwell has 11 wells screened in the Gordon aquifer and pumping, on average, 2.3 mgd (million gallons per day) (Newcome, 1990).

Examination of the hydrographs also indicates a 2-month time lag in water-level lows between the aquifers. In the Crouch Branch, lows occur at the end of August 1989 and at the beginning of October 1990. In the Gordon, lows occur in June 1989 and in August 1990, about

Figure 26. Hydrograph of the Crouch Branch aquifer at site C-6 (Feb. 1989 to Jun. 1991).

2 months earlier than in the Crouch Branch. In other words, the Gordon draws down more rapidly than the Crouch Branch. Water-level highs, however, occur at about the same time, generally in April or early May.

Hydrographs made of the Crouch Branch aquifer during the drought of 1993 (April 1993 to November 1993) show that water levels dropped 3.2 ft at site C-6 (Fig. 27), similar to the drop observed in the overlying Gordon aquifer (3.4 ft) (Fig. 24). These declines, however, are not thought to be directly caused by lack of recharge to the aquifer, since water levels near the recharge area do not show significant declines during this period. At site C-3, for example, water levels declined by only 1 ft; at site C-2, they remained constant or increased slightly (Appendix 7). The effects of prolonged periods of drought would be more strongly reflected in wells located in recharge areas of the aquifer (that is, at sites C-2 and C-3) than they would be in downdip areas (that is, at site C-6). The drop in water level at C-6, therefore, probably is due to pumping and not directly to the drought conditions that prevailed throughout the spring and summer months of 1993. The impact of the drought, however, would be felt indirectly through an increase in pumpage for irrigation.

A multivariate-statistical analysis was made by relating grain-size distribution parameters of the Crouch Branch aquifer to geophysical-log response at site C-5. Mean grain size, permeability derived from sieve analyses (Beard and Weyl, 1973), and log-permeability were regressed against the suite of geophysical logs to determine if permeability and grain size can be estimated from the logs. The R-square statistic was used to gage the accuracy of each model. An R-square value of 1.0 indicates an exact linear relationship between the independent and dependent variables. An R-square of 0.0 indicates no linear relationship. Every possible combination of logs was used to determine which subset would give the most accurate prediction of permeability and grain size. Geophysical data included the gamma-ray, 16- and 64-inch normals, single-point resistance, 72-inch lateral, and spontaneous-potential logs. The 89 sieve samples used in the analysis represent, on average, one sample every 2.7 ft in the Crouch Branch aquifer at site C-5.

R-square values from the analysis were very low, indicating that the logs cannot accurately predict grain size or permeability derived from sieve analyses. Utilizing all six logs in each model, the highest possible R-square statistic for predicting grain size was 0.24; for permeability, 0.11; and for log-permeability, 0.18. These poor results probably reflect the strong influence that other parameters, such as water chemistry and mineralogy, have on the geophysical logs.

Hydraulic characteristics of the Crouch Branch aquifer are variable across the study area (Aadland and others, in press). In the northern part of SRS, a single-well pumping test (Siple, 1967) had a transmissivity of 4,500 ft²/d and a hydraulic conductivity of 28 ft/d (Table 10). South of A-M Area, in GSA, pumping tests indicate transmissivities between 10,000 and 15,000 ft²/d and hydraulic-conductivity values between 57 and 86 ft/d. South of GSA, near the center of SRS, transmissivities range from about 11,000 to 27,000 ft²/d and hydraulic-conductivity values from 93 to 227 ft/d.

Transmissivity and hydraulic conductivity decrease in the southern part of SRS. Single-well pumping tests made at two production wells in L-Area at SRS produced transmissivity values of 79,000 and 76,000 gal/d/ft (10,560 and 10,160 ft²/d) (Table 7; Fig. 19). Assuming a sand thickness of 139 ft, which was measured in nearby well P-15, a hydraulic conductivity of 76 ft/d is calculated at well 905-104L and 73 ft/d at well 905-105L.

South of SRS, transmissivity and hydraulic conductivity further decrease. A pumping test made just south of SRS at Creek Plantation near Martin, S.C. (ALL-66) (Table 7; Fig. 19) produced a transmissivity of 50,000 gal/d/ft (6,700 ft²/d) (Newcome, 1993). From geophysical logs, the total sand thickness of the Crouch Branch aquifer is 156 ft, resulting in a hydraulic conductivity of 43 ft/d. Farther south, at well ALL-27 (Fig. 19), a single-well pumping test

Figure 27. Hydrograph of the Crouch Branch aquifer at site C-6 (Apr. 1993 to Nov. 1993).

Table 10. Summary of pumping tests of the Crouch Branch and McQueen Branch aquifers (modified from Siple, 1967)

Aquifer unit	Date tested	Area	Well pumped	Well observed	Average pumping rate (gal/min)	Sand thickness (ft)	Transmissivity		Hydraulic conductivity		Storage coefficient
							(gal/d/ft)	(ft ² /d)	(gal/d/ft ²)	(ft/d)	
Crouch Br.	09/20/51	P	25-P	25-P	540	219	63,500	8,500	290	39	—
Crouch Br.	11/03/51	P	30-P	30-P	540	144	52,000	6,700	361	48	—
Crouch Br.	10/09/51	R	27-R	27-R	560	—	90,000	12,000	—	—	—
Crouch Br.	08/10/52	R	27-R	105-R	440	103	90,000	12,000	874	117	0.0004
Crouch Br.	12/31/51	K	33-K	33-K	578	154	109,000	14,600	708	95	—
Crouch Br.	05/26/52	C	51-C	51-C	589	—	95,000	12,700	—	—	—
Crouch Br.	06/16/52	C	52-C	52-C	567	136	140,000	18,700	1,029	138	—
Crouch Br.	08/03/52	P	25-P	105-P	370	219	46,000	6,200	210	28	0.0004
Crouch Br.	11/28/51	L	29-L	29-L	525	124	71,000	9,500	573	77	—
Crouch Br.	04/23/51	M	15-M	15-M	450	160	33,500	4,500	209	28	—
Crouch Br.	03/10/53	Aiken	AK-266	AK-266	383	138	95,000	12,700	690	92	—
McQueen Br.	04/28/52	F	49-F	49-F	562	267	105,000	14,000	393	53	—
McQueen Br.	11/16/51	F	21-F	24-F	1,870	237	252,000	33,700	1,065	142	0.0007
McQueen Br.	09/29/51	F	24-F	24-F	610	237	253,000	33,800	1,063	142	—
McQueen Br.	09/29/51	F	24-F	21-F	600	237	215,000	28,700	907	121	0.0008
McQueen Br.	05/08/52	H	35-H	35-H	1,350	273	196,000	26,200	720	96	—
McQueen Br.	01/03/52	H	35-H	35-H	560	273	198,000	26,500	725	97	—
McQueen Br.	02/23/52	H	43-H	43-H	560	277	204,000	27,300	736	98	—
McQueen Br.	05/06/52	H	48-H	48-H	600	260	198,000	26,500	762	102	—
McQueen Br.	03/17/52	H	44-H	44-H	570	239	375,000	50,100	1,569	210	—
McQueen Br.	02/29/52	F	37-F	37-F	589	213	178,000	23,800	836	112	—
McQueen Br.	01/19/52	M	31-M	4-M, 20-M	1,500	181	147,000	19,700	812	109	0.0003
McQueen Br.	09/10/52	Williston	BW-44	BW-44	530	255	120,000	16,000	470	63	—

indicates a transmissivity of 68,000 gal/d/ft (9,100 ft²/d) and a hydraulic conductivity of 45 ft/d (based on a sand thickness of 201 ft).

A 60-day, multiple-well pumping test was made at the Barnwell Nuclear Fuel Plant, utilizing two observation wells (Table 7; Fig. 19). The pumping well (BRN-72) was screened in the lower part of the Crouch Branch and in the upper part of the McQueen Branch aquifers. Average transmissivity calculated from the three wells was 140,000 gal/d/ft (18,700 ft²/d) (Newcome, 1993). The pumping well had a specific capacity of 32 gal/min/ft while pumping at a rate of 2,000 gal/min. A sand thickness of 380 ft was determined from geophysical logs and a hydraulic conductivity of 49 ft/d was calculated from the test.

Many wells in the northern regions of the study area are also multiple-aquifer wells, screened in the Crouch Branch and McQueen Branch aquifers. Transmissivities in these wells range from 10,000 to 20,000 ft²/d, while hydraulic conductivities range from about 35 to 50 ft/d. The relative contributions of the two aquifers, however, are unknown. A municipal well in Williston (BRN-79) produced a transmissivity of 110,000 gal/d/ft (14,700 ft²/d) and a specific capacity of 11 gal/min/ft while pumping at a rate of 1,404 gal/min (Newcome, 1993) (Table 7; Fig. 19). A sand thickness of 300 ft was estimated from a driller's log and from geophysical logs, and a hydraulic conductivity value of 49 ft/d was calculated. In A-M Area, a multiple-well pumping test (Geraghty and Miller, 1983) had a transmissivity of 79,000 gal/d/ft (10,500 ft²/d) and a hydraulic conductivity of 37 ft/d, based on a sand thickness of 286 ft. Well AIK-452 (Fig. 19), located near A-M Area, had a transmissivity of 70,000 gal/d/ft (9,400 ft²/d) (Newcome, 1993) (Table 7). A sand thickness of 200 ft was determined from geophysical logs and a hydraulic conductivity of 47 ft/d was calculated for the aquifers. Well AIK-830, located just south of the town of Aiken (Fig. 19), produced a transmissivity of 150,000 gal/d/ft (20,100 ft²/d) while pumping at a rate of 1,005 gal/min. The specific capacity of the well was 43 gal/min/ft. Sand thickness is 400 ft and a hydraulic conductivity of 50 ft/d was calculated.

McQueen Branch - The McQueen Branch aquifer is present beneath the entire study area and is an integral part of the Midville, Dublin-Midville, and the Floridan-Midville aquifer systems (Fig. 13; Plate 9). It is overlain by the McQueen Branch confining unit and underlain by the Appleton confining system. The aquifer thickens from 123 ft at site C-2 to 339 ft at well C-10.

The McQueen Branch aquifer is defined for the hydrogeologic properties of sediments penetrated by well P-27 near the center of the study area (Aadland and others, in press) and is named for McQueen Branch, a tributary of Upper Three Runs Creek. Here, the aquifer is 203 ft thick and consists of medium- to very coarse-grained sand of the Middendorf Formation, and clayey, micaceous, poorly- to moderately well-sorted, fine to medium sand and silty clay of the lower third of the Black Creek Formation.

Thin sections of the McQueen Branch (Thayer, 1989 and personal communication) shows that they are quartzarenites and subarkoses (Folk, 1980 classification) whose framework grains consist of subangular to subrounded, monocrystalline and polycrystalline quartz with minor to trace amounts of plagioclase, K-feldspar (microcline and orthoclase), muscovite, metavolcanic rock fragments, sedimentary rock fragments, glauconite, detrital "books" of kaolinite, and heavy and opaque minerals. Minor authigenic quartz and kaolinite are present as pore-filling cement. Mud matrix forms 5 to 15 percent of whole-rock volume and consists of silt-size grains of quartz and muscovite mixed with clay minerals. Sand in the aquifer is believed to have originally contained considerably more feldspar, as indicated by the presence of corroded "skeletal" feldspar grains and the abundance of authigenic kaolinite "books" that probably are replacements of original feldspar grains.

X-ray diffraction of clay samples from C-well sites indicates that kaolinite is the dominant clay mineral, averaging 75 percent.

SUMMARY STATISTIC OF CLAY MINERALOGY IN THE MCQUEEN BRANCH AQUIFER										
	Illite (%)	Kaolinite (%)	Chlorite (%)	Illite/smectite (%)	Smectite (%)	Total clay (%)	Quartz (%)	Feldspar (%)	Calcite (%)	Total (%)
Mean	15.63	75.22	0.07	6.52	1.93	99.37	0.63	0.00	0.00	100.00
Median	12.00	82.00	0.00	5.00	1.00	100.00	0.00	0.00	0.00	100.00
Std. Dev.	14.45	21.00	0.38	6.57	2.27	1.84	1.84	0.00	0.00	0.00
Variance	208.78	441.10	0.15	43.11	5.15	3.40	3.40	0.00	0.00	0.00
Range	55.00	76.00	2.00	28.00	6.00	7.00	7.00	0.00	0.00	0.00
Minimum	0.00	24.00	0.00	0.00	0.00	93.00	0.00	0.00	0.00	100.00
Maximum	55.00	100.00	2.00	28.00	6.00	100.00	7.00	0.00	0.00	100.00
Sum	422.00	2031.00	2.00	176.00	52.00	2683.00	17.00	0.00	0.00	2700.00
Count	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00

Sieve analyses of 180 sand samples from the aquifer (Appendix 3) indicate that mean grain size ranges from lower fine to lower very coarse (2.92 to 0.43 ϕ) and averages upper-medium (1.35 ϕ). The most commonly occurring grain size is lower medium but there is a high frequency of upper medium and lower coarse samples (Fig. 15). Grain size is relatively consistent across the study area. At the southernmost site, C-10, grain size averages 1.35 ϕ (upper-medium), the same average as the composite data set. Sorting of the 180 samples ranges from moderately well to very poor (0.58 to 2.15 ϕ). Gravel averages 3 percent, sand 85 percent, and mud 12 percent. Porosity and permeability were estimated from the sieve analyses by the method of Beard and Weyl (1973). Porosity averages 33 percent and the geometric mean permeability is 99 ft/d.

SUMMARY STATISTICS OF SIEVE ANALYSES IN THE MCQUEEN BRANCH AQUIFER											
	Folk and Ward		Trask			Gravel (%)	Sand (%)	Mud (%)	Porosity (%)	Permeability	
	Mean (ϕ)	Sorting (ϕ)	Median (ϕ)	Sorting (ϕ)	Sorting (mm)					(Darcy)	(ft/d)
Mean	1.35	1.43	1.12	0.81	1.78	3	85	12	33	59	143
Geometric mean	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	99
Standard error	0.05	0.02	0.05	0.02	0.03	0	0	0	0	4	11
Median	1.33	1.41	1.17	0.77	1.71	1	86	11	33	42	102
Mode	1.73	1.18	1.15	1.06	2.08	0	88	7	34	19	46
Std. Dev.	0.65	0.32	0.63	0.25	0.34	4	6	5	2	58	141
Variance	0.42	0.10	0.40	0.06	0.12	18	41	29	6	3353	19853
Kurtosis	-0.33	-0.42	-0.12	0.72	2.46	7	0	0	0	20	20
Skewness	-0.08	0.22	0.08	0.84	1.40	2	-1	0	0	3	3
Range	3.34	1.57	3.40	1.39	2.05	24	34	29	14	503	1224
Minimum	-0.43	0.58	-0.50	0.33	1.26	0	64	1	26	2	5
Maximum	2.92	2.15	2.90	1.72	3.30	24	98	30	40	505	1229
Sum	243.71	257.71	201.13	145.60	320.46	557	15361	2083	5855	10546	25660
Count	180	180	180	180	180	180	180	180	180	180	180

Hydrographs constructed for the McQueen Branch aquifer at site C-2 (Appendix 7) show slight, but steady, water-level declines from April 1988 to January 1991, dropping about 2 ft during the period (Fig. 28). Below-normal precipitation in 26 months during the period from

Figure 28. Hydrograph of the McQueen Branch aquifer at site C-2 (Feb. 1989 to Jun. 1991).

1988 to 1991 (Fig. 29) probably caused the declines. By 1993, water levels had recovered to their previous levels recorded in early 1988 (Appendix 7).

The aquifer shows little or no effects from the drought of 1993 (Fig. 30). In general, water levels dropped less than 1 foot at each site during the period from April 1993 to November 1993 (Appendix 7). At site C-2, water levels actually rose during the drought.

The McQueen Branch is the most permeable aquifer in the study area owing to the relative abundance of coarse-grained sand in the aquifer (Fig. 15). Siple (1967) reported the results of 11 pumping tests of the McQueen Branch aquifer made in 1951 and 1952 at SRS. Two of the pumping tests duplicated previous tests, thus the results from nine tests are used in the following discussion (Table 10). One pumping test was made in A-M Area (Siple, 1967) that produced a transmissivity of 147,000 gal/d/ft (19,700 ft²/d). Using a sand thickness of 181 ft, a hydraulic conductivity of 812 gal/d/ft² (109 ft/d) is calculated.

Figure 29. Departures from normal precipitation at station 380074 in Aiken, S.C. (Jan. 1988 to Dec. 1991).

The remaining eight pumping tests were made in F- and H-Areas of GSA. Transmissivities from these tests ranged from 105,000 to 375,000 gal/d/ft (14,000 to 50,100 ft²/d) and averaged 216,000 gal/d/ft (28,900 ft²/d). Hydraulic conductivity ranged from 393 to 1,569 gal/d/ft² (53 to 210 ft/d) and averaged 874 gal/d/ft² (117 ft/d).

A pumping test made at production well 905-102F (BRN-901), located in the north-central part of SRS (Fig. 19), produced a transmissivity of 200,000 gal/d/ft (26,700 ft²/d) (Table 7). The well is screened solely in the McQueen Branch aquifer. With sand thickness of 156 ft, which was measured at nearby well P-28, the hydraulic conductivity is indicated to be 171 ft/d.

Figure 30. Hydrograph of the McQueen Branch aquifer at site C-2 (Apr. 1993 to Nov. 1993).

Confining Systems

Meyers Branch - The Meyers Branch confining system separates the Floridan aquifer system from the underlying Dublin and Dublin-Midville aquifer systems (Fig. 13; Plate 9). North of the updip limit of the confining system (Fig. 14), the Floridan and Dublin-Midville aquifer systems are in hydraulic communication and coalesce to form the Floridan-Midville aquifer system.

The Meyers Branch is correlative with the Chattahoochee River confining unit of Miller and Renken (1988), with the unnamed confining unit that separates the Black Creek aquifer of Aucott and others (1987) from the overlying Tertiary sand/Floridan aquifer in South Carolina, and with the Baker Hill-Nanafalia unit in neighboring eastern Georgia (Clarke and others, 1985). Sediments of the system correspond to clay and interbedded sand of the upper Steel Creek Formation, and lignitic, sandy clay and clay of the Lang Syne/Sawdust Landing and Snapp Formations (Fig. 10).

In the study area, the Meyers Branch confining system consists of a single confining unit, the Crouch Branch, which includes several thick, relatively continuous (over several miles), clay beds. The Crouch Branch confining unit extends north of the updip limit of the Meyers Branch (Fig. 14; Plate 9), where clay beds of the confining unit thin and are locally absent. Here, the Crouch Branch confining unit no longer regionally separates the Floridan aquifer system from the other aquifer systems but simply separates the Steed Pond aquifer from the underlying Crouch Branch aquifer of the Floridan-Midville aquifer system.

Allendale - The Allendale confining system is present in the southeastern half of the study area and separates the Midville aquifer system from the overlying Dublin aquifer system (Fig. 13; Plate 9). The system is correlative with the unnamed confining unit that separates the Middendorf and Black Creek aquifers of Aucott and others (1987) and with the Black Creek-Cusseta confining unit of Clarke and others (1985). In the study area, the Allendale consists of a single confining unit, the McQueen Branch. The updip limit of the system is established where pronounced thinning of clay beds occurs parallel to the Pen Branch Fault.

The Allendale confining system is defined for hydrogeologic characteristics of sediments penetrated at site C-10 (Aadland and others, in press). Here, the system is 162 ft thick and consists primarily of micritic clay and micritic silty clay with minor interbedded sand and clayey sand. Total clay thickness is 158 ft, or 98 percent of the total thickness of the system. Updip, the system consists of beds of slightly lignitic, glauconite-bearing, very micaceous clay, with occasional silty, sandy clay and clayey sand beds present.

Appleton - The Appleton confining system is the lowermost confining system of the Southeastern Coastal Plain hydrogeologic province and separates the province from the underlying Piedmont hydrogeologic province (Fig. 13; Plate 9). The Appleton is equivalent to the Black Warrior River aquifer and the Black Warrior River confining unit of Miller and Renken (1988) and to the basal unnamed confining unit of Aucott and others (1987). It consists of saprolite and indurated, poorly sorted, silty, sand and clayey sand and clay of the basal Cape Fear Formation. Saprolite ranges from 6 to 47 ft in the study area and reflects the depth of weathering attained on the basement unconformity prior to deposition of the Cape Fear Formation. Sediments of the Cape Fear Formation are generally more indurated than sediments in the overlying aquifers and confining units. In the northern part of the study area the Cape Fear Formation pinches out and the Appleton consists solely of saprolite. The system thickens from 15 ft at site C-2 to 237 ft at site C-10 (Table 6).

The Appleton confining system is defined by the hydrogeologic properties of sediments penetrated at site C-10 (Aadland and others, in press). Here, the system is 237 feet thick and consists of 6 ft of saprolite and interbedded sand, clayey sand, and clay of the Cape Fear Formation. The Cape Fear Formation consists of stiff gray, brown, or variegated, silty clay and micaceous, very clayey, very silty, feldspathic, very fine to very coarse sand. Some coarse pebble zones are present.

The confining system is thought to consist of a single confining unit throughout the study area. Towards the coast, however, the Appleton confining system thickens considerably and includes several aquifers (Clarke and others, 1985). Aquifers included in the confining system in downdip regions are poorly defined because few wells penetrate them. No aquifer units or zones are delineated in the Appleton in the northern and central parts of the study area. At sites C-6 and C-10, however, unconsolidated sand beds are present that may constitute the updip edge of the aquifers observed in the Appleton south of the study area.

Three silty clay samples from the Appleton confining system at C-10 were analyzed for grain size (Core Laboratories, 1992) (Appendix 4). Sand averaged 21 percent; silt 64 percent; and clay 14 percent. Mean grain size ranged from 3.5 ϕ (very fine sand) to 5.4 ϕ (medium silt size) and averaged 4.5 ϕ (coarse silt size). Each sample was fine-skewed. Laboratory-derived porosity from the three mud samples (Core Laboratories, 1992) ranged from 26.0 percent to 30.6 percent and averaged 28.1 percent (Appendix 4). Vertical hydraulic-conductivity values ranged from 3.8 x 10⁻³ to 1.6 x 10⁻² ft/d and averaged 1.1 x 10⁻² ft/d.

Fourteen samples were analyzed for clay mineralogy by x-ray diffraction (Appendix 3). Although kaolinite is most abundant, illite and mixed-layer illite/smectite are also common. Results of the analyses are summarized below. Three samples from the confining system were analyzed by Core Laboratories (1992) with infrared spectroscopy (MINERALOG™) (Appendix 4). Illite and smectite ranged from 12.6 to 22.2 percent and averaged 18.8 percent. Kaolinite ranged from 14.8 to 20.8 percent and averaged 18.2 percent.

SUMMARY STATISTICS OF CLAY MINERALOGY IN THE APPLETON CONFINING SYSTEM										
	Illite (%)	Kaolinite (%)	Chlorite (%)	Illite/smectite (%)	Smectite (%)	Total clay (%)	Quartz (%)	Feldspar (%)	Calcite (%)	Total (%)
Mean	28.57	45.00	0.21	23.86	2.36	100.00	0.00	0.00	0.00	100.00
Median	29.50	46.00	0.00	26.50	1.00	100.00	0.00	0.00	0.00	100.00
Std. Dev.	13.66	21.49	0.58	12.20	2.21	0.00	0.00	0.00	0.00	0.00
Variance	186.57	461.85	0.34	148.90	4.86	0.00	0.00	0.00	0.00	0.00
Range	51.00	83.00	2.00	38.00	6.00	0.00	0.00	0.00	0.00	0.00
Minimum	3.00	14.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00	100.00
Maximum	54.00	97.00	2.00	38.00	6.00	100.00	0.00	0.00	0.00	100.00
Sum	400.00	630.00	3.00	334.00	33.00	1400.00	0.00	0.00	0.00	1400.00
Count	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00

Confining Units

Gordon - Fine-grained, glauconitic, clayey sand and clay of the Warley Hill Formation and clayey micrite of the Blue Bluff Member of the Santee Limestone (Fig. 10) constitute the Gordon confining unit. The Gordon confining unit separates the Gordon aquifer from the overlying Upper Three Runs aquifer (Fig. 13; Plate 9).

In the area of Upper Three Runs Creek to the vicinity of L Lake and Par Pond at SRS, the confining unit generally consists of one or more thin clay or sandy clay beds of the Warley

Hill Formation. Southward from L Lake and Par Pond, however, the stratigraphic interval that includes the Gordon confining unit undergoes a facies change to clayey micrite and limy clay typical of the Blue Bluff Member of the overlying Santee Limestone. The Blue Bluff reaches its maximum thickness at site C-7, where it is 86 ft thick (Table 6). Between sites C-7 and C-10 and between sites C-6 and C-10, the Blue Bluff thins owing to a facies change from micrite and limy clay of the Blue Bluff Member to shelly limestone of the Santee (Fig. 11; Plate 9).

Thin-section analysis indicates that the dominant allochems in the Blue Bluff are forams, echinoderms, pelecypods, bryozoans, and broken skeletal debris (Thayer, 1989 and personal communication). Monocrystalline quartz and clay matrix are the chief terrigenous constituents. Other constituents are authigenic pyrite, collophane, muscovite, and heavy and opaque minerals. Glauconite, up to 30 percent, is present in some places.

Clay mineralogy of the Gordon confining unit at the C-well sites was determined from x-ray diffraction techniques and is summarized below. Illite is the most abundant clay mineral, averaging 65 percent. With the exception of the Appleton confining system, illite is very common in each of the confining units. Kaolinite, on the other hand, is common in the aquifers. This could be due to a number of factors, including hydraulic sorting of clay minerals, degradation of illite to kaolinite caused by slow but persistent flushing of the aquifers, or, as seen in several of the thin-section analyses (Thayer, 1989 and personal communication), by weathering of feldspars and replacement by kaolinite. It is believed, for example, that the McQueen Branch aquifer contained considerably more feldspar. This is indicated by the presence of corroded "skeletal" feldspar grains in the aquifer and by the abundance of authigenic kaolinitic "books", which probably are replacements of original feldspar grains.

SUMMARY STATISTICS OF CLAY MINERALOGY IN THE GORDON CONFINING UNIT										
	Illite (%)	Kaolinite (%)	Chlorite (%)	Illite/smectite (%)	Smectite (%)	Total clay (%)	Quartz (%)	Feldspar (%)	Calcite (%)	Total (%)
Mean	65.00	7.25	0.25	25.50	2.00	100.00	0.00	0.00	0.00	100.00
Median	66.50	7.00	0.00	25.00	2.00	100.00	0.00	0.00	0.00	100.00
Std. Dev.	4.83	4.57	0.50	1.00	1.83	0.00	0.00	0.00	0.00	0.00
Variance	23.33	20.92	0.25	1.00	3.33	0.00	0.00	0.00	0.00	0.00
Range	11.00	11.00	1.00	2.00	4.00	0.00	0.00	0.00	0.00	0.00
Minimum	58.00	2.00	0.00	25.00	0.00	100.00	0.00	0.00	0.00	100.00
Maximum	69.00	13.00	1.00	27.00	4.00	100.00	0.00	0.00	0.00	100.00
Sum	260.00	29.00	1.00	102.00	8.00	400.00	0.00	0.00	0.00	400.00
Count	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00

Effective leakance coefficients were calculated at each well by using lab-derived vertical hydraulic-conductivity values and lithology thicknesses at each well (Aadland and others, in press). The geometric mean vertical hydraulic conductivity of 55 sandy clay and clay samples from the P-well series core at SRS is 1.67×10^{-4} ft/d. The geometric mean vertical hydraulic conductivity of 28 clayey sand samples from the P-well series core is 8.90×10^{-3} ft/d. Leakance values for the clay beds were calculated by dividing the geometric mean vertical hydraulic conductivity value of the clay samples (1.67×10^{-4} ft/d) by the total clay thickness in the confining unit. Likewise, leakance values for the clayey sand beds were calculated by dividing the geometric mean vertical hydraulic conductivity value of the clayey sand samples (8.90×10^{-3} ft/d) by the total clayey sand in the confining unit. Effective leakance is the sum of the two leakance values added in series. Effective leakance coefficients of the Gordon confining unit in the "C" wells range from 1.94×10^{-6} /d, at site C-7, to 2.37×10^{-5} /d, at site C-5 (Table 6).

Three Blue Bluff micrite samples were analyzed in the laboratory, two from site C-6 and one from site C-7. Vertical hydraulic-conductivity values range from 1.22×10^{-4} to 1.95×10^{-4} ft/d. The geometric mean value of the three measurements is 1.51×10^{-4} ft/d. This value is similar to the geometric mean calculated for the sandy clay to clay samples (1.67×10^{-4} /d) from the "P" wells. Average porosity of the three Blue Bluff samples is 14.2 percent.

BLUE BLUFF SAMPLES ANALYZED IN LABORATORY			
<u>Cluster site</u>	<u>Depth (ft, lsd)</u>	<u>Porosity (percent)</u>	<u>Vertical hydraulic conductivity (ft/d)</u>
C-6	177	11.4	1.46×10^{-4}
C-6	199	19.1	1.95×10^{-4}
C-7	266	12.0	1.22×10^{-4}

Hydraulic-head relationships across the confining units are presented on Plates 1-7. The Gordon confining unit supports a head of 33.7 ft at site C-7 (Plate 6), where the Blue Bluff lithologies are thickest. The unit supports a head of 13.8 ft at site C-6 (Plate 5) and 29.0 ft at site C-5 (Plate 4). At each site, the vertical gradient is downward from the Upper Three Runs aquifer to the underlying Gordon aquifer.

Crouch Branch - The Crouch Branch confining unit extends from north of SRS, where it is an integral part of the Floridan-Midville aquifer system, southward through the study area where it constitutes the Meyers Branch confining system (Fig. 14). Thickness of the Crouch Branch in the "C" wells ranges from 11 ft at site C-2 to 147 ft at site C-10 (Table 6).

The Crouch Branch confining unit is defined by the hydrogeologic characteristics of sediments penetrated in well P-27, near the center of SRS, and is named for Crouch Branch, a tributary of Upper Three Runs Creek (Aadland and others, in press). At its type-well location, the confining unit is 130 ft thick and consists of clay and silty clay of the uppermost part of the Steel Creek Formation and dark-gray clay and silty clay, interbedded with dark-gray to black, lignitic, silty, and clayey sand of the Lang Syne/Sawdust Landing and Snapp Formations.

Clay mineralogy determined for the unit is summarized below. Illite is the most abundant clay mineral, averaging 39 percent.

SUMMARY STATISTICS OF CLAY MINERALOGY IN THE CROUCH BRANCH CONFINING UNIT										
	Illite (%)	Kaolinite (%)	Chlorite (%)	Illite/ smectite (%)	Smectite (%)	Total clay (%)	Quartz (%)	Feldspar (%)	Calcite (%)	Total (%)
Mean	38.67	35.67	0.11	23.11	1.67	99.22	0.78	0.00	0.00	100.00
Median	46.00	32.00	0.00	24.00	0.00	100.00	0.00	0.00	0.00	100.00
Std. Dev.	17.54	25.31	0.33	10.99	2.29	1.99	1.99	0.00	0.00	0.00
Variance	307.50	640.75	0.11	120.86	5.25	3.94	3.94	0.00	0.00	0.00
Range	50.00	72.00	1.00	32.00	5.00	6.00	6.00	0.00	0.00	0.00
Minimum	15.00	6.00	0.00	7.00	0.00	94.00	0.00	0.00	0.00	100.00
Maximum	65.00	78.00	1.00	39.00	5.00	100.00	6.00	0.00	0.00	100.00
Sum	348.00	321.00	1.00	208.00	15.00	893.00	7.00	0.00	0.00	900.00
Count	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00

Leakance coefficients in the "C" wells range from 1.52×10^{-5} /d to 1.56×10^{-6} /d (Table 6). In the vicinity of C-1, clay beds of the Crouch Branch thicken dramatically and the calculated

leakance is $3.61 \times 10^{-6}/d$, similar to leakance values obtained in the southern regions of the study area.

The unit supports a head of 9.1 ft at site C-5, 8.3 ft at site C-6, and 26.4 ft at site C-7 (Plates 4-6). At sites C-6 and C-7, an upward gradient exists from the Crouch Branch to the overlying Gordon. At site C-5, however, the gradient is reversed and the potential is downwards from the Gordon aquifer to the underlying Crouch Branch aquifer. A downward vertical gradient extends from site C-5 to H-Area and south to L- and P-Areas (Aadland and others, in press). These probably are areas of recharge to the Gordon aquifer. Areas of upward gradients occur at SRS along Upper Three Runs Creek, where the Gordon is deeply incised and drained by the creek. Upward gradients also occur along the Savannah River and in southern regions of SRS and the study area. In updip areas, upward gradients generally occur near discharge boundaries of the Gordon aquifer. In downdip areas, upward gradients exist where confining beds of the overlying Gordon confining unit are thick, such as in the area where carbonate mud of the Blue Bluff lithology was deposited.

McQueen Branch -The McQueen Branch confining unit constitutes the Allendale confining system in the southern part of the study area and is an integral part of the Dublin-Midville and Floridan-Midville aquifer systems to the north. Throughout the study area the confining unit separates the McQueen Branch aquifer from the overlying Crouch Branch aquifer (Fig. 13; Plate 9). Thickness of the unit at the "C" wells ranges from 22 ft at site C-2 to 162 ft at site C-10 (Table 6).

The McQueen Branch confining unit is defined by the hydrogeologic properties of the sediments penetrated in well P-27, near the center of SRS, and is named for McQueen Branch, a tributary of Upper Three Runs Creek (Aadland and others, in press). The confining unit is 55 ft thick in well P-27 and consists of clay and interbedded silty, often sandy clay and sand beds that constitute the middle third of the Black Creek Formation.

Clay mineralogy of the confining unit determined from x-ray diffraction is summarized below. Illite is the most abundant clay mineral, averaging 42 percent. Mineralogy of four samples from the confining unit was determined with infrared spectroscopy (Core Laboratories, 1992) (Appendix 4). The predominant clay minerals were illite and smectite, followed by kaolinite and traces of chlorite.

SUMMARY STATISTICS OF CLAY MINERALOGY IN THE MCQUEEN BRANCH CONFINING UNIT										
	Illite (%)	Kaolinite (%)	Chlorite (%)	Illite/smectite (%)	Smectite (%)	Total clay (%)	Quartz (%)	Feldspar (%)	Calcite (%)	Total (%)
Mean	42.22	30.78	0.33	23.33	2.78	99.44	0.56	0.00	0.00	100.00
Median	39.00	13.00	0.00	25.00	3.00	100.00	0.00	0.00	0.00	100.00
Std. Dev.	20.63	29.34	0.71	13.21	2.17	1.67	1.67	0.00	0.00	0.00
Variance	425.44	860.94	0.50	174.50	4.69	2.78	2.78	0.00	0.00	0.00
Range	58.00	81.00	2.00	44.00	6.00	5.00	5.00	0.00	0.00	0.00
Minimum	12.00	3.00	0.00	4.00	0.00	95.00	0.00	0.00	0.00	100.00
Maximum	70.00	84.00	2.00	48.00	6.00	100.00	5.00	0.00	0.00	100.00
Sum	380.00	277.00	3.00	210.00	25.00	895.00	5.00	0.00	0.00	900.00
Count	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00

Four mud samples from site C-10 were analyzed for grain size with high-resolution, laser techniques (Core Laboratories, 1992) (Appendix 4). On average, the samples consist of 17.4 percent sand, 71.5 percent silt, and 11.1 percent clay. Mean grain size ranges from 5.7φ

(medium silt size) to 4.4 ϕ (coarse silt size) and averages 5.0 ϕ (medium-coarse silt boundary). The samples are fine-skewed.

A petrographic analysis of one mudstone from well C-10 (-738 ft msl) shows that the sample is a fossiliferous silty clay consisting of monocrystalline quartz and clay minerals with trace amounts of muscovite, collophane, heavy minerals, organic debris, pyrite, and skeletal fragments, including forams, pelecypods, and bryozoans (Thayer, 1994). The confining unit supports a head of 0.3 ft at updip site C-3, where the confining unit is a part of the Floridan-Midville aquifer system, and 25.3 ft at downdip site C-7, where the unit is part of the regional Allendale confining system. There is an upward vertical gradient between the McQueen Branch and Crouch Branch aquifers at each site.

DISCUSSION

Inspection of chemical analyses of water from each aquifer suggests that many of the samples may have been contaminated by leaching of grout along the annuli of the wells. As noted above, wells in the network were pressure-grouted from about 15 ft above the screen setting to land surface in order to hydraulically isolate zones that were of importance to the study. In many cases, therefore, grout was emplaced in the aquifer and water is in contact with grouted sections of the well. Stiff diagrams, which show the relative concentrations of major cations and anions, were constructed for wells at site C-2 (Fig. 31). Site C-2 is located updip, north of SRS (Fig. 1). Although no carbonate sediments are present in the sedimentary sequence this far updip, the chemical analyses indicate that the water has relatively high concentrations of calcium and bicarbonate and plots as a calcium bicarbonate water type on the diagrams. The pH of the water ranges from 5.7 to 7.8 (1991 data). Examination of Stiff diagrams from other wells in the network reveals the same pattern. These data suggest that leaching of grout has elevated the calcium and bicarbonate concentrations in the immediate vicinity of the wells. A second plausible explanation for the calcium bicarbonate water is that the wells may not have been properly developed, causing drilling fluid to remain trapped in the invaded zone of the aquifer.

Sieve analyses provide hard data regarding the granularity of sediments. Relating sieve data to hydraulic properties, however, is speculative and should be viewed as such. The empirical methodology of Beard and Weyl (1973) has been used consistently at SRS over the years (Paul Thayer, personal communication). The same method was used in this report for the purpose of making comparisons between hydraulic properties of aquifers outside SRS with those onsite. It has been found that the method seems to overestimate hydraulic conductivity and in at least one case, as in the Upper Three Runs aquifer, is poorly correlated with data derived from field tests. Evans and Parizek (1991) used regression analysis and found no correlation between hydraulic conductivity calculated from slug tests and those calculated from sieve analyses of the Upper Three Runs aquifer in GSA. Weak correlations were also found among slug-test results and median grain size and the Trask sorting coefficient. These poor correlations probably are due to high clay content in the aquifer but can also be due to the effects of other parameters not characterized by sieve analyses, such as cementation and grain shape. Sampling bias may also skew results. Sieve samples collected solely from clean, sandy portions of screened intervals will not represent the lithologic heterogeneity of sediments of the Upper Three Runs aquifer and will have elevated hydraulic-conductivity values relative to those calculated from field methods.

Hydraulic conductivity derived from three pumping tests of the Gordon aquifer in Barnwell and Blackville, S.C., range from 32 to 41 ft/d and average 38 ft/d. In comparison, sieve data of the aquifer from sites C-5 and C-6 indicate an average hydraulic conductivity of 117 ft/d, three times as great as that derived from pumping test data. The geometric mean hydraulic conductivity of the sieve data is 72 ft/d, which is more in line with results from the pumping tests.

Sieve analyses of the Crouch Branch and McQueen Branch aquifers at site C-5 were made, on average, every 3.6 ft through the aquifers ($n = 151$). The average hydraulic conductivity is 129 ft/d and the geometric mean is 84 ft/d. In comparison, a hydraulic conductivity of 49 ft/d was calculated from a pumping test of a well screened in the Crouch Branch and McQueen Branch aquifers in Williston, S.C., located about 5 mi north of C-5. The value obtained from the sieve data is, again, much higher. In every aquifer in the study area, hydraulic conductivity calculated from sieve data is higher than that calculated from pumping

Note: The CaHCO_3 water type indicated on these graphs is erroneous due to leaching of grout along the annulus of the wells.

Figure 31. Stiff diagrams of wells at site C-2.

tests. It is unclear whether this is due to sampling biases or to shortcomings associated with the methodology.

A comparison of grain size and sorting (Fig. 32) indicates that the McQueen Branch is the coarsest grained aquifer; the Upper Three Runs is the finest grained aquifer. This makes sense in terms of the relative permeability of aquifers in the study area. In general, the Upper Three Runs is the least permeable and the McQueen Branch is the most permeable aquifer (determined from pumping tests). On average, the two Cretaceous aquifers, the Crouch Branch and the McQueen Branch, are more poorly sorted than the Tertiary aquifers (Fig. 32). The Upper Three Runs aquifer, however, has a greater range of sorting classes than other aquifers. This probably is due to the high clay content of the aquifer, which greatly affects the sorting coefficient.

As discussed, clay mineralogy of aquifers is different from that for confining units. Most aquifers are enriched in kaolinite and confining units in illite and mixed-layer illite/smectite. Results of the 100 x-ray diffraction analyses made for this study were averaged over all of the aquifers and confining units and are summarized below. Aquifers have nearly twice the amount of kaolinite as confining units, while confining units have nearly twice the amount of illite and mixed-layer illite/smectite. Exceptions to this trend include the Gordon aquifer, which has greater amounts of illite than kaolinite, and the Appleton confining system, which has greater amounts of kaolinite.

Figure 32. Comparison of grain size and sorting among aquifers.

Percentage of clay minerals in aquifers and confining units				
	<u>Kaolinite</u>	<u>Illite</u>	<u>Illite/Smectite</u>	<u>Smectite</u>
Aquifers ($n = 64$)	63	23	11	2
Confining units ($n = 36$)	35	39	24	2

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APPENDICES

APPENDIX 1. Grain-size cumulative curves of selected screen intervals.

<u>Cluster site</u>	<u>Well</u>	<u>Screen depth (ft)</u>	<u>Sieve depth (ft)</u>
C-1	AIK-902	496-506	499
C-1	AIK-902	496-506	505
C-2	AIK-823	153-163	158
C-2	AIK-825	216-226	217
C-2	AIK-824	350-360	355
C-2	AIK-818	410-420	415
C-2	AIK-817	520-530	525
C-3	AIK-849	82-92	81, 85, 88
C-3	AIK-848	116-126	116
C-3	AIK-847	178-188	183, 186
C-3	AIK-846	240-250	244, 246, 248
C-3	AIK-845	341-351	344, 347, 353
C-3	AIK-826	485-495	487, 490
C-5	BRN-360	125-134	131
C-5	BRN-359	199-209	205, 208
C-5	BRN-367	270-280	275, 279
C-5	BRN-368	428-438	428, 431
C-5	BRN-365	524-534	528
C-5	BRN-366	700-710	707
C-5	BRN-358	832-842	835, 837, 840
C-6	BRN-351	80-90	85
C-6	BRN-350	155-165	156, 164
C-6	BRN-352	278-288	284
C-6	BRN-354	396-406	398
C-6	BRN-353	573-583	580
C-6	BRN-355	686-696	693
C-6	BRN-356	914-924	920
C-6	BRN-349	1,030-1,040	1,040
C-7	ALL-358	1,108-1,118	1,116
C-10	ALL-347	1,408-1,418	1,417
C-10	ALL-348	1,575-1,600	1,590

· APPENDIX 2, Well-construction diagrams.

APPENDIX 3. Grain-size distribution parameters; gravel, sand, and mud percentages; and porosity and permeability estimated from sieve data.

Grain-Size Parameters and Derivations

Grain Size Scales

<u>phi units (ϕ)</u>	<u>Millimeters (mm)</u>	<u>U.S. Standard Sieve Series</u>	<u>Grade name</u>
< -1	> 2.000	< No. 10	Gravel
-1	2.000	No. 10	Very Coarse
0	1.000	No. 18	
+1	0.500	No. 35	Coarse
+2	0.250	No. 60	Medium
+3	0.125	No. 120	Fine
+4	0.062	No. 230	Very Fine
>+4	< 0.062	> No. 230	
			Mud

Folk and Ward (1957)

Mean: $M_z = \frac{Q_{16} + Q_{50} + Q_{84}}{3}$, where Q = Quartile, in phi units.

Sorting: $I = \frac{Q_{84} - Q_{16}}{4} + \frac{Q_{95} - Q_5}{6.6}$, where Q = Quartile, in phi units.

< 0.35 ϕ	very well sorted	1.00 to 2.00 ϕ	poorly sorted
0.35 to 0.50 ϕ	well sorted	2.00 to 4.00 ϕ	very poorly sorted
0.50 to 0.71 ϕ	moderately well sorted	> 4.00 ϕ	extremely poorly sorted
0.71 to 1.00 ϕ	moderately sorted		

Trask (1930)

Median: The diameter in millimeters that is larger than 50 percent of the diameter in the distribution and smaller than the other 50 percent. Shown on the cumulative curve, it is the point where the 50th percent line crosses the curve.

Sorting (S_o): $S_o = \frac{\sqrt{Q_{75} - Q_{25}}}{Q_{25}}$, where Q = Quartile, in phi units.

STEED POND AQUIFER SIEVE ANALYSIS															
Well	Altitude (ft, msl)	Depth (ft, lsd)	Folk and Ward		Trask			Gravel (%)	Sand (%)	Mud (%)	Porosity (%)	Permeability		Description (Folk and Ward)	Formation
			Mean	Sorting	Median	Sorting	Sort (mm)					(Darcy)	(ft/d)		
C-1	219	16	1.46	1.21	1.39	0.57	1.48	0.57	88.70	10.73	35.2	21.0	51.1	Upper m sand; poorly sorted	Unknown
	200	35	2.33	0.78	2.41	0.39	1.31	0.17	93.99	5.84	38.3	14.0	34.1	Upper f sand; moderately sorted	Unknown
	185	50	1.42	1.40	1.42	0.95	1.93	1.83	91.41	6.76	30.6	24.0	58.4	Upper m sand; poorly sorted	Unknown
	168	67	1.88	1.65	1.31	0.89	1.85	0.36	83.15	16.49	31.2	31.0	75.4	Lower m sand; poorly sorted	Unknown
	153	82	2.00	0.80	1.97	0.57	1.48	0.14	95.68	4.18	35.0	18.0	43.8	Upper f sand; moderately sorted	Unknown
	147	88	3.16	0.79	3.17	0.59	1.50	0.00	85.92	14.08	36.2	3.0	7.3	Upper vf sand; moderately sorted	Unknown
	399	20	1.25	1.43	0.91	0.76	1.70	1.69	87.38	10.93	32.8	60.0	146.0	Upper m sand; poorly sorted	Upland unit
	386	33	0.95	1.18	0.95	0.71	1.64	0.91	94.29	4.80	33.1	61.0	148.4	Lower c sand; poorly sorted	Tobacco Road
C-2	357	62	0.10	1.31	0.12	0.80	1.75	18.73	78.42	2.85	32.7	160.0	389.3	Upper c sand; poorly sorted	Tobacco Road
	334	85	1.23	1.80	1.20	1.30	2.47	7.26	82.70	10.04	27.8	12.0	29.2	Upper m sand; poorly sorted	Dry Branch
	309	110	2.77	0.60	2.67	0.35	1.27	0.00	96.02	3.98	39.1	9.0	21.9	Lower f sand; well sorted	Congaree/Fourmile
	279	140	1.29	0.86	1.31	0.57	1.49	0.08	96.80	3.12	34.2	44.0	107.1	Upper m sand; moderately sorted	Congaree/Fourmile
	261	158	1.89	0.67	1.82	0.52	1.44	0.00	98.23	1.77	35.1	23.0	56.0	Lower m sand; well sorted	Congaree/Fourmile
	281	14	2.08	0.94	2.07	0.65	1.56	0.23	95.00	4.77	34.2	15.0	36.5	Upper f sand; moderately sorted	Dry Branch
	275	20	1.87	1.04	1.76	0.68	1.60	0.12	95.31	4.57	33.8	18.0	43.8	Lower m sand; poorly sorted	Dry Branch
	271	24	2.65	1.04	2.57	0.60	1.51	0.12	88.84	11.04	35.2	8.0	19.5	Lower f sand; poorly sorted	Dry Branch
	262	33	1.12	0.85	1.20	0.57	1.49	1.43	97.73	0.84	34.2	50.0	121.7	Upper m sand; moderately sorted	Congaree/Fourmile
	258	37	-0.25	1.23	-0.30	0.85	1.81	27.65	71.38	0.97	33.7	321.0	781.0	Lower vc sand; poorly sorted	Congaree/Fourmile
C-3	251	44	0.32	1.80	-0.08	1.61	3.06	31.77	66.40	1.83	27.8	25.0	60.8	Upper c sand; poorly sorted	Congaree/Fourmile
	246	49	1.86	0.83	1.75	0.55	1.46	0.75	97.37	1.88	35.0	23.0	56.0	Lower m sand; moderately sorted	Congaree/Fourmile
	244	51	2.42	1.28	1.88	0.70	1.63	0.12	81.29	18.59	33.6	18.0	43.8	Upper f sand; poorly sorted	Congaree/Fourmile
	219	76	2.19	1.34	1.69	0.66	1.58	0.24	84.50	15.26	34.0	23.0	56.0	Upper f sand; poorly sorted	Lang Syne/Sawdust
	214	81	1.30	1.32	1.01	0.77	1.70	0.12	89.95	9.93	32.8	53.0	129.0	Upper m sand; poorly sorted	Lang Syne/Sawdust
	210	85	1.43	1.15	1.39	0.56	1.48	0.24	91.26	8.50	34.6	40.0	97.3	Upper m sand; poorly sorted	Lang Syne/Sawdust
	207	88	1.46	1.09	1.45	0.45	1.36	0.38	90.73	8.89	36.4	43.0	104.6	Upper m sand; poorly sorted	Lang Syne/Sawdust

UPPER THREE RUNS AQUIFER SIEVE ANALYSIS

Well	Altitude (ft, msl)	Depth (ft, lsd)	Folk and Ward		Trask			Gravel (%)	Sand (%)	Mud (%)	Porosity (%)	Permeability		Description (Folk and Ward)	Formation
			Mean	Sorting	Median	Sorting	Sort (mm)					(Darcy)	(ft/d)		
	243	22	0.62	1.49	0.49	0.89	1.85	4.87	84.02	11.11	31.3	92.0	223.9	Lower c sand; poorly sorted	Tobacco Road
	234	31	2.26	1.48	1.69	0.75	1.68	0.12	81.26	18.62	33.1	19.0	46.2	Upper f sand; poorly sorted	Tobacco Road
	213	52	0.65	2.12	-0.07	1.54	2.91	22.74	65.19	12.07	28.2	38.0	92.5	Lower c sand; v poorly sorted	Tobacco Road
	206	59	2.44	1.70	2.36	1.20	2.30	3.02	75.70	21.28	29.6	4.0	9.7	Upper f sand; poorly sorted	Tobacco Road
	196	69	1.24	0.76	1.33	0.47	1.39	0.10	96.29	3.61	35.5	47.0	114.4	Upper m sand; moderately sorted	Dry Branch
C-5	180	85	2.19	1.03	2.35	0.55	1.46	0.12	92.16	7.72	35.3	10.0	24.3	Upper f sand; poorly sorted	Dry Branch
	172	93	2.51	0.69	2.51	0.33	1.26	0.12	92.58	7.30	39.2	13.0	31.6	Lower f sand; well sorted	Dry Branch
	159	106	1.99	1.44	1.70	0.84	1.79	0.00	85.73	14.27	32.1	19.0	46.2	Lower m sand; poorly sorted	Dry Branch
	154	111	1.60	1.34	1.48	0.81	1.75	0.12	88.62	11.26	32.4	28.0	68.1	Lower m sand; poorly sorted	Dry Branch
	142	123	2.01	1.11	2.14	0.72	1.65	0.12	93.62	6.26	33.8	12.0	29.2	Upper f sand; poorly sorted	Dry Branch
	134	131	1.47	1.09	1.44	0.48	1.39	0.10	92.40	7.50	35.5	38.0	92.5	Upper m sand; poorly sorted	Dry Branch
	119	146	2.62	0.94	2.61	0.63	1.55	0.00	94.82	5.18	35.1	6.0	14.6	Lower f sand; moderately sorted	Dry Branch
	107	158	1.70	1.10	1.62	0.66	1.58	0.35	95.32	4.33	33.9	20.0	48.7	Lower m sand; poorly sorted	Dry Branch
	164	45	2.17	0.89	2.28	0.54	1.45	0.13	94.42	5.45	35.6	12.0	29.2	Upper f sand; moderately sorted	Dry Branch
	154	55	1.81	0.79	1.72	0.55	1.46	0.00	96.92	3.08	34.9	24.0	58.4	Lower m sand; moderately sorted	Dry Branch
	149	60	2.61	0.61	2.58	0.31	1.24	0.00	89.91	10.09	39.8	13.0	31.6	Lower f sand; well sorted	Dry Branch
	134	75	1.43	0.76	1.47	0.41	1.33	0.12	97.16	2.72	37.1	42.0	102.2	Upper m sand; moderately sorted	Dry Branch
C-6	124	85	2.43	0.79	2.47	0.40	1.32	0.00	94.33	5.67	38.0	13.0	31.6	Upper f sand; moderately sorted	Dry Branch
	94	115	1.64	0.71	1.56	0.37	1.30	0.00	96.46	3.54	37.8	41.0	99.8	Lower m sand; well sorted	Dry Branch
	79	130	1.64	0.75	1.55	0.40	1.32	0.00	98.04	1.96	37.3	42.0	102.2	Lower m sand; moderately sorted	Dry Branch
	67	142	1.70	0.67	1.62	0.37	1.29	0.00	98.06	1.94	38.0	38.0	92.5	Lower m sand; well sorted	Dry Branch
	53	156	1.98	1.94	1.87	1.33	2.51	7.42	74.97	17.61	28.3	5.0	12.2	Lower m sand; poorly sorted	Clinchfield
	175	77	1.32	0.90	1.39	0.36	1.28	0.00	94.28	5.72	38.1	60.0	146.0	Upper m sand; moderately sorted	Dry Branch
	151	101	1.50	0.33	1.50	0.27	1.21	0.00	97.03	2.97	39.8	58.0	141.1	Upper m sand; v well sorted	Dry Branch
C-7	131	121	1.52	0.75	1.52	0.30	1.23	0.00	91.87	8.13	39.8	54.0	131.4	Lower m sand; moderately sorted	Dry Branch
	111	141	1.29	0.90	1.37	0.38	1.30	0.00	94.88	5.12	37.8	53.0	129.0	Upper m sand; moderately sorted	Dry Branch
	86	166	1.37	0.64	1.42	0.35	1.27	0.00	96.80	3.20	38.4	53.0	129.0	Upper m sand; well sorted	Dry Branch
	60	192	1.69	0.78	1.59	0.45	1.37	0.00	96.32	3.68	34.5	36.0	87.6	Lower m sand; moderately sorted	Dry Branch
	258	32	0.85	1.63	0.62	0.80	1.74	6.63	79.97	13.40	32.3	39.0	94.9	Lower c sand; poorly sorted	Tobacco Road
	214	76	1.74	1.77	1.08	0.75	1.68	0.91	82.88	16.21	32.8	49.0	119.2	Lower m sand; poorly sorted	Tobacco Road
	192	98	0.47	2.06	-0.18	1.00	2.00	24.82	60.36	14.82	30.8	146.0	355.2	Upper c sand; v poorly sorted	Tobacco Road
C-10	182	108	1.42	1.69	0.70	0.73	1.66	2.27	82.43	15.30	33.1	85.0	206.8	Upper m sand; poorly sorted	Tobacco Road
	165	125	1.73	1.68	0.95	0.72	1.65	0.34	83.36	16.30	33.1	61.0	148.4	Lower m sand; poorly sorted	Tobacco Road
	148	142	1.13	2.41	0.42	1.86	3.63	24.23	52.68	23.09	26.8	17.0	41.4	Upper m sand; v poorly sorted	Tobacco Road
	118	172	1.98	1.63	1.38	0.65	1.56	0.16	81.72	18.12	33.9	38.0	92.5	Lower m sand; poorly sorted	Dry Branch
	-24	314	1.72	0.57	1.64	0.33	1.26	0.00	97.36	2.64	38.8	40.0	97.3	Lower m sand; well sorted	Dry Branch

GORDON AQUIFER SIEVE ANALYSIS

Well	Altitude (ft. msl)	Depth (ft. lsd)	Folk and Ward		Trask			Gravel (%)	Sand (%)	Mud (%)	Porosity (%)	Permeability		Description (Folk and Ward)	Formation
			Mean	Sorting	Median	Sorting	Sort (mm)					(Darcy)	(ft/d)		
	88	177	1.83	1.03	1.68	0.57	1.49	0.11	92.99	6.90	34.6	25.0	60.8	Lower m sand; poorly sorted	Tinker/Santee
	83	182	2.49	1.04	2.43	0.53	1.45	0.19	88.49	11.32	35.8	8.0	19.5	Upper f sand; poorly sorted	Tinker/Santee
	79	186	1.58	1.37	1.55	0.89	1.85	3.46	91.86	4.68	31.6	21.0	51.1	Lower m sand; poorly sorted	Tinker/Santee
	70	195	1.45	0.91	1.48	0.42	1.34	0.23	96.06	3.71	34.8	44.0	107.1	Upper m sand; moderately sorted	Tinker/Santee
	60	205	1.18	0.90	1.14	0.64	1.56	0.11	97.01	2.88	33.8	45.0	109.5	Upper m sand; moderately sorted	Congaree/Fourmile
	57	208	1.03	0.88	0.93	0.63	1.55	0.00	98.14	1.86	33.9	65.0	158.2	Upper m sand; moderately sorted	Congaree/Fourmile
	52	213	0.39	0.73	0.45	0.40	1.32	0.08	99.07	0.85	37.4	168.0	408.8	Upper c sand; moderately sorted	Congaree/Fourmile
	41	224	0.91	0.89	0.83	0.60	1.52	1.23	97.44	1.33	34.0	80.0	194.7	Lower c sand; moderately sorted	Congaree/Fourmile
	37	228	1.25	0.84	1.31	0.55	1.47	0.22	97.01	2.77	34.7	41.0	99.8	Upper m sand; moderately sorted	Congaree/Fourmile
	35	230	1.87	1.04	1.70	0.58	1.49	0.18	91.82	8.00	34.5	24.0	58.4	Lower m sand; poorly sorted	Congaree/Fourmile
C-5	33	232	1.83	1.05	1.65	0.54	1.45	0.00	91.32	8.68	35.0	26.0	63.3	Lower m sand; poorly sorted	Congaree/Fourmile
	31	234	1.79	0.96	1.65	0.46	1.38	0.19	93.30	6.51	36.0	29.0	70.6	Lower m sand; moderately sorted	Congaree/Fourmile
	24	241	2.11	1.10	1.82	0.67	1.59	0.11	88.51	11.38	34.0	23.0	56.0	Upper f sand; poorly sorted	Congaree/Fourmile
	20	245	1.74	0.61	1.64	0.35	1.27	0.10	96.94	2.96	38.3	39.0	94.9	Lower m sand; well sorted	Congaree/Fourmile
	16	249	1.51	1.49	1.28	0.87	1.83	2.15	88.28	9.57	31.6	30.0	73.0	Lower m sand; poorly sorted	Congaree/Fourmile
	10	255	1.08	1.34	0.80	0.76	1.69	0.60	93.15	6.25	32.8	74.0	180.1	Upper m sand; poorly sorted	Congaree/Fourmile
	7	258	0.47	1.05	0.44	0.50	1.41	0.65	96.98	2.37	35.2	140.0	340.6	Upper c sand; poorly sorted	Congaree/Fourmile
	5	260	0.72	0.72	0.62	0.40	1.32	0.10	99.28	0.62	37.3	142.0	345.5	Lower c sand; moderately sorted	Congaree/Fourmile
	0	265	0.76	1.40	0.77	0.94	1.91	5.78	89.94	4.28	30.3	58.0	141.1	Lower c sand; poorly sorted	Congaree/Fourmile
	-10	275	0.25	1.27	0.00	0.78	1.72	9.54	88.15	2.31	32.8	172.0	418.5	Upper c sand; poorly sorted	Congaree/Fourmile
	-14	279	2.26	0.98	2.36	0.54	1.45	0.22	91.25	8.53	35.7	9.0	21.9	Upper f sand; moderately sorted	Congaree/Fourmile
	-60	269	2.09	0.88	2.16	0.56	1.48	0.26	94.77	4.97	35.1	13.0	31.6	Upper f sand; moderately sorted	Congaree/Fourmile
	-75	284	2.11	0.98	2.14	0.60	1.52	1.05	89.19	9.76	34.8	12.0	29.2	Upper f sand; moderately sorted	Congaree/Fourmile
	-89	298	2.60	0.77	2.54	0.35	1.28	0.09	89.18	10.73	38.9	11.0	26.8	Lower f sand; moderately sorted	Congaree/Fourmile
	-94	303	3.07	0.95	2.77	0.72	1.65	0.11	78.17	21.72	34.4	4.0	9.7	Upper vf sand; moderately sorted	Congaree/Fourmile
C-6	-109	318	1.73	0.95	1.61	0.54	1.45	0.20	96.89	2.91	34.8	28.0	68.1	Lower m sand; moderately sorted	Congaree/Fourmile
	-130	339	0.99	0.75	0.94	0.55	1.47	0.18	98.62	1.20	34.7	75.0	182.5	Lower c sand; moderately sorted	Congaree/Fourmile
	-146	355	1.99	1.45	1.62	0.79	1.73	0.09	85.67	14.24	32.4	22.0	53.5	Lower m sand; poorly sorted	Congaree/Fourmile
	-165	374	3.12	0.79	3.09	0.60	1.51	0.00	86.36	13.64	32.0	3.0	7.3	Upper vf sand; moderately sorted	Congaree/Fourmile
	-189	398	2.79	1.10	2.60	0.57	1.49	0.00	84.95	15.05	35.5	7.0	17.0	Lower f sand; poorly sorted	Snapp
	-74	326	1.85	1.01	1.67	0.50	1.42	0.15	89.98	9.87	35.1	28.0	68.1	Lower m sand; poorly sorted	Congaree/Fourmile
	-94	346	1.55	0.62	1.54	0.34	1.27	0.00	96.50	3.50	38.3	48.0	116.8	Lower m sand; well sorted	Congaree/Fourmile
C-7	-114	366	1.25	0.90	1.35	0.55	1.46	0.40	96.96	2.64	34.7	41.0	99.8	Upper m sand; moderately sorted	Congaree/Fourmile
	-134	386	0.92	0.97	0.90	0.65	1.57	0.94	96.25	2.81	33.9	73.0	177.6	Lower c sand; moderately sorted	Congaree/Fourmile
	-154	406	2.36	1.26	2.50	0.87	1.83	0.16	93.77	6.07	32.7	6.0	14.6	Upper f sand; poorly sorted	Snapp
	-190	480	1.23	1.05	1.27	0.57	1.49	0.00	91.58	8.42	34.2	41.0	99.8	Upper m sand; poorly sorted	Congaree/Fourmile
C-10	-255	545	1.94	1.06	1.89	0.69	1.62	0.15	94.17	5.68	33.8	18.0	43.8	Lower m sand; poorly sorted	Congaree/Fourmile
	-274	564	0.98	0.76	0.95	0.56	1.48	0.00	97.08	2.92	34.3	72.0	175.2	Lower c sand; moderately sorted	Snapp

CROUCH BRANCH AQUIFER SIEVE ANALYSIS															
Well	Altitude (ft. msl.)	Depth (ft. bed)	Folk and Ward		Trask			Gravel (%)	Sand (%)	Mud (%)	Porosity (%)	Permeability		Description (Folk and Ward)	Formation
			Mean	Sorting	Median	Sorting	Sort (mm)					(Darcy)	(ft/d)		
C-1	50	185	0.45	1.59	0.17	0.75	1.68	8.60	80.72	10.68	33.2	160.0	389.3	Upper c sand; poorly sorted	Black Creek
	39	196	2.74	1.19	2.55	0.62	1.53	0.14	82.59	17.27	35.1	7.0	17.0	Lower f sand; poorly sorted	Black Creek
	22	213	1.18	1.60	0.62	0.71	1.63	1.34	85.53	13.13	33.2	96.0	233.6	Upper m sand; poorly sorted	Black Creek
	2	233	1.15	1.40	0.71	0.65	1.57	0.54	87.36	12.10	33.8	92.0	223.9	Upper m sand; poorly sorted	Black Creek
	-18	253	2.00	1.37	1.66	0.75	1.68	0.29	85.85	13.86	33.0	21.0	51.1	Lower m sand; poorly sorted	Black Creek
	-38	273	1.21	1.59	0.75	0.77	1.70	3.20	83.57	13.23	32.8	75.0	182.5	Upper m sand; poorly sorted	Black Creek
C-2	214	205	1.72	1.74	0.96	0.78	1.72	0.09	83.49	16.42	32.5	61.0	148.4	Lower m sand; poorly sorted	Black Creek
	202	217	0.44	1.95	0.19	1.45	2.73	28.51	63.05	8.44	28.8	38.0	92.5	Upper c sand; poorly sorted	Black Creek
	179	240	1.07	1.56	0.68	0.81	1.75	0.95	87.72	11.33	32.1	78.0	189.8	Upper m sand; poorly sorted	Black Creek
	150	269	0.52	1.21	0.48	0.45	1.37	1.92	91.90	6.18	36.2	152.0	369.8	Lower c sand; poorly sorted	Black Creek
	116	303	1.47	1.96	0.72	1.11	2.16	2.71	80.23	17.06	29.2	48.0	116.8	Upper m sand; poorly sorted	Black Creek
	89	330	0.87	1.37	0.73	0.77	1.71	1.28	91.84	6.88	32.7	80.0	194.7	Lower c sand; poorly sorted	Black Creek
	64	355	1.64	1.51	1.33	0.75	1.68	0.60	85.46	13.94	33.0	35.0	85.2	Lower m sand; poorly sorted	Black Creek
	49	370	0.34	1.83	-0.20	0.96	1.95	19.05	70.80	10.15	30.8	151.0	367.4	Upper c sand; poorly sorted	Black Creek
	169	126	3.27	0.93	3.19	0.73	1.65	0.80	75.17	24.03	35.3	3.0	7.3	Upper vf sand; moderately sorted	Steel Creek
	168	127	2.65	0.86	2.55	0.41	1.33	0.12	91.32	8.56	38.0	10.0	24.3	Lower f sand; moderately sorted	Steel Creek
C-3	162	133	1.89	0.84	1.75	0.49	1.40	0.00	94.12	5.88	35.7	25.0	60.8	Lower m sand; moderately sorted	Steel Creek
	161	134	1.83	0.81	1.69	0.44	1.35	0.13	94.82	5.05	36.8	34.0	82.7	Lower m sand; moderately sorted	Steel Creek
	159	136	0.54	0.87	0.54	0.33	1.26	0.10	95.05	4.85	38.8	181.0	440.4	Lower c sand; moderately sorted	Steel Creek
	140	155	1.85	1.44	1.60	0.83	1.78	0.37	86.29	13.34	32.0	22.0	53.5	Lower m sand; poorly sorted	Black Creek
	135	160	2.18	1.38	1.78	0.79	1.72	0.35	84.96	14.69	32.9	19.0	46.2	Upper f sand; poorly sorted	Black Creek
	126	169	1.22	1.58	1.02	0.86	1.81	3.79	85.42	10.79	31.7	42.0	102.2	Upper m sand; poorly sorted	Black Creek
	121	174	1.28	1.25	1.05	0.67	1.59	0.11	89.05	10.84	33.7	60.0	146.0	Upper m sand; poorly sorted	Black Creek
	112	183	0.42	1.48	0.09	0.69	1.61	3.68	86.97	9.35	33.9	220.0	535.3	Upper c sand; poorly sorted	Black Creek
	109	186	0.36	1.19	0.42	0.43	1.35	2.73	86.45	10.82	36.7	173.0	420.9	Upper c sand; poorly sorted	Black Creek
	106	189	2.45	1.34	2.02	0.77	1.71	0.24	81.61	18.15	33.2	14.0	34.1	Upper f sand; poorly sorted	Black Creek
	99	196	-1.75	0.92	1.61	0.37	1.29	0.12	92.09	7.79	38.0	43.0	104.6	Lower m sand; moderately sorted	Black Creek
	96	199	1.82	1.03	1.64	0.47	1.38	0.12	90.38	9.50	36.0	31.0	75.4	Lower m sand; poorly sorted	Black Creek
	92	203	1.80	1.25	1.65	0.73	1.66	0.13	87.92	11.95	33.2	22.0	53.5	Lower m sand; poorly sorted	Black Creek
	87	208	0.40	1.34	0.26	0.65	1.56	1.47	91.29	7.24	34.1	155.0	377.1	Upper c sand; poorly sorted	Black Creek
	76	219	1.40	1.13	1.39	0.54	1.45	0.13	90.68	9.19	34.8	42.0	102.2	Upper m sand; poorly sorted	Black Creek
	71	224	1.82	1.59	1.50	1.05	2.07	0.12	85.63	14.25	29.8	18.0	43.8	Lower m sand; poorly sorted	Black Creek
	66	229	1.85	1.41	1.56	0.75	1.68	0.26	85.51	14.23	33.1	25.0	60.8	Lower m sand; poorly sorted	Black Creek
	61	234	1.11	1.67	0.78	0.98	1.97	3.65	84.41	11.94	30.2	52.0	126.5	Upper m sand; poorly sorted	Black Creek
	56	239	1.04	1.52	0.74	0.81	1.76	2.79	87.39	9.82	32.1	73.0	177.6	Upper m sand; poorly sorted	Black Creek
	51	244	1.42	1.49	1.10	0.84	1.79	0.99	86.00	13.01	31.9	42.0	102.2	Upper m sand; poorly sorted	Black Creek
	49	246	0.56	2.11	-0.23	0.92	1.90	23.71	61.64	14.65	32.3	160.0	389.3	Lower c sand; v poorly sorted	Black Creek
	47	248	1.63	1.41	1.35	0.67	1.59	0.50	85.73	13.77	33.7	38.0	92.5	Lower m sand; poorly sorted	Black Creek
	35	260	0.35	1.57	0.17	0.79	1.73	11.49	78.96	9.55	32.6	150.0	365.0	Upper c sand; poorly sorted	Black Creek
	30	265	1.04	1.12	0.97	0.63	1.54	0.25	91.33	8.42	32.8	68.0	165.5	Upper m sand; poorly sorted	Black Creek
	28	267	1.46	1.15	1.41	0.55	1.46	0.00	91.78	8.22	34.9	39.0	94.9	Upper m sand; poorly sorted	Black Creek

CROUCH BRANCH AQUIFER SIEVE ANALYSIS

Well	Altitude (ft. msl)	Depth (ft. lsd)	Folk and Ward		Track			Gravel (%)	Sand (%)	Mud (%)	Porosity (%)	Permeability		Description (Folk and Ward)	Formation
			Mean	Sorting	Median	Sorting	Sort.(mm)					(Darcy)	(ft/d)		
	-52	317	2.21	1.54	1.97	0.90	1.87	0.12	83.85	16.03	30.8	11.0	26.8	Upper f sand; poorly sorted	Lang Syne/Sawdust
	-54	319	0.90	0.78	0.86	0.58	1.50	0.80	98.10	1.10	34.4	82.0	199.5	Lower c sand; moderately sorted	Lang Syne/Sawdust
	-64	329	1.97	1.61	1.41	1.06	2.09	0.13	82.61	17.26	29.8	21.0	51.1	Lower m sand; poorly sorted	Lang Syne/Sawdust
	-66	331	2.13	1.58	1.74	0.96	1.94	0.60	82.07	17.33	31.9	16.0	38.9	Upper f sand; poorly sorted	Lang Syne/Sawdust
	-68	333	0.69	1.35	0.50	0.49	1.41	2.22	91.57	6.21	35.3	125.0	304.1	Lower c sand; poorly sorted	Lang Syne/Sawdust
	-70	335	0.93	1.42	0.58	0.62	1.54	0.79	91.66	7.55	34.0	111.0	270.1	Lower c sand; poorly sorted	Lang Syne/Sawdust
	-72	337	1.23	1.56	0.76	0.78	1.71	1.11	85.08	13.81	32.5	78.0	189.8	Upper m sand; poorly sorted	Lang Syne/Sawdust
	-75	340	1.59	0.93	1.52	0.39	1.31	0.13	93.72	6.15	37.7	45.0	109.5	Lower m sand; poorly sorted	Lang Syne/Sawdust
	-78	343	1.15	1.59	0.65	0.74	1.67	0.94	86.60	12.47	33.0	96.0	233.6	Upper m sand; poorly sorted	Lang Syne/Sawdust
	-79	344	1.36	1.44	1.09	0.74	1.67	0.75	87.75	11.50	32.8	50.0	121.7	Upper m sand; poorly sorted	Steel Creek
	-82	347	0.59	1.43	0.41	0.59	1.51	3.29	88.26	8.45	34.3	135.0	328.5	Lower c sand; poorly sorted	Steel Creek
	-84	349	0.72	1.76	0.27	1.00	2.00	8.41	80.93	10.67	30.1	98.0	238.4	Lower c sand; poorly sorted	Steel Creek
	-87	352	1.96	1.73	1.51	1.02	2.03	1.14	81.70	17.16	30.0	19.0	46.2	Lower m sand; poorly sorted	Steel Creek
	-88	353	2.12	1.70	1.74	1.02	2.02	2.07	79.10	18.83	30.3	13.0	31.6	Upper f sand; poorly sorted	Steel Creek
	-90	355	0.61	0.79	0.55	0.43	1.35	0.46	98.16	1.38	36.7	149.0	362.5	Lower c sand; moderately sorted	Steel Creek
	-92	357	0.48	1.95	-0.27	0.97	1.96	18.39	69.78	11.83	30.8	163.0	396.6	Upper c sand; poorly sorted	Steel Creek
	-93	358	0.58	1.80	-0.14	0.90	1.87	8.92	80.36	10.72	31.9	170.0	413.6	Lower c sand; poorly sorted	Steel Creek
	-94	359	0.06	1.82	-0.39	1.00	1.99	29.20	61.76	9.04	31.6	197.0	479.3	Upper c sand; poorly sorted	Steel Creek
	-98	363	1.07	1.45	0.67	0.68	1.60	2.74	85.30	11.96	33.7	95.0	231.1	Upper m sand; poorly sorted	Steel Creek
C-5	-101	366	0.76	1.79	0.40	1.20	2.30	10.65	79.96	9.39	29.0	62.0	150.9	Lower c sand; poorly sorted	Steel Creek
	-104	369	0.71	1.37	0.58	0.75	1.68	1.78	91.93	6.29	33.0	99.0	240.9	Lower c sand; poorly sorted	Steel Creek
	-106	371	1.06	2.21	0.18	1.32	2.50	15.83	68.21	15.97	28.4	53.0	129.0	Upper m sand; v poorly sorted	Steel Creek
	-108	373	1.68	1.45	1.70	0.91	1.88	0.64	88.19	11.17	32.8	19.0	46.2	Lower m sand; poorly sorted	Steel Creek
	-111	376	2.28	1.16	1.96	0.70	1.62	0.00	86.32	13.68	33.9	16.0	38.9	Upper f sand; poorly sorted	Steel Creek
	-114	379	2.11	0.95	2.06	0.61	1.53	0.13	88.63	11.24	34.8	15.0	36.5	Upper f sand; moderately sorted	Steel Creek
	-116	381	1.95	1.05	1.81	0.63	1.55	0.11	90.00	9.89	34.4	20.0	48.7	Lower m sand; poorly sorted	Steel Creek
	-118	383	1.66	1.29	1.44	0.53	1.44	0.13	86.53	13.34	35.0	39.0	94.9	Lower m sand; poorly sorted	Steel Creek
	-120	385	1.91	1.66	1.43	0.83	1.78	1.12	82.96	15.92	32.0	27.0	65.7	Lower m sand; poorly sorted	Steel Creek
	-122	387	1.58	1.54	1.29	0.72	1.64	1.57	83.71	14.72	33.1	39.0	94.9	Lower m sand; poorly sorted	Steel Creek
	-124	389	1.58	1.60	1.23	0.77	1.71	1.52	83.66	14.82	32.5	39.0	94.9	Lower m sand; poorly sorted	Steel Creek
	-126	391	1.03	2.08	0.38	1.05	2.07	13.26	71.24	15.49	29.7	78.0	189.8	Upper m sand; v poorly sorted	Steel Creek
	-129	394	1.70	1.80	1.04	0.81	1.75	2.23	81.85	15.92	32.1	44.0	107.1	Lower m sand; poorly sorted	Steel Creek
	-132	397	1.16	1.25	1.09	0.89	1.85	3.24	94.65	2.12	31.4	40.0	97.3	Upper m sand; poorly sorted	Steel Creek
	-134	399	1.63	1.27	1.53	0.56	1.47	1.34	88.07	10.59	34.8	34.0	82.7	Lower m sand; poorly sorted	Steel Creek
	-138	403	1.44	1.24	1.37	0.60	1.52	1.18	89.07	9.75	34.0	39.0	94.9	Upper m sand; poorly sorted	Steel Creek
	-139	404	0.74	1.69	0.40	1.25	2.38	7.25	85.50	7.25	29.6	51.0	124.1	Lower c sand; poorly sorted	Steel Creek
	-143	408	0.17	0.65	0.27	0.48	1.40	4.01	94.94	1.05	35.8	178.0	433.1	Upper c sand; well sorted	Steel Creek
	-146	411	1.61	2.00	1.22	1.27	2.42	6.80	77.15	16.05	27.9	16.0	38.9	Lower m sand; v poorly sorted	Steel Creek
	-147	412	1.17	1.85	1.24	0.97	1.96	12.57	75.27	12.16	30.5	29.0	70.6	Upper m sand; poorly sorted	Steel Creek
	-150	415	1.46	1.65	1.52	1.02	2.03	5.45	82.69	11.86	30.0	19.0	46.2	Upper m sand; poorly sorted	Steel Creek
	-153	418	2.34	1.64	1.96	1.30	2.46	0.82	75.03	24.15	28.3	5.0	12.2	Upper f sand; poorly sorted	Steel Creek
	-155	420	1.87	1.67	1.26	0.84	1.79	0.41	82.62	16.97	32.0	36.0	87.6	Lower m sand; poorly sorted	Steel Creek

CROUCH BRANCH AQUIFER SIEVE ANALYSIS															
Well	Altitude (ft. msl)	Depth (ft. lsd)	Folk and Ward		Trask			Gravel (%)	Sand (%)	Mud (%)	Porosity (%)	Permeability		Description (Folk and Ward)	Formation
			Mean	Sorting	Median	Sorting	Sort (mm)					(Darcy)	(ft/d)		
	-157	422	1.47	1.30	1.28	0.66	1.58	0.35	88.55	11.10	33.8	40.0	97.3	Upper m sand; poorly sorted	Steel Creek
	-160	425	1.98	1.20	1.72	0.69	1.61	0.11	87.20	12.69	33.7	20.0	48.7	Lower m sand; poorly sorted	Steel Creek
	-163	428	1.47	1.53	1.41	0.75	1.68	5.63	83.22	11.15	33.0	33.0	80.3	Upper m sand; poorly sorted	Steel Creek
	-166	431	1.29	1.53	1.28	0.77	1.71	6.48	83.51	10.01	32.6	38.0	92.5	Upper m sand; poorly sorted	Steel Creek
	-168	433	1.63	1.59	1.26	0.93	1.90	0.37	86.40	13.23	30.8	28.0	68.1	Lower m sand; poorly sorted	Steel Creek
	-178	443	0.96	1.29	0.79	0.70	1.62	0.93	89.35	9.72	33.7	80.0	194.7	Lower c sand; poorly sorted	Steel Creek
	-180	445	1.30	1.34	1.20	0.68	1.60	1.22	87.29	11.49	33.7	47.0	114.4	Upper m sand; poorly sorted	Steel Creek
	-182	447	1.33	1.46	1.11	0.77	1.70	1.49	86.97	11.54	31.6	44.0	107.1	Upper m sand; poorly sorted	Steel Creek
	-184	449	0.72	1.61	0.52	0.94	1.91	6.62	83.46	9.93	30.8	78.0	189.8	Lower c sand; poorly sorted	Steel Creek
	-186	451	1.56	1.93	0.93	1.09	2.13	3.40	80.07	16.53	29.3	36.0	87.6	Lower m sand; poorly sorted	Steel Creek
	-191	456	2.45	1.37	2.04	0.79	1.72	0.10	81.53	18.37	33.0	13.0	31.6	Upper f sand; poorly sorted	Steel Creek
	-194	459	2.05	1.16	2.01	0.71	1.64	0.38	87.48	12.14	33.9	15.0	36.5	Upper f sand; poorly sorted	Steel Creek
	-198	463	0.94	0.88	0.81	0.59	1.50	0.25	97.34	2.41	34.1	86.0	209.3	Lower c sand; moderately sorted	Steel Creek
	-200	465	0.97	1.53	0.82	0.87	1.83	3.52	87.50	8.98	31.7	63.0	153.3	Lower c sand; moderately sorted	Steel Creek
	-202	467	0.62	1.34	0.58	0.77	1.70	4.27	90.28	5.45	33.7	98.0	238.4	Lower c sand; poorly sorted	Steel Creek
	-204	469	1.16	1.30	1.16	0.72	1.65	1.80	90.90	7.31	33.0	43.0	104.6	Upper m sand; poorly sorted	Steel Creek
	-206	471	0.58	1.17	0.53	0.56	1.48	3.01	92.85	4.14	35.3	132.0	321.2	Lower c sand; poorly sorted	Steel Creek
	-210	475	1.21	2.24	0.35	1.38	2.61	13.70	66.55	19.76	28.0	39.0	94.9	Upper m sand; v poorly sorted	Steel Creek
	-213	478	1.11	1.08	1.15	0.63	1.55	0.64	94.55	4.81	33.9	51.0	124.1	Upper m sand; poorly sorted	Black Creek
	-214	479	1.75	1.46	1.75	1.01	2.01	0.86	89.41	9.73	30.2	13.0	31.6	Lower m sand; poorly sorted	Black Creek
C-5	-219	484	1.64	1.96	1.09	1.20	2.29	4.29	77.73	17.98	28.5	24.0	58.4	Lower m sand; poorly sorted	Black Creek
	-222	487	1.64	1.79	0.86	0.95	1.94	1.17	82.84	15.99	30.6	50.0	121.7	Lower m sand; poorly sorted	Black Creek
	-224	489	1.39	1.46	1.02	0.75	1.68	0.26	87.90	11.84	33.0	52.0	126.5	Upper m sand; poorly sorted	Black Creek
	-228	493	1.08	1.28	0.91	0.72	1.65	0.87	91.93	7.21	33.1	63.0	153.3	Upper m sand; poorly sorted	Black Creek
	-230	495	1.26	1.98	0.68	1.26	2.40	5.69	79.34	14.97	28.3	39.0	94.9	Upper m sand; poorly sorted	Black Creek
	-232	497	1.42	1.28	1.22	0.65	1.57	0.00	88.20	11.80	33.8	44.0	107.1	Upper m sand; poorly sorted	Black Creek
	-235	500	1.55	1.98	0.82	1.26	2.39	2.29	78.60	19.11	28.3	32.0	77.9	Lower m sand; poorly sorted	Black Creek
	-236	501	0.84	1.42	0.59	0.65	1.57	0.85	88.62	10.53	34.0	105.0	255.5	Lower c sand; poorly sorted	Black Creek
	-238	503	1.37	1.98	0.57	0.95	1.93	2.92	80.48	16.60	30.5	75.0	182.5	Upper m sand; poorly sorted	Black Creek
	-243	508	0.56	1.48	0.34	0.73	1.66	3.58	86.76	9.66	33.3	138.0	335.8	Lower c sand; poorly sorted	Black Creek
	-244	509	0.89	1.66	0.54	0.94	1.92	4.22	83.98	11.81	30.8	81.0	197.1	Lower c sand; poorly sorted	Black Creek
	-246	511	1.16	1.74	0.97	0.97	1.95	6.18	81.46	12.36	30.4	40.0	97.3	Upper m sand; poorly sorted	Black Creek
	-248	513	1.28	1.33	0.80	0.69	1.61	0.27	88.56	11.17	33.6	80.0	194.7	Upper m sand; poorly sorted	Black Creek
	-250	515	1.19	1.29	0.72	0.60	1.52	0.32	89.32	10.36	34.1	97.0	236.0	Upper m sand; poorly sorted	Black Creek
	-252	517	0.60	1.46	0.38	0.62	1.53	3.63	87.73	8.64	34.2	143.0	347.9	Lower c sand; poorly sorted	Black Creek
	-254	519	0.98	1.79	0.55	1.01	2.01	6.50	80.49	13.01	30.0	74.0	180.1	Lower c sand; poorly sorted	Black Creek
	-256	521	1.33	1.79	0.70	1.09	2.13	0.56	86.80	12.64	29.3	50.0	121.7	Upper m sand; poorly sorted	Black Creek
	-258	523	2.37	1.80	2.79	1.59	3.00	1.36	80.45	18.19	28.7	1.0	2.7	Upper f sand; poorly sorted	Black Creek
	-263	528	3.05	0.86	3.07	0.61	1.53	0.12	89.38	10.50	35.9	4.0	9.7	Upper vf sand; moderately sorted	Black Creek
	-266	531	2.28	1.51	1.69	0.90	1.87	0.25	79.57	20.18	31.6	19.0	46.2	Upper f sand; poorly sorted	Black Creek
	-268	533	2.38	1.28	2.44	1.00	1.99	0.15	93.30	6.55	31.4	5.0	12.2	Upper f sand; poorly sorted	Black Creek

CROUCH BRANCH AQUIFER SIEVE ANALYSIS

Well	Altitude (ft. msl)	Depth (ft. lsd)	Folk and Ward			Track		Gravel (%)	Sand (%)	Mud (%)	Porosity (%)	Permeability		Description (Folk and Ward)	Formation
			Mean	Sorting	Median	Sorting	Sort (mm)					(Darcy)	(ft/d)		
C-5	-270	535	2.14	1.22	1.86	0.71	1.63	0.12	86.35	13.53	33.5	39.0	94.9	Upper f sand; poorly sorted	Black Creek
	-272	537	2.73	1.14	2.54	0.57	1.48	0.00	83.92	16.08	35.7	8.0	19.5	Lower f sand; poorly sorted	Black Creek
	-274	539	2.36	1.42	1.98	0.79	1.73	0.15	82.98	16.87	32.7	14.0	34.1	Upper f sand; poorly sorted	Black Creek
	-276	541	2.82	1.61	2.85	1.47	2.77	0.15	59.30	40.55	29.0	1.0	70.6	Lower f sand; poorly sorted	Black Creek
	-278	543	1.65	1.36	1.47	0.71	1.63	0.80	87.30	11.90	33.2	32.0	77.9	Lower m sand; poorly sorted	Black Creek
C-6	-282	547	2.99	1.37	2.84	1.02	2.02	0.14	69.43	30.43	31.9	3.0	7.3	Lower f sand; poorly sorted	Black Creek
	-371	580	1.25	1.29	1.15	0.69	1.61	0.42	90.57	9.01	33.4	49.0	119.2	Upper m sand; poorly sorted	Steel Creek
	-376	585	1.33	1.22	1.22	0.63	1.55	0.21	87.56	12.23	33.9	41.0	99.8	Upper m sand; poorly sorted	Steel Creek
	-378	587	2.58	1.22	2.33	0.64	1.55	0.10	83.38	16.52	34.8	9.0	21.9	Lower f sand; poorly sorted	Steel Creek
	-382	591	2.61	1.31	2.37	0.71	1.63	0.09	81.52	18.39	34.0	8.0	19.5	Lower f sand; poorly sorted	Steel Creek
	-384	593	2.78	1.18	2.53	0.61	1.53	0.10	80.77	19.13	35.1	7.0	17.0	Lower f sand; poorly sorted	Steel Creek
	-395	604	1.47	2.11	0.86	1.11	2.16	8.50	72.98	18.52	29.3	39.0	94.9	Upper m sand; v poorly sorted	Steel Creek
	-396	605	1.19	1.50	0.95	0.81	1.76	1.96	86.59	11.45	32.1	51.0	124.1	Upper m sand; poorly sorted	Steel Creek
	-461	670	3.21	0.77	3.26	0.56	1.47	0.00	86.13	13.87	36.9	3.0	7.3	Upper vf sand; moderately sorted	Steel Creek
	-484	693	2.95	0.73	2.87	0.55	1.47	0.00	92.98	7.02	36.0	5.0	12.2	Lower f sand; moderately sorted	Black Creek
C-7	-499	708	1.63	1.27	1.45	0.57	1.48	0.00	88.78	11.22	34.7	37.0	90.0	Lower m sand; poorly sorted	Black Creek
	-282	534	1.40	1.13	1.43	0.48	1.39	1.42	92.73	5.85	35.5	39.0	94.9	Upper m sand; poorly sorted	Lang Syne/Sawdust
	-291	543	1.20	1.57	0.98	1.13	2.19	2.30	89.43	8.27	29.3	32.0	77.9	Upper m sand; poorly sorted	Steel Creek
	-305	557	0.40	1.44	0.01	0.70	1.63	1.14	91.79	7.07	33.8	195.0	474.5	Upper c sand; poorly sorted	Steel Creek
	-349	601	1.54	1.96	0.80	0.90	1.87	4.15	77.97	17.88	31.3	62.0	150.9	Lower m sand; poorly sorted	Steel Creek
	-360	612	2.32	1.39	1.82	0.75	1.68	0.16	83.35	16.49	33.2	19.0	46.2	Upper f sand; poorly sorted	Steel Creek
	-399	651	1.16	1.38	1.05	0.75	1.69	2.27	88.18	9.55	32.8	50.0	121.7	Upper m sand; poorly sorted	Steel Creek
	-425	677	1.75	1.19	1.58	0.54	1.45	0.16	87.63	12.21	34.9	30.0	73.0	Lower m sand; poorly sorted	Steel Creek
	-482	734	0.63	1.36	0.49	0.53	1.44	3.08	90.13	6.79	35.0	128.0	311.4	Lower c sand; poorly sorted	Black Creek
	-505	757	1.96	1.61	1.48	0.93	1.91	0.31	83.74	15.95	39.1	22.0	53.5	Lower m sand; poorly sorted	Black Creek
C-10	-526	778	2.73	0.89	2.57	0.41	1.33	0.00	89.19	10.81	38.0	10.0	24.3	Lower f sand; moderately sorted	Black Creek
	-547	799	1.44	1.01	1.46	0.44	1.36	0.31	94.53	5.16	36.3	43.0	104.6	Upper m sand; poorly sorted	Black Creek
	-461	751	1.47	1.42	1.43	0.86	1.82	2.09	88.59	9.32	31.8	25.0	60.8	Upper m sand; poorly sorted	Steel Creek
	-470	760	0.59	1.32	0.60	0.69	1.61	6.68	88.53	4.79	33.7	100.0	243.3	Lower c sand; poorly sorted	Steel Creek
	-502	792	1.64	1.37	1.52	0.73	1.66	0.44	87.47	12.09	33.2	27.0	65.7	Lower m sand; poorly sorted	Steel Creek
	-520	810	1.57	0.86	1.54	0.34	1.27	0.15	91.48	8.37	38.3	48.0	116.8	Lower m sand; moderately sorted	Steel Creek
	-537	827	0.70	1.21	0.54	0.42	1.34	0.43	91.96	7.61	37.0	148.0	360.1	Lower c sand; poorly sorted	Steel Creek
	-552	842	1.00	1.92	0.64	1.28	2.44	11.20	75.07	13.73	28.2	35.0	85.2	Lower c sand; poorly sorted	Steel Creek
	-572	862	1.48	1.38	1.36	0.64	1.56	0.82	87.64	11.54	33.9	38.0	92.5	Upper m sand; poorly sorted	Steel Creek
	-605	895	0.75	1.31	0.56	0.50	1.41	1.70	90.06	8.24	35.2	120.0	292.0	Lower c sand; poorly sorted	Black Creek
	-624	914	1.71	1.69	1.34	1.07	2.09	2.37	83.86	13.77	29.7	20.0	48.7	Lower m sand; poorly sorted	Black Creek
	-641	931	1.30	1.30	1.24	0.67	1.59	0.30	90.26	9.44	33.7	40.0	97.3	Upper m sand; poorly sorted	Black Creek
	-664	954	3.05	0.75	3.01	0.57	1.48	0.00	90.47	9.53	36.1	3.0	7.3	Upper vf sand; moderately sorted	Black Creek
	-688	978	2.40	1.02	2.39	0.52	1.44	0.20	86.63	13.17	35.8	10.0	24.3	Upper f sand; poorly sorted	Black Creek

MCQUEEN BRANCH AQUIFER SIEVE ANALYSIS

Well	Altitude (ft. msl)	Depth (ft.)	Folk and Ward		Trask			Gravel (%)	Sand (%)	Mud (%)	Porosity (%)	Permeability		Description (Folk and Ward)	Formation
			Mean	Sorting	Median	Sorting	Sort (mm)					(Darcy)	(ft/d)		
	-127	362	1.62	1.59	1.39	1.04	2.05	1.34	86.20	12.46	29.8	22.0	53.5	Lower m sand; poorly sorted	Middendorf
	-128	363	1.73	1.57	1.65	1.01	2.02	1.40	86.52	12.08	30.1	15.0	36.5	Lower m sand; poorly sorted	Middendorf
	-139	374	0.67	1.43	0.55	0.71	1.64	4.81	85.57	9.62	33.2	108.0	262.8	Lower c sand; poorly sorted	Middendorf
	-164	399	1.50	1.59	1.30	0.93	1.91	3.31	83.45	13.24	30.9	28.0	68.1	Upper m sand; poorly sorted	Middendorf
C-1	-182	417	1.61	1.50	1.46	0.90	1.87	1.68	85.44	12.88	31.3	23.0	56.0	Lower m sand; poorly sorted	Middendorf
	-198	433	1.93	1.90	1.75	1.20	2.30	4.72	77.58	17.70	28.8	8.0	19.5	Lower m sand; poorly sorted	Middendorf
	-222	457	0.41	1.18	0.44	0.46	1.37	3.09	91.00	5.91	36.4	170.0	413.6	Upper c sand; poorly sorted	Middendorf
	-242	477	1.26	1.04	1.37	0.48	1.39	1.06	92.69	6.25	35.7	47.0	114.4	Upper m sand; poorly sorted	Middendorf
	-264	499	1.53	1.33	1.50	0.49	1.40	3.40	87.72	8.88	35.2	38.0	92.5	Lower m sand; poorly sorted	Middendorf
	-270	505	0.12	1.40	-0.12	0.69	1.61	8.52	84.42	7.06	33.8	199.0	484.2	Upper c sand; poorly sorted	Middendorf
	4	415	1.14	1.08	1.15	0.62	1.54	0.18	92.25	7.57	33.9	52.0	126.5	Upper m sand; poorly sorted	Middendorf
	-1	420	1.76	1.50	1.33	0.67	1.59	0.23	84.99	14.78	33.6	38.0	92.5	Lower m sand; poorly sorted	Middendorf
	-14	433	1.44	1.13	1.42	0.55	1.47	0.27	92.72	7.01	34.8	39.0	94.9	Upper m sand; poorly sorted	Middendorf
	-15	434	1.30	1.34	1.28	0.74	1.67	1.60	91.31	7.09	32.9	39.0	94.9	Upper m sand; poorly sorted	Middendorf
	-17	436	-0.43	1.23	-0.50	0.48	1.40	24.10	71.57	4.33	36.0	250.0	608.3	Lower vc sand; poorly sorted	Middendorf
	-19	438	1.29	1.87	0.62	0.92	1.90	1.85	82.86	15.29	30.9	76.0	184.9	Upper m sand; poorly sorted	Middendorf
	-27	446	1.89	1.84	1.50	1.14	2.21	2.72	79.79	17.49	29.1	15.0	36.5	Lower m sand; poorly sorted	Middendorf
	-29	448	0.87	1.93	0.29	1.35	2.55	10.36	76.04	13.60	28.2	48.0	116.8	Lower c sand; poorly sorted	Middendorf
	-31	450	0.37	1.67	0.18	1.09	2.13	16.78	76.30	6.92	29.7	90.0	219.0	Upper c sand; poorly sorted	Middendorf
	-32	451	0.26	1.39	0.10	0.68	1.60	6.10	85.15	8.75	33.9	186.0	452.6	Upper c sand; poorly sorted	Middendorf
	-35	454	1.97	1.84	1.55	1.35	2.55	0.64	78.64	20.72	27.9	37.0	90.0	Lower m sand; poorly sorted	Middendorf
	-37	456	0.65	2.11	-0.11	1.20	2.29	21.27	64.18	14.55	29.3	89.0	216.6	Lower c sand; v poorly sorted	Middendorf
	-39	458	0.61	1.55	0.42	0.76	1.70	6.42	83.39	10.18	32.9	113.0	274.9	Lower c sand; v poorly sorted	Middendorf
	-41	460	1.23	2.12	0.46	1.06	2.08	9.82	74.22	15.97	29.8	76.0	184.9	Upper m sand; v poorly sorted	Middendorf
C-2	-42	461	1.34	2.15	0.54	1.15	2.22	9.02	71.86	19.13	29.1	61.0	148.4	Upper m sand; v poorly sorted	Middendorf
	-43	462	0.82	1.47	0.57	0.63	1.54	3.89	83.86	12.25	34.0	114.0	277.4	Lower c sand; poorly sorted	Middendorf
	-46	465	1.96	1.77	1.46	0.91	1.88	2.93	79.03	18.04	31.7	25.0	60.8	Lower m sand; poorly sorted	Middendorf
	-48	467	1.15	1.97	0.70	1.06	2.09	10.18	75.27	14.56	29.6	53.0	129.0	Upper m sand; poorly sorted	Middendorf
	-60	479	2.07	1.77	1.78	1.10	2.14	0.72	80.49	18.79	29.8	12.0	29.2	Upper f sand; poorly sorted	Middendorf
	-62	481	0.90	1.53	0.78	0.83	1.78	5.16	84.01	10.83	32.0	75.0	182.5	Lower c sand; poorly sorted	Middendorf
	-64	483	0.62	1.51	0.55	0.92	1.90	7.64	85.76	6.60	30.9	78.0	189.8	Lower c sand; poorly sorted	Middendorf
	-66	485	1.08	1.44	1.04	0.83	1.78	3.35	89.43	7.22	31.9	47.0	114.4	Upper m sand; poorly sorted	Middendorf
	-68	487	0.65	1.48	0.63	0.86	1.82	8.05	85.91	6.04	31.8	86.0	209.3	Lower c sand; poorly sorted	Middendorf
	-70	489	0.53	1.67	0.37	1.06	2.08	13.54	78.11	8.34	29.8	78.0	189.8	Lower c sand; poorly sorted	Middendorf
	-72	491	1.95	1.06	1.90	0.64	1.56	0.58	91.47	7.95	34.2	19.0	46.2	Lower m sand; poorly sorted	Middendorf
	-74	493	-0.39	0.58	-0.42	0.33	1.26	6.38	91.70	1.93	39.9	505.0	1228.7	Lower vc sand; well sorted	Middendorf
	-75	494	1.67	1.66	1.17	0.78	1.72	0.97	83.80	15.24	32.2	42.0	102.2	Lower m sand; poorly sorted	Middendorf
	-84	503	1.27	1.48	1.11	0.80	1.74	3.43	86.29	10.28	32.2	46.0	111.9	Upper m sand; poorly sorted	Middendorf
	-86	505	1.55	1.39	1.43	0.78	1.72	0.59	86.75	12.66	32.3	30.0	73.0	Lower m sand; poorly sorted	Middendorf
	-87	506	0.62	1.33	0.53	0.54	1.46	3.99	88.11	7.90	35.0	129.0	313.9	Lower c sand; poorly sorted	Middendorf

MCQUEEN BRANCH AQUIFER SIEVE ANALYSIS															Description (Folk and Ward)	Formation
Well	Altitude (ft. msl)	Depth (ft)	Folk and Ward		Trask			Gravel (%)	Sand (%)	Mud (%)	Porosity (%)	Permeability				
			Mean	Sorting	Median	Sorting	Sort (mm)					(Darcy)	(ft/d)			
C-2	-88	507	1.11	1.23	1.18	0.65	1.57	1.60	87.52	10.89	33.8	50.0	121.7	Upper m sand; poorly sorted	Middendorf	
	-90	509	2.03	1.74	1.58	1.01	2.02	0.73	80.06	19.21	30.1	19.0	46.2	Upper f sand; poorly sorted	Middendorf	
	-92	511	1.13	1.82	0.55	1.31	2.48	2.30	84.98	12.72	28.2	38.0	92.5	Upper m sand; poorly sorted	Middendorf	
	-94	513	0.79	1.96	0.22	1.32	2.50	14.29	72.64	13.07	28.5	53.0	129.0	Lower c sand; poorly sorted	Middendorf	
	-103	522	2.11	1.54	1.89	0.85	1.80	1.34	83.62	15.03	32.0	15.0	36.5	Upper f sand; poorly sorted	Middendorf	
	-105	524	1.50	1.30	1.35	0.66	1.58	0.13	88.86	11.01	33.8	39.0	94.9	Lower m sand; poorly sorted	Middendorf	
	-106	525	1.40	1.34	1.24	0.72	1.65	0.83	89.43	9.74	33.1	40.0	97.3	Upper m sand; poorly sorted	Middendorf	
	-107	526	1.36	1.39	1.22	0.73	1.66	0.25	89.21	10.53	33.1	41.0	99.8	Upper m sand; poorly sorted	Middendorf	
	-109	528	1.90	1.31	1.59	0.62	1.54	0.13	86.11	13.76	34.1	28.0	68.1	Lower m sand; poorly sorted	Middendorf	
	-111	530	1.08	1.48	0.88	0.80	1.74	1.96	86.99	11.05	32.1	68.0	165.5	Upper m sand; poorly sorted	Middendorf	
	-113	532	1.32	1.49	1.15	0.81	1.75	1.66	87.20	11.14	32.1	44.0	107.1	Upper m sand; poorly sorted	Middendorf	
	-116	535	1.86	1.33	1.67	0.74	1.68	0.14	86.69	13.18	33.1	21.0	51.1	Lower m sand; poorly sorted	Middendorf	
C-3	-30	325	0.79	1.75	0.39	1.01	2.01	7.29	80.70	12.01	29.9	86.0	209.3	Lower c sand; poorly sorted	Black Creek	
	-33	328	1.93	1.64	1.39	0.63	1.54	0.72	83.10	16.18	33.9	38.0	92.5	Lower m sand; poorly sorted	Black Creek	
	-43	338	1.66	1.13	1.50	0.41	1.33	0.00	87.39	12.61	37.1	47.0	114.4	Lower m sand; poorly sorted	Black Creek	
	-49	344	1.75	1.13	1.64	0.60	1.52	0.37	90.97	8.66	34.2	25.0	60.8	Lower m sand; moderately sorted	Middendorf	
	-52	347	1.65	0.92	1.56	0.36	1.28	0.12	91.39	8.49	38.2	47.0	114.4	Lower m sand; moderately sorted	Middendorf	
	-58	353	1.42	1.53	1.16	0.78	1.71	0.73	85.23	14.04	32.6	40.0	97.3	Upper m sand; poorly sorted	Middendorf	
	-70	365	1.28	1.40	1.03	0.71	1.64	1.13	86.36	12.51	33.1	56.0	136.3	Upper m sand; poorly sorted	Middendorf	
	-75	370	1.32	1.51	0.98	0.75	1.68	1.27	84.99	13.74	33.0	56.0	136.3	Upper m sand; poorly sorted	Middendorf	
	-79	374	1.02	1.83	0.70	0.94	1.92	9.02	76.46	14.52	30.8	67.0	163.0	Upper m sand; poorly sorted	Middendorf	
	-90	385	1.76	1.71	1.24	0.74	1.68	0.83	83.35	15.82	32.9	40.0	97.3	Lower m sand; poorly sorted	Middendorf	
	-99	395	1.42	1.40	1.22	0.77	1.71	1.21	86.87	11.92	32.7	40.0	97.3	Upper m sand; poorly sorted	Middendorf	
	-129	424	0.85	1.61	0.54	0.79	1.73	4.91	81.44	13.65	32.3	99.0	240.9	Lower c sand; poorly sorted	Middendorf	
C-5	-138	433	1.00	1.16	0.98	0.63	1.55	0.67	92.00	7.33	33.9	70.0	170.3	Upper m sand; poorly sorted	Middendorf	
	-141	436	0.66	1.25	0.59	0.60	1.51	2.66	92.01	5.33	34.2	115.0	279.8	Lower c sand; poorly sorted	Middendorf	
	-147	442	0.93	1.29	0.86	0.71	1.64	2.03	87.95	10.02	33.2	73.0	177.6	Lower c sand; poorly sorted	Middendorf	
	-149	444	1.54	1.40	1.43	0.80	1.74	0.97	86.97	12.06	32.2	28.0	68.1	Lower m sand; poorly sorted	Middendorf	
	-158	453	1.03	1.23	0.96	0.69	1.61	0.45	90.17	9.38	33.4	65.0	158.2	Upper m sand; poorly sorted	Middendorf	
	-166	461	1.74	1.76	1.18	0.88	1.84	1.40	82.79	15.81	31.4	37.0	90.0	Lower m sand; poorly sorted	Middendorf	
	-173	468	0.86	1.78	0.28	0.88	1.84	5.12	81.64	13.24	31.7	120.0	292.0	Lower c sand; poorly sorted	Middendorf	
	-192	487	0.82	1.18	0.79	0.81	1.76	2.97	93.40	3.63	32.0	70.0	170.3	Lower c sand; poorly sorted	Middendorf	
	-195	490	0.10	1.68	-0.12	0.97	1.96	23.13	69.83	7.04	31.0	160.0	389.3	Upper c sand; poorly sorted	Middendorf	
	-376	641	1.21	1.02	1.29	0.55	1.46	0.26	93.53	6.21	34.7	44.0	107.1	Upper m sand; poorly sorted	Black Creek	
	-382	647	2.46	0.77	2.49	0.37	1.29	0.00	89.66	10.34	38.4	13.0	31.6	Upper f sand; moderately sorted	Black Creek	
	-386	651	2.43	1.12	2.30	0.61	1.53	0.00	85.68	14.32	34.8	10.0	24.3	Upper f sand; poorly sorted	Black Creek	

MCQUEEN BRANCH AQUIFER SIEVE ANALYSIS

Well	Altitude (ft, msl)	Depth (ft)	Folk and Ward		Trask			Gravel (%)	Sand (%)	Mud (%)	Porosity (%)	Permeability		Description (Folk and Ward)	Formation
			Mean	Sorting	Median	Sorting	Sort (mm)					(Darcy)	(ft/d)		
	-409	674	1.88	1.84	1.31	1.40	2.64	0.78	78.96	20.26	27.2	8.0	19.5	Lower m sand; poorly sorted	Black Creek
	-411	676	1.94	1.71	1.61	1.10	2.15	1.06	83.35	15.59	29.5	13.0	31.6	Lower m sand; poorly sorted	Black Creek
	-412	677	1.63	1.39	1.48	0.67	1.59	0.91	86.65	12.44	33.7	30.0	73.0	Lower m sand; poorly sorted	Black Creek
	-413	678	1.29	1.03	1.38	0.48	1.39	0.15	89.76	10.09	35.5	42.0	102.2	Upper m sand; poorly sorted	Black Creek
	-427	692	1.29	1.32	1.23	0.71	1.64	1.72	90.69	7.59	33.1	39.0	94.9	Upper m sand; poorly sorted	Black Creek
	-442	707	0.23	0.96	0.27	0.64	1.55	7.60	90.80	1.60	34.1	152.0	369.8	Upper c sand; moderately sorted	Black Creek
	-447	712	2.00	1.06	2.00	0.64	1.56	0.17	91.06	8.77	35.0	17.0	41.4	Upper f sand; poorly sorted	Black Creek
	-453	718	0.31	1.22	0.24	0.77	1.70	10.35	87.72	1.93	33.0	138.0	335.8	Upper c sand; poorly sorted	Black Creek
	-456	721	1.26	2.14	0.65	1.21	2.32	11.94	72.21	15.85	28.6	42.0	102.2	Upper m sand; v poorly sorted	Black Creek
	-460	725	0.69	1.47	0.62	0.86	1.81	5.01	84.11	10.88	31.7	77.0	187.4	Lower c sand; poorly sorted	Black Creek
	-464	729	1.92	1.10	1.78	0.64	1.56	0.08	88.70	11.22	34.1	20.0	48.7	Lower m sand; poorly sorted	Black Creek
	-468	733	1.98	1.69	1.38	0.97	1.96	0.62	78.85	20.53	30.4	23.0	56.0	Lower m sand; poorly sorted	Black Creek
	-472	737	2.78	1.36	2.56	0.85	1.81	0.10	77.10	22.80	32.8	5.0	12.2	Lower f sand; poorly sorted	Black Creek
	-475	740	1.96	1.08	1.85	0.65	1.57	0.10	88.43	11.47	34.1	19.0	46.2	Lower m sand; poorly sorted	Black Creek
	-479	744	0.84	1.64	0.55	1.19	2.29	2.93	87.95	9.12	28.8	49.0	119.2	Lower c sand; poorly sorted	Black Creek
	-481	746	0.07	1.14	-0.20	0.66	1.58	6.16	91.59	2.25	34.5	240.0	584.0	Upper c sand; poorly sorted	Black Creek
	-483	748	2.09	1.61	1.62	0.78	1.72	0.57	81.97	17.46	32.6	22.0	53.5	Upper f sand; poorly sorted	Black Creek
C-5	-489	754	1.99	1.77	1.46	1.11	2.15	1.09	78.29	20.62	29.5	18.0	43.8	Lower m sand; poorly sorted	Black Creek
	-491	756	0.82	1.18	0.73	0.77	1.71	2.46	96.88	0.66	32.6	75.0	182.5	Lower c sand; poorly sorted	Black Creek
	-494	759	1.41	2.14	0.70	1.47	2.76	7.45	72.25	20.30	27.1	20.0	48.7	Upper m sand; v poorly sorted	Black Creek
	-494	759	1.41	2.14	0.70	1.47	2.76	7.45	72.25	20.30	27.1	20.0	48.7	Lower f sand; poorly sorted	Black Creek
	-513	778	1.73	1.84	0.96	0.81	1.75	0.87	80.28	18.85	36.2	52.0	126.5	Lower m sand; poorly sorted	Middendorf
	-515	780	2.13	1.65	1.63	0.88	1.84	0.23	79.38	20.39	31.8	19.0	46.2	Upper f sand; poorly sorted	Middendorf
	-518	783	2.07	1.67	1.55	0.91	1.88	0.47	79.39	20.14	31.3	20.0	48.7	Upper f sand; poorly sorted	Middendorf
	-524	789	2.31	1.55	1.92	0.83	1.78	0.66	79.96	19.38	32.5	13.0	31.6	Upper f sand; poorly sorted	Middendorf
	-527	792	2.62	1.18	2.42	0.52	1.43	0.26	83.88	15.86	35.8	9.0	21.9	Lower f sand; poorly sorted	Middendorf
	-530	795	2.43	1.08	2.34	0.57	1.48	0.23	85.25	14.52	35.6	10.0	24.3	Upper f sand; poorly sorted	Middendorf
	-537	802	2.32	1.18	1.90	0.65	1.57	0.09	84.46	15.45	34.1	18.0	43.8	Upper f sand; poorly sorted	Middendorf
	-540	805	2.13	1.08	1.92	0.66	1.58	0.00	86.08	13.92	34.0	18.0	43.8	Upper f sand; poorly sorted	Middendorf
	-543	808	2.27	1.19	1.89	0.66	1.58	0.00	84.61	15.39	33.9	19.0	46.2	Upper f sand; poorly sorted	Middendorf
	-546	811	1.98	1.01	1.83	0.62	1.53	0.00	88.36	11.64	34.1	19.0	46.2	Lower m sand; poorly sorted	Middendorf
	-550	815	1.51	1.28	1.42	0.69	1.62	0.07	89.40	10.53	33.3	31.0	75.4	Lower m sand; poorly sorted	Middendorf
	-552	817	1.96	1.05	1.75	0.61	1.52	0.07	86.36	13.57	34.2	23.0	56.0	Lower m sand; poorly sorted	Middendorf
	-556	821	0.75	0.89	0.73	0.63	1.54	1.46	97.89	0.65	34.0	88.0	214.1	Lower c sand; moderately sorted	Middendorf
	-565	830	1.39	1.97	1.43	1.34	2.53	11.87	75.92	12.21	27.7	9.0	21.9	Upper m sand; poorly sorted	Middendorf
	-575	840	1.69	1.29	1.54	0.70	1.63	0.50	86.60	12.90	33.4	27.0	65.7	Lower m sand; poorly sorted	Middendorf
	-581	846	1.37	1.62	0.91	0.83	1.78	2.53	83.37	14.10	31.9	53.0	129.0	Upper m sand; poorly sorted	Middendorf
	-585	850	0.70	1.06	0.68	0.67	1.59	4.56	94.33	1.11	33.8	98.0	238.4	Lower c sand; poorly sorted	Middendorf
	-588	853	0.94	1.24	0.80	0.79	1.73	1.95	94.87	3.18	32.2	71.0	172.8	Lower c sand; poorly sorted	Middendorf
	-590	855	2.46	1.44	2.22	0.80	1.74	0.11	82.30	17.59	33.1	9.0	21.9	Upper f sand; poorly sorted	Middendorf
	-593	858	1.49	1.08	1.47	0.80	1.74	0.26	96.99	2.75	32.2	27.0	65.7	Upper m sand; poorly sorted	Middendorf
	-595	860	0.76	0.79	0.64	0.39	1.31	0.10	98.07	1.83	31.7	149.0	362.5	Lower c sand; moderately sorted	Middendorf
	-599	864	0.85	1.62	0.53	0.83	1.77	4.50	82.61	12.89	32.0	93.0	226.3	Lower c sand; poorly sorted	Middendorf

MCQUEEN BRANCH AQUIFER SIEVE ANALYSIS															
Well	Altitude (ft, masl)	Depth (ft)	Folk and Ward		Trask			Gravel (%)	Sand (%)	Mud (%)	Porosity (%)	Permeability		Description (Folk and Ward)	Formation
			Mean	Sorting	Median	Sorting	Sort (mm)					(Darcy)	(ft/d)		
	-602	867	0.37	0.88	0.44	0.40	1.32	1.92	95.84	2.24	37.5	178.0	433.1	Upper c sand; moderately sorted	Middendorf
	-604	869	0.37	0.92	0.43	0.42	1.34	2.02	95.58	2.40	37.0	170.0	413.6	Upper c sand; moderately sorted	Middendorf
	-608	873	2.56	1.52	2.32	1.29	2.45	0.15	75.56	24.29	29.2	3.0	7.3	Lower f sand; poorly sorted	Middendorf
	-613	878	1.33	1.38	1.11	0.73	1.66	0.31	87.14	12.55	32.9	48.0	116.8	Upper m sand; poorly sorted	Middendorf
	-618	883	1.26	1.61	1.05	0.87	1.83	3.30	84.06	12.64	31.4	45.0	109.5	Upper m sand; poorly sorted	Middendorf
C-5	-620	885	2.92	1.45	2.90	1.08	2.11	0.16	70.22	29.62	31.6	2.0	4.9	Lower f sand; poorly sorted	Middendorf
	-626	891	1.42	1.34	1.33	0.68	1.60	0.83	89.34	9.83	33.7	37.0	90.0	Upper m sand; poorly sorted	Middendorf
	-636	901	2.29	1.60	1.95	0.90	1.87	1.00	78.97	20.03	31.7	12.0	29.2	Upper f sand; poorly sorted	Middendorf
	-641	906	1.03	1.68	0.79	0.90	1.86	5.64	81.71	12.65	31.2	66.0	160.6	Upper m sand; poorly sorted	Middendorf
	-656	921	1.68	1.95	0.92	1.25	2.37	2.46	75.97	21.57	28.2	27.0	65.7	Lower m sand; poorly sorted	Middendorf
	-657	922	1.73	1.92	1.13	1.06	2.08	3.43	77.55	19.02	29.6	28.0	68.1	Lower m sand; poorly sorted	Middendorf
	-731	940	0.54	1.37	0.42	0.78	1.72	1.94	91.48	6.58	32.6	115.0	279.8	Lower c sand; poorly sorted	Black Creek
	-746	955	1.23	1.41	1.23	0.77	1.70	3.01	88.48	8.51	32.8	39.0	94.9	Upper m sand; poorly sorted	Black Creek
	-751	960	0.96	1.05	0.90	0.60	1.51	1.31	93.97	4.72	34.1	75.0	182.5	Lower c sand; poorly sorted	Black Creek
	-769	978	0.47	1.57	0.43	0.85	1.80	12.06	79.15	8.79	31.9	99.0	240.9	Upper c sand; poorly sorted	Black Creek
	-777	986	1.93	0.94	1.76	0.55	1.46	0.00	89.70	10.30	35.0	22.0	53.5	Lower m sand; moderately sorted	Black Creek
	-806	1015	2.34	1.40	1.88	0.80	1.74	0.12	83.05	16.83	32.7	16.0	38.9	Upper f sand; poorly sorted	Middendorf
	-816	1025	1.15	1.62	0.89	0.91	1.88	3.66	85.02	11.32	31.0	50.0	121.7	Upper m sand; poorly sorted	Middendorf
	-831	1040	1.30	1.21	1.18	0.65	1.57	0.35	90.20	9.45	33.8	49.0	119.2	Upper m sand; poorly sorted	Middendorf
C-6	-841	1050	0.81	1.49	0.63	0.86	1.82	3.87	88.78	7.35	31.7	76.0	184.9	Lower c sand; poorly sorted	Middendorf
	-856	1065	0.97	2.10	0.12	1.21	2.32	12.48	72.58	14.94	29.1	77.0	187.4	Lower c sand; v poorly sorted	Middendorf
	-866	1075	2.20	1.47	1.65	0.79	1.72	0.00	82.71	17.29	33.7	21.0	51.1	Upper f sand; poorly sorted	Middendorf
	-881	1090	0.13	1.47	-0.18	0.74	1.68	12.30	81.78	5.92	33.9	205.0	498.8	Upper c sand; poorly sorted	Middendorf
	-896	1105	2.76	1.27	2.65	0.80	1.74	0.15	82.03	17.82	33.6	5.0	12.2	Lower f sand; poorly sorted	Middendorf
	-910	1119	1.73	1.43	1.39	0.79	1.73	0.12	86.98	12.90	32.3	28.0	68.1	Lower m sand; poorly sorted	Middendorf
	-936	1145	0.97	1.14	0.85	0.63	1.54	0.42	92.48	7.10	33.9	78.0	189.8	Lower c sand; poorly sorted	Middendorf
	-956	1165	1.59	2.12	1.02	1.72	3.30	6.16	71.10	22.74	26.2	8.0	19.5	Lower m sand; v poorly sorted	Middendorf
	-996	1205	1.65	1.08	1.53	0.44	1.35	0.23	91.69	8.08	36.7	39.0	94.9	Lower m sand; poorly sorted	Cape Fear
	-706	958	1.64	1.08	1.55	0.45	1.36	0.43	92.19	7.38	36.8	37.0	90.0	Lower m sand; poorly sorted	Black Creek
	-715	967	1.30	0.99	1.39	0.46	1.37	0.14	93.52	6.34	36.2	45.0	109.5	Upper m sand; moderately sorted	Black Creek
	-745	997	2.21	1.49	1.78	0.78	1.71	0.44	83.48	16.08	32.9	19.0	46.2	Upper f sand; poorly sorted	Black Creek
	-769	1021	1.84	1.85	1.28	1.09	2.13	1.69	79.29	19.02	29.4	22.0	53.5	Lower m sand; poorly sorted	Middendorf
	-804	1056	1.21	1.25	1.24	0.66	1.58	1.28	90.88	7.84	33.8	40.0	97.3	Upper m sand; poorly sorted	Middendorf
C-7	-826	1078	0.99	1.18	1.01	0.66	1.58	0.59	93.34	6.07	33.7	61.0	148.4	Lower c sand; poorly sorted	Middendorf
	-849	1101	2.26	0.88	2.34	0.50	1.42	0.15	89.40	10.45	35.8	11.0	26.8	Upper f sand; moderately sorted	Middendorf
	-864	1116	0.57	1.38	0.52	0.72	1.64	5.52	88.19	6.29	33.3	102.0	248.2	Lower c sand; poorly sorted	Middendorf
	-884	1136	1.53	1.27	1.49	0.76	1.70	0.31	91.69	8.00	33.8	28.0	68.1	Lower m sand; poorly sorted	Middendorf
	-908	1160	0.90	0.97	0.81	0.63	1.55	0.32	96.54	3.14	33.9	80.0	194.7	Lower c sand; moderately sorted	Middendorf
	-925	1177	0.34	1.18	0.33	0.58	1.50	3.35	92.02	4.63	34.4	150.0	365.0	Upper c sand; poorly sorted	Middendorf

MCQUEEN BRANCH AQUIFER SIEVE ANALYSIS															
Well	Altitude (ft. msl)	Depth (ft)	Folk and Ward		Trask			Gravel (%)	Sand (%)	Mud (%)	Porosity (%)	Permeability		Description (Folk and Ward)	Formation
			Mean	Sorting	Median	Sorting	Sort (mm)					(Darcy)	(ft/d)		
C-10	-871	1161	1.52	1.73	1.21	1.12	2.18	2.12	84.20	13.68	29.1	21.0	51.1	Lower m sand; poorly sorted	Black Creek
	-884	1174	1.82	1.98	1.37	1.48	2.79	4.51	73.61	21.88	26.7	7.0	17.0	Lower m sand; poorly sorted	Black Creek
	-899	1189	1.23	1.42	1.05	0.78	1.72	2.13	88.46	9.41	36.3	50.0	121.7	Upper m sand; poorly sorted	Black Creek
	-914	1204	2.21	1.05	2.03	0.65	1.57	0.00	86.68	13.32	32.4	14.0	34.1	Upper f sand; poorly sorted	Black Creek
	-934	1224	2.00	1.65	1.66	0.97	1.96	0.61	83.64	15.75	30.7	16.0	38.9	Lower m sand; poorly sorted	Black Creek
	-949	1239	2.43	1.30	2.12	0.77	1.71	0.00	84.38	15.62	35.2	11.0	26.8	Upper f sand; poorly sorted	Middendorf
	-991	1281	1.88	1.16	1.87	0.70	1.62	0.60	91.73	7.67	33.8	18.0	43.8	Lower m sand; poorly sorted	Middendorf
	-1008	1298	0.27	1.30	0.19	0.66	1.58	5.48	88.81	5.71	34.0	160.0	389.3	Upper c sand; poorly sorted	Middendorf
	-1031	1321	0.94	1.17	0.78	0.62	1.54	0.15	91.91	7.94	33.9	80.0	194.7	Lower c sand; poorly sorted	Middendorf
	-1049	1339	0.70	1.61	0.34	0.96	1.95	5.01	85.65	9.34	30.3	83.0	202.0	Lower c sand; poorly sorted	Middendorf
	-1070	1360	1.32	1.28	1.02	0.69	1.61	0.45	89.54	10.01	33.7	56.0	136.3	Upper m sand; poorly sorted	Middendorf
	-1085	1375	1.15	1.05	1.20	0.59	1.51	0.14	93.22	6.64	34.1	49.0	119.2	Upper m sand; poorly sorted	Middendorf
	-1127	1417	1.87	1.82	1.44	1.06	2.08	4.78	79.14	16.08	29.8	19.0	46.2	Lower m sand; poorly sorted	Middendorf
	-1138	1428	0.93	1.22	0.81	0.69	1.62	1.61	92.47	5.92	33.2	75.0	182.5	Lower c sand; poorly sorted	Middendorf
	-1152	1442	0.76	1.44	0.62	0.80	1.74	4.04	88.63	7.33	32.2	83.0	202.0	Lower c sand; poorly sorted	Middendorf
-1184	1474	0.62	1.26	0.59	0.75	1.68	5.43	90.53	4.04	33.0	90.0	219.0	Lower c sand; poorly sorted	Middendorf	

APPENDIX 4. Petrophysical analyses made by Core Laboratories.

CORE LABORATORIES Laser Particle Size Analysis

Depth: 1032.3 ft

Company : S. Carolina Water Resource
: Commission
Site : C-10
County, State :
File No. : 57161-11079A
Analyst : Vickery, Cantwell, Ugon

Routine Core Analysis

Perm	Porosity	Saturation (Bulk Volume)			Critical Water Satn
mD	%	Oil %	Gas %	Water %	% Vp
71.58	35.2				
Description: See footnotes on detailed report

Permeability vs Porosity

MineralogTM

Laser Particle Size Analysis

The analyses, opinions or interpretations contained in this report are based upon observations and material supplied by the client for whose exclusive and confidential use this report has been made. The interpretations or opinions expressed represent the best judgment of Core Laboratories. Core Laboratories, however, assumes no responsibility and makes no warranty or representation, express or implied, as to the productivity, proper operation, or profitability of any oil, gas, coal or other mineral property, well or sand in connection with which such report is used or relied upon for any reason whatsoever. This report shall not be reproduced, except in its entirety, without the written approval of Core Laboratories.

CORE LABORATORIES Laser Particle Size Analysis

Depth: 1004.2 ft

Company : S. Carolina Water Resource
Commission
Site : C-10
County, State :
File No. : 57161-11079A
Analyst : Vickery, Cantwell, Ligon

Routine Core Analysis

Perm	Porosity	Saturation (Bulk Volume)			Critical Water Satn
mD	%	Oil %	Gas %	Water %	% Vp
35.61	34.3				
Description. See footnotes on detailed report

Permeability vs Porosity

MineralogTM

Laser Particle Size Analysis

[illegible]

CORE LABORATORIES Laser Particle Size Analysis

Depth: 1540.8 ft

Company : S. Carolina Water Resource
: Commission
Site : C-10
County, State :
File No. : 57161-11079A
Analyst : Vickery, Cantwell, Ligon

Routine Core Analysis

Perm	Porosity	Saturation (Bulk Volume)			Critical Water Satn
mD	%	Oil %	Gas %	Water %	% Vp
42.2	27.8				
Description: See footnotes on detailed report

Permeability vs Porosity

MineralogTM

Laser Particle Size Analysis

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CORE LABORATORIES Laser Particle Size Analysis

Depth: 1539.9 ft

Company : S. Carolina Water Resource
: Commission
Site : C-10
County, State :
File No. : 57161-11079A
Analyst : Vickery, Cantwell, Ligon

Routine Core Analysis

Perm mD	Porosity %	Saturation (Bulk Volume)			Critical Water Satn % V _p
		Oil %	Gas %	Water %	
52.06	30.6				
Description: See footnotes on detailed report

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Permeability vs Porosity

MineralogTM

Laser Particle Size Analysis

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CORE LABORATORIES Laser Particle Size Analysis

Depth: 1536.6 ft

Company : S. Carolina Water Resource
: Commission
Site : C-10
County, State :
File No. : 57161-11079A
Analyst : Vickery, Cantwell, Ligon

Routine Core Analysis

Perm	Porosity	Saturation (Bulk Volume)			Critical Water Satn
mD	%	Oil %	Gas %	Water %	% Vp
13.04	26				
Description: See footnotes on detailed report.

Permeability vs Porosity

MineralogTM

Laser Particle Size Analysis

CORE LABORATORIES Laser Particle Size Analysis

Depth: 1033.1 ft

Company : S. Carolina Water Resource
Commission :
Site : C-10
County, State :
File No. : 57161-11079A
Analyst : Vickery, Cantwell, Ligon

Routine Core Analysis

Perm	Porosity	Saturation (Bulk Volume)			Critical Water Satn
mD	%	Oil %	Gas %	Water %	% Vp
97.67	34.8				
Description: See footnotes on detailed report

Permeability vs Porosity

MineralogTM

Laser Particle Size Analysis

CORE LABORATORIES

South Carolina Water Resource Commission
Site C-10

FILE NO.: 57161-11079ACN
DATE: 3-Jun-92
ANALYST: W. Cantwell
PAGE NO.: 1/1

MINERALOG(TM) DATA (Weight percent)

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Sample Depth (ft)	Grain Dens.	Qtz	Plg	Ksp	Cal	Dol	Pyr	Gyp	Alb	Total Clay	Kao	Chl	Ill+Smc
1003.3	2.60	27	0	4	0	0	0	3	0	66	6	8	52
1004.2	2.61	34	0	5	0	0	0	2	0	59	7	7	45
1032.3	2.59	38	0	8	3	0	0	5	0	46	4	3	39
1033.1	2.61	38	0	9	5	0	0	2	0	46	2	3	41
1536.6	2.62	50	0	13	0	0	0	0	0	37	20	0	17
1539.9	2.61	33	0	5	0	0	0	0	0	62	30	0	32
1540.8	2.61	40	0	4	0	0	0	0	0	56	26	0	30

Qtz - Quartz Plg - Plagioclase Ksp - K-Feldspar
Cal - Calcite Dol - Dolomite Pyr - Pyrite Gyp - Gypsum
Alb - Albite Kao - Kaolinite Chl - Chlorite Ill+Smc - Illite + Smectite

Grain dens. - Calculated grain density, based on mineralogical determinations.

CORE LABORATORIES - NEW ORLEANS

COMPANY South Carolina Water Resource Commission
WELL Site C-10
FIELD
LOCATION

ONE INCH DIAMETER PLUGS FROM SOFT CORE

FILE NO : 57161-11079acn
DATE : 3-Jun-92
ANALYST : V.V. - D.L.M.

CMS 300 REPORT

Sample I.D.	Sample Depth feet	Confining Stress psi	Adjusted PV cc	Porosity Helium %	Kinf md	Kair md	b factor psi	Beta ft-l
1	1003.3	800	3.61	32.5	90.72	127.24	1.961E+01	2.633E+08
2	1004.2	800	4.81	34.3	35.61	42.57	9.972E+00	5.028E+08
3	1032.3	800	4.75	35.2	71.58	85.49	9.574E+00	2.371E+08
4	1033.1	800	3.26	34.8	97.67	114.73	8.479E+00	8.523E+07
7	1536.6	800	4.01	26.0	13.04	15.60	1.055E+01	4.885E+09
5	1539.9	800	4.56	30.6	52.06	64.71	1.216E+01	8.366E+08
6	1540.8	800	3.01	27.8	42.20	50.12	9.491E+00	7.602E+08

NOTE: MINERALOGICAL ANALYSIS OF THIS ROCK HAS SHOWN IT TO CONTAIN A LARGE AMOUNT OF CLAY. THE PROCEDURE USED HERE IS DESIGNED FOR RESERVOIR TYPE ROCK. WE FEEL THAT THAT THIS ROCK COULD BETTER BE ANALYZED WITH PROCEDURES DESIGNED FOR AQUITARD EVALUATION.

DUE TO FRACTURES IN THE PLUGS AND EXCESSIVE CLAY SHRINKAGE THE PERMEABILITIES AND POROSITIES REPORTED HEREIN ARE OPTIMISTIC.

APPENDIX 5. Clay and bulk mineralogy determined by x-ray diffraction analysis.

CLAY MINERALOGY DETERMINED BY X-RAY DIFFRACTION ANALYSES (SORTED BY HYDROSTRATIGRAPHIC UNIT)

Well site	Depth (ft)	Illite %	Kaolinite %	Chlorite %	Illite/Smectite %	Smectite %	Total clay %	Quartz %	Feldspar %	Calcite %	Total %	Hydrostratigraphic unit	Stratigraphic unit
C-2	15	7	60	0	3	0	70	30	0	0	100	Steed Pond aquifer	Upland unit
C-2	40	15	52	0	5	0	72	28	0	0	100	Steed Pond aquifer	Tobacco Road
C-3	28	8	84	0	6	2	100	0	0	0	100	Steed Pond aquifer	Dry Branch
C-3	54	33	41	0	23	3	100	0	0	0	100	Steed Pond aquifer	Congaree/Fourmile
C-3	63	37	35	0	24	4	100	0	0	0	100	Steed Pond aquifer	Lang Syne/Sawdust
C-10	41	0	100	0	0	0	100	0	0	0	100	Upper Three Runs aquifer	Tobacco Road
C-10	53	31	41	0	27	1	100	0	0	0	100	Upper Three Runs aquifer	Tobacco Road
C-10	87	11	89	0	0	0	100	0	0	0	100	Upper Three Runs aquifer	Tobacco Road
C-10	106	0	100	0	0	0	100	0	0	0	100	Upper Three Runs aquifer	Tobacco Road
C-10	150	12	88	0	0	0	100	0	0	0	100	Upper Three Runs aquifer	Tobacco Road
C-10	168	19	60	0	21	0	100	0	0	0	100	Upper Three Runs aquifer	Dry Branch
C-10	293	60	8	0	32	0	100	0	0	0	100	Upper Three Runs aquifer	Dry Branch
C-10	313	64	9	0	27	0	100	0	0	0	100	Upper Three Runs aquifer	Dry Branch
C-5	48	6	94	0	0	0	100	0	0	0	100	Upper Three Runs aquifer	Tobacco Road
C-5	94	33	38	0	27	0	98	2	0	0	100	Upper Three Runs aquifer	Dry Branch
C-5	116	50	12	0	36	0	98	2	0	0	100	Upper Three Runs aquifer	Dry Branch
C-6	100	21	60	0	16	3	100	0	0	0	100	Upper Three Runs aquifer	Dry Branch
C-10	430	67	6	0	27	0	100	0	0	0	100	Gordon confining unit	Tinker/Santee
C-5	168	66	8	0	25	1	100	0	0	0	100	Gordon confining unit	Tinker/Santee
C-6	198	69	2	1	25	3	100	0	0	0	100	Gordon confining unit	Tinker/Santee
C-6	236	58	13	0	25	4	100	0	0	0	100	Gordon confining unit	Tinker/Santee
C-10	460	60	9	0	31	0	100	0	0	0	100	Gordon aquifer	Warley Hill
C-10	491	59	9	0	32	0	100	0	0	0	100	Gordon aquifer	Congaree/Fourmile
C-10	570	58	6	0	36	0	100	0	0	0	100	Gordon aquifer	Snapp
C-5	250	54	31	0	15	0	100	0	0	0	100	Gordon aquifer	Congaree/Fourmile
C-6	364	61	4	0	31	4	100	0	0	0	100	Gordon aquifer	Congaree/Fourmile
C-10	614	16	57	0	27	0	100	0	0	0	100	Crouch Br. confining unit	Lang Syne/Sawdust
C-10	678	46	10	0	39	5	100	0	0	0	100	Crouch Br. confining unit	Lang Syne/Sawdust
C-10	718	32	34	0	34	0	100	0	0	0	100	Crouch Br. confining unit	Steel Creek
C-2	184	15	78	0	7	0	100	0	0	0	100	Crouch Br. confining unit	Lang Syne/Sawdust
C-3	101	25	62	0	7	0	94	6	0	0	100	Crouch Br. confining unit	Steel Creek
C-5	283	48	32	0	18	1	99	1	0	0	100	Crouch Br. confining unit	Snapp
C-5	311	46	31	0	23	0	100	0	0	0	100	Crouch Br. confining unit	Lang Syne/Sawdust
C-6	430	65	6	0	24	5	100	0	0	0	100	Crouch Br. confining unit	Lang Syne/Sawdust
C-6	501	55	11	1	29	4	100	0	0	0	100	Crouch Br. confining unit	Lang Syne/Sawdust
C-10	775	0	100	0	0	0	100	0	0	0	100	Crouch Br. aquifer	Steel Creek
C-10	887	26	57	0	6	11	100	0	0	0	100	Crouch Br. aquifer	Black Creek

CLAY MINERALOGY DETERMINED BY X-RAY DIFFRACTION ANALYSES (SORTED BY HYDROSTRATIGRAPHIC UNIT)

Well site	Depth (ft)	Illite %	Kaolinite %	Chlorite %	Illite/Smectite %	Smectite %	Total clay %	Quartz %	Feldspar %	Calcite %	Total %	Hydrostratigraphic unit	Stratigraphic unit
C-10	965	35	59	0	0	0	100	0	0	0	100	Crouch Br. aquifer	Black Creek
C-2	288	25	65	0	7	3	100	0	0	0	100	Crouch Br. aquifer	Black Creek
C-3	112	18	75	0	7	0	100	0	0	0	100	Crouch Br. aquifer	Steel Creek
C-3	124	23	44	0	27	6	100	0	0	0	100	Crouch Br. aquifer	Steel Creek
C-3	138	29	55	0	7	3	94	0	0	0	100	Crouch Br. aquifer	Steel Creek
C-3	153	18	60	0	17	5	100	0	0	0	100	Crouch Br. aquifer	Black Creek
C-3	212	19	56	0	16	6	97	3	0	0	100	Crouch Br. aquifer	Black Creek
C-5	364	2	98	0	0	0	100	0	0	0	100	Crouch Br. aquifer	Steel Creek
C-5	441	5	92	0	2	1	100	0	0	0	100	Crouch Br. aquifer	Steel Creek
C-6	598	17	79	0	4	0	100	0	0	0	100	Crouch Br. aquifer	Steel Creek
C-6	619	17	76	0	7	0	100	0	0	0	100	Crouch Br. aquifer	Steel Creek
C-6	678	45	38	0	17	0	100	0	0	0	100	Crouch Br. aquifer	Black Creek
C-6	728	56	15	0	29	0	100	0	0	0	100	Crouch Br. aquifer	Black Creek
C-10	1044	39	13	0	48	0	100	0	0	0	100	McQueen Br. confining unit	Black Creek
C-10	1135	61	8	0	25	6	100	0	0	0	100	McQueen Br. confining unit	Black Creek
C-2	393	24	60	0	12	4	100	0	0	0	100	McQueen Br. confining unit	Black Creek
C-3	284	12	84	0	4	0	100	0	0	0	100	McQueen Br. confining unit	Black Creek
C-3	310	27	53	0	11	4	95	5	0	0	100	McQueen Br. confining unit	Black Creek
C-5	586	32	39	0	28	1	100	0	0	0	100	McQueen Br. confining unit	Black Creek
C-6	770	70	4	1	22	3	100	0	0	0	100	McQueen Br. confining unit	Black Creek
C-6	812	68	3	0	27	2	100	0	0	0	100	McQueen Br. confining unit	Black Creek
C-6	890	47	13	2	33	5	100	0	0	0	100	McQueen Br. confining unit	Black Creek
C-10	1256	0	100	0	0	0	100	0	0	0	100	McQueen Br. aquifer	Middendorf
C-10	1336	16	56	0	28	0	100	0	0	0	100	McQueen Br. aquifer	Middendorf
C-10	1394	0	100	0	0	0	100	0	0	0	100	McQueen Br. aquifer	Middendorf
C-10	1438	40	46	0	10	4	100	0	0	0	100	McQueen Br. aquifer	Middendorf
C-10	1454	29	55	0	10	6	100	0	0	0	100	McQueen Br. aquifer	Middendorf
C-2	425	27	53	0	12	3	95	5	0	0	100	McQueen Br. aquifer	Middendorf
C-2	468	16	62	0	12	3	93	7	0	0	100	McQueen Br. aquifer	Middendorf
C-3	357	26	51	0	12	6	95	5	0	0	100	McQueen Br. aquifer	Middendorf
C-3	404	31	57	0	7	5	100	0	0	0	100	McQueen Br. aquifer	Middendorf
C-3	454	13	76	0	7	4	100	0	0	0	100	McQueen Br. aquifer	Middendorf
C-3	480	14	82	0	4	0	100	0	0	0	100	McQueen Br. aquifer	Middendorf
C-3	499	13	77	0	10	0	100	0	0	0	100	McQueen Br. aquifer	Middendorf
C-5	629	55	24	0	20	1	100	0	0	0	100	McQueen Br. aquifer	Black Creek
C-5	667	10	90	0	0	0	100	0	0	0	100	McQueen Br. aquifer	Black Creek
C-5	684	0	100	0	0	0	100	0	0	0	100	McQueen Br. aquifer	Black Creek

CLAY MINERALOGY DETERMINED BY X-RAY DIFFRACTION ANALYSES (SORTED BY HYDROSTRATIGRAPHIC UNIT)

Well site	Depth (ft)	Illite %	Kaolinite %	Chlorite %	Illite/ Smectite %	Smectite %	Total clay %	Quartz %	Feldspar %	Calcite %	Total %	Hydrostratigraphic unit	Stratigraphic unit
C-5	767	7	90	0	2	1	100	0	0	0	100	McQueen Br. aquifer	Middendorf
C-5	785	5	94	0	1	0	100	0	0	0	100	McQueen Br. aquifer	Middendorf
C-5	834	7	90	0	3	0	100	0	0	0	100	McQueen Br. aquifer	Middendorf
C-5	859	3	95	0	1	1	100	0	0	0	100	McQueen Br. aquifer	Middendorf
C-5	875	10	86	0	4	0	100	0	0	0	100	McQueen Br. aquifer	Middendorf
C-5	897	0	100	0	0	0	100	0	0	0	100	McQueen Br. aquifer	Middendorf
C-6	947	6	85	0	5	4	100	0	0	0	100	McQueen Br. aquifer	Black Creek
C-6	971	19	72	0	5	4	100	0	0	0	100	McQueen Br. aquifer	Black Creek
C-6	1002	6	89	0	5	0	100	0	0	0	100	McQueen Br. aquifer	Middendorf
C-6	1100	46	40	0	10	4	100	0	0	0	100	McQueen Br. aquifer	Middendorf
C-6	1127	12	78	0	4	6	100	0	0	0	100	McQueen Br. aquifer	Middendorf
C-6	1187	11	83	2	4	0	100	0	0	0	100	McQueen Br. aquifer	Middendorf
C-10	1504	41	44	0	14	1	100	0	0	0	100	McQueen Br. aquifer	Cape Fear
C-10	1575	13	48	0	33	6	100	0	0	0	100	Appleton confining system	Cape Fear
C-10	1608	30	35	0	31	4	100	0	0	0	100	Appleton confining system	Cape Fear
C-10	1649	20	49	0	31	0	100	0	0	0	100	Appleton confining system	Cape Fear
C-2	552	29	56	2	9	4	100	0	0	0	100	Appleton confining system	Saprolite
C-3	512	16	70	0	10	4	100	0	0	0	100	Appleton confining system	Saprolite
C-5	960	3	97	0	0	0	100	0	0	0	100	Appleton confining system	Cape Fear
C-5	990	33	51	0	15	1	100	0	0	0	100	Appleton confining system	Cape Fear
C-5	1024	22	52	0	25	1	100	0	0	0	100	Appleton confining system	Cape Fear
C-5	1029	28	33	0	38	1	100	0	0	0	100	Appleton confining system	Cape Fear
C-5	1066	30	26	0	38	6	100	0	0	0	100	Appleton confining system	Saprolite
C-6	1234	32	39	0	25	4	100	0	0	0	100	Appleton confining system	Cape Fear
C-6	1300	54	16	1	28	1	100	0	0	0	100	Appleton confining system	Cape Fear
C-6	1350	49	14	0	37	0	100	0	0	0	100	Appleton confining system	Saprolite

CLAY MINERALOGY DETERMINED BY X-RAY DIFFRACTION ANALYSES (SORTED BY STRATIGRAPHIC UNIT)

Well site	Depth (ft)	Illite %	Kaolinite %	Chlorite %	Illite/ Smectite %	Smectite %	Total clay %	Quartz %	Feldspar %	Calcite %	Total %	Hydrostratigraphic unit	Stratigraphic unit
C-2	15	7	60	0	3	0	70	30	0	0	100	Steed Pond aquifer	Upland unit
C-10	41	0	100	0	0	0	100	0	0	0	100	Upper Three Runs aquifer	Tobacco Road
C-10	53	31	41	0	27	1	100	0	0	0	100	Upper Three Runs aquifer	Tobacco Road
C-10	87	11	89	0	0	0	100	0	0	0	100	Upper Three Runs aquifer	Tobacco Road
C-10	106	0	100	0	0	0	100	0	0	0	100	Upper Three Runs aquifer	Tobacco Road
C-10	150	12	88	0	0	0	100	0	0	0	100	Upper Three Runs aquifer	Tobacco Road
C-2	40	15	52	0	5	0	72	28	0	0	100	Steed Pond aquifer	Tobacco Road
C-5	48	6	94	0	0	0	100	0	0	0	100	Upper Three Runs aquifer	Tobacco Road
C-10	168	19	60	0	21	0	100	0	0	0	100	Upper Three Runs aquifer	Dry Branch
C-10	293	60	8	0	32	0	100	0	0	0	100	Upper Three Runs aquifer	Dry Branch
C-10	313	64	9	0	27	0	100	0	0	0	100	Upper Three Runs aquifer	Dry Branch
C-3	28	8	84	0	6	2	100	0	0	0	100	Steed Pond aquifer	Dry Branch
C-5	94	33	38	0	27	0	98	2	0	0	100	Upper Three Runs aquifer	Dry Branch
C-5	116	50	12	0	36	0	98	2	0	0	100	Upper Three Runs aquifer	Dry Branch
C-6	100	21	60	0	16	3	100	0	0	0	100	Upper Three Runs aquifer	Dry Branch
C-10	430	67	6	0	27	0	100	0	0	0	100	Gordon confining unit	Tinker/Santee
C-5	168	66	8	0	25	1	100	0	0	0	100	Gordon confining unit	Tinker/Santee
C-6	198	69	2	1	25	3	100	0	0	0	100	Gordon confining unit	Tinker/Santee
C-6	236	58	13	0	25	4	100	0	0	0	100	Gordon confining unit	Tinker/Santee
C-10	460	60	9	0	31	0	100	0	0	0	100	Gordon aquifer	Warley Hill
C-10	491	59	9	0	32	0	100	0	0	0	100	Gordon aquifer	Congaree/Fourmile
C-3	54	33	41	0	23	3	100	0	0	0	100	Steed Pond aquifer	Congaree/Fourmile
C-5	250	54	31	0	15	0	100	0	0	0	100	Gordon aquifer	Congaree/Fourmile
C-6	364	61	4	0	31	4	100	0	0	0	100	Gordon aquifer	Congaree/Fourmile
C-10	570	58	6	0	36	0	100	0	0	0	100	Gordon aquifer	Snapp
C-5	283	48	32	0	18	1	99	1	0	0	100	Crouch Br. confining unit	Snapp
C-10	614	16	57	0	27	0	100	0	0	0	100	Crouch Br. confining unit	Lang Syne/Sawdust
C-10	678	46	10	0	39	5	100	0	0	0	100	Crouch Br. confining unit	Lang Syne/Sawdust
C-2	184	15	78	0	7	0	100	0	0	0	100	Crouch Br. confining unit	Lang Syne/Sawdust
C-3	63	37	35	0	24	4	100	0	0	0	100	Steed Pond aquifer	Lang Syne/Sawdust
C-5	311	46	31	0	23	0	100	0	0	0	100	Crouch Br. confining unit	Lang Syne/Sawdust
C-6	430	65	6	0	24	5	100	0	0	0	100	Crouch Br. confining unit	Lang Syne/Sawdust
C-6	501	55	11	1	29	4	100	0	0	0	100	Crouch Br. confining unit	Lang Syne/Sawdust
C-10	718	32	34	0	34	0	100	0	0	0	100	Crouch Br. confining unit	Steel Creek
C-10	775	0	100	0	0	0	100	0	0	0	100	Crouch Br. aquifer	Steel Creek
C-3	101	25	62	0	7	0	94	6	0	0	100	Crouch Br. confining unit	Steel Creek
C-3	112	18	75	0	7	0	100	0	0	0	100	Crouch Br. aquifer	Steel Creek

CLAY MINERALOGY DETERMINED BY X-RAY DIFFRACTION ANALYSES (SORTED BY STRATIGRAPHIC UNIT)

Well site	Depth (ft)	Illite %	Kaolinite %	Chlorite %	Illite/Smectite %	Smectite %	Total clay %	Quartz %	Feldspar %	Calcite %	Total %	Hydrostratigraphic unit	Stratigraphic unit
C-3	124	23	44	0	27	6	100	0	0	0	100	Crouch Br. aquifer	Steel Creek
C-3	138	29	55	0	7	3	94	0	0	0	100	Crouch Br. aquifer	Steel Creek
C-5	364	2	98	0	0	0	100	0	0	0	100	Crouch Br. aquifer	Steel Creek
C-5	441	5	92	0	2	1	100	0	0	0	100	Crouch Br. aquifer	Steel Creek
C-6	598	17	79	0	4	0	100	0	0	0	100	Crouch Br. aquifer	Steel Creek
C-6	619	17	76	0	7	0	100	0	0	0	100	Crouch Br. aquifer	Steel Creek
C-10	887	26	57	0	6	11	100	0	0	0	100	Crouch Br. aquifer	Black Creek
C-10	965	35	59	0	0	0	100	0	0	0	100	Crouch Br. aquifer	Black Creek
C-10	1044	39	13	0	48	0	100	0	0	0	100	McQueen Br. confining unit	Black Creek
C-10	1135	61	8	0	25	6	100	0	0	0	100	McQueen Br. confining unit	Black Creek
C-2	288	25	65	0	7	3	100	0	0	0	100	Crouch Br. aquifer	Black Creek
C-2	393	24	60	0	12	4	100	0	0	0	100	McQueen Br. confining unit	Black Creek
C-3	153	18	60	0	17	5	100	0	0	0	100	Crouch Br. aquifer	Black Creek
C-3	212	19	56	0	16	6	97	3	0	0	100	Crouch Br. aquifer	Black Creek
C-3	284	12	84	0	4	0	100	0	0	0	100	McQueen Br. confining unit	Black Creek
C-3	310	27	53	0	11	4	95	5	0	0	100	McQueen Br. confining unit	Black Creek
C-5	586	32	39	0	28	1	100	0	0	0	100	McQueen Br. confining unit	Black Creek
C-5	629	55	24	0	20	1	100	0	0	0	100	McQueen Br. aquifer	Black Creek
C-5	667	10	90	0	0	0	100	0	0	0	100	McQueen Br. aquifer	Black Creek
C-5	684	0	100	0	0	0	100	0	0	0	100	McQueen Br. aquifer	Black Creek
C-6	678	45	38	0	17	0	100	0	0	0	100	Crouch Br. aquifer	Black Creek
C-6	728	56	15	0	29	0	100	0	0	0	100	Crouch Br. aquifer	Black Creek
C-6	770	70	4	1	22	3	100	0	0	0	100	McQueen Br. confining unit	Black Creek
C-6	812	68	3	0	27	2	100	0	0	0	100	McQueen Br. confining unit	Black Creek
C-6	890	47	13	2	33	5	100	0	0	0	100	McQueen Br. confining unit	Black Creek
C-6	947	6	85	0	5	4	100	0	0	0	100	McQueen Br. aquifer	Black Creek
C-6	971	19	72	0	5	4	100	0	0	0	100	McQueen Br. aquifer	Black Creek
C-10	1256	0	100	0	0	0	100	0	0	0	100	McQueen Br. aquifer	Middendorf
C-10	1336	16	56	0	28	0	100	0	0	0	100	McQueen Br. aquifer	Middendorf
C-10	1394	0	100	0	0	0	100	0	0	0	100	McQueen Br. aquifer	Middendorf
C-10	1438	40	46	0	10	4	100	0	0	0	100	McQueen Br. aquifer	Middendorf
C-10	1454	29	55	0	10	6	100	0	0	0	100	McQueen Br. aquifer	Middendorf
C-2	425	27	53	0	12	3	95	5	0	0	100	McQueen Br. aquifer	Middendorf
C-2	468	16	62	0	12	3	93	7	0	0	100	McQueen Br. aquifer	Middendorf
C-3	357	26	51	0	12	6	95	5	0	0	100	McQueen Br. aquifer	Middendorf
C-3	404	31	57	0	7	5	100	0	0	0	100	McQueen Br. aquifer	Middendorf
C-3	454	13	76	0	7	4	100	0	0	0	100	McQueen Br. aquifer	Middendorf

CLAY MINERALOGY DETERMINED BY X-RAY DIFFRACTION ANALYSES (SORTED BY STRATIGRAPHIC UNIT)

Well site	Depth (ft)	Illite %	Kaolinite %	Chlorite %	Illite/ Smectite %	Smectite %	Total clay %	Quartz %	Feldspar %	Calcite %	Total %	Hydrostratigraphic unit	Stratigraphic unit
C-3	480	14	82	0	4	0	100	0	0	0	100	McQueen Br. aquifer	Middendorf
C-3	499	13	77	0	10	0	100	0	0	0	100	McQueen Br. aquifer	Middendorf
C-5	767	7	90	0	2	1	100	0	0	0	100	McQueen Br. aquifer	Middendorf
C-5	785	5	94	0	1	0	100	0	0	0	100	McQueen Br. aquifer	Middendorf
C-5	834	7	90	0	3	0	100	0	0	0	100	McQueen Br. aquifer	Middendorf
C-5	859	3	95	0	1	1	100	0	0	0	100	McQueen Br. aquifer	Middendorf
C-5	875	10	86	0	4	0	100	0	0	0	100	McQueen Br. aquifer	Middendorf
C-5	897	0	100	0	0	0	100	0	0	0	100	McQueen Br. aquifer	Middendorf
C-6	1002	6	89	0	5	0	100	0	0	0	100	McQueen Br. aquifer	Middendorf
C-6	1100	46	40	0	10	4	100	0	0	0	100	McQueen Br. aquifer	Middendorf
C-6	1127	12	78	0	4	6	100	0	0	0	100	McQueen Br. aquifer	Middendorf
C-10	1504	41	44	0	14	1	100	0	0	0	100	Appleton confining system	Cape Fear
C-10	1575	13	48	0	33	6	100	0	0	0	100	Appleton confining system	Cape Fear
C-10	1608	30	35	0	31	4	100	0	0	0	100	Appleton confining system	Cape Fear
C-10	1649	20	49	0	31	0	100	0	0	0	100	Appleton confining system	Cape Fear
C-5	960	3	97	0	0	0	100	0	0	0	100	Appleton confining system	Cape Fear
C-5	990	33	51	0	15	1	100	0	0	0	100	Appleton confining system	Cape Fear
C-5	1024	22	52	0	25	1	100	0	0	0	100	Appleton confining system	Cape Fear
C-5	1029	28	33	0	38	1	100	0	0	0	100	Appleton confining system	Cape Fear
C-6	1187	11	83	2	4	0	100	0	0	0	100	McQueen Br. aquifer	Cape Fear
C-6	1234	32	39	0	25	4	100	0	0	0	100	Appleton confining system	Cape Fear
C-6	1300	54	16	1	28	1	100	0	0	0	100	Appleton confining system	Cape Fear
C-2	552	29	56	2	9	4	100	0	0	0	100	Appleton confining system	Saprolite
C-3	512	16	70	0	10	4	100	0	0	0	100	Appleton confining system	Saprolite
C-5	1066	30	26	0	38	6	100	0	0	0	100	Appleton confining system	Saprolite
C-6	1350	49	14	0	37	0	100	0	0	0	100	Appleton confining system	Saprolite

BULK MINERALOGY DETERMINED FROM X-RAY DIFFRACTION ANALYSES (SORTED BY HYDROSTRATIGRAPHIC UNIT)

Well site	Depth (ft)	Illite %	Kaolinite %	Chlorite %	Illite/Smectite %	Smectite %	Total clay %	Quartz %	Feldspar %	Calcite %	Total %	Hydrostratigraphic unit	Stratigraphic unit
C-2	15	19	28	0	9	0	56	44	0	0	100	Steed Pond aquifer	Upland unit
C-2	40	41	5	1	7	6	60	40	0	0	100	Steed Pond aquifer	Tobacco Road
C-3	28	25	21	0	15	0	61	39	0	0	100	Steed Pond aquifer	Dry Branch
C-3	54	43	38	0	7	3	91	9	0	0	100	Steed Pond aquifer	Congaree/Fourmile
C-3	63	45	23	5	18	0	91	9	0	0	100	Steed Pond aquifer	Lang Syne/Sawdust
C-10	41	0	33	0	0	0	33	67	0	0	100	Upper Three Runs aquifer	Tobacco Road
C-10	53	38	32	0	21	0	91	9	0	0	100	Upper Three Runs aquifer	Tobacco Road
C-10	87	24	65	0	2	0	91	9	0	0	100	Upper Three Runs aquifer	Tobacco Road
C-10	106	20	36	0	0	0	56	44	0	0	100	Upper Three Runs aquifer	Tobacco Road
C-10	150	24	59	0	5	0	88	12	0	0	100	Upper Three Runs aquifer	Tobacco Road
C-10	168	0	28	0	0	0	28	72	0	0	100	Upper Three Runs aquifer	Dry Branch
C-10	293	0	0	0	0	0	0	100	0	low	100	Upper Three Runs aquifer	Dry Branch
C-10	313	0	0	0	0	0	0	100	0	low	100	Upper Three Runs aquifer	Dry Branch
C-5	48	35	38	0	5	0	78	22	0	0	100	Upper Three Runs aquifer	Tobacco Road
C-5	94	58	0	0	0	0	58	42	0	0	100	Upper Three Runs aquifer	Dry Branch
C-5	116	49	14	0	12	4	79	21	0	0	100	Upper Three Runs aquifer	Dry Branch
C-6	100	0	0	0	0	0	0	100	0	0	100	Upper Three Runs aquifer	Dry Branch
C-10	430	73	0	0	0	0	73	27	0	high	100	Gordon confining unit	Tinker/Santee
C-5	168	63	10	0	20	0	93	7	0	0	100	Gordon confining unit	Tinker/Santee
C-6	198	32	11	0	21	0	64	36	0	high	100	Gordon confining unit	Tinker/Santee
C-6	236	0	50	0	0	0	50	50	0	high	100	Gordon confining unit	Tinker/Santee
C-10	460	0	0	0	0	0	0	100	0	high	100	Gordon aquifer	Warley Hill
C-10	491	0	0	0	0	0	0	100	0	high	100	Gordon aquifer	Congaree/Fourmile
C-10	570	0	0	0	0	0	0	100	0	0	100	Gordon aquifer	Snapp
C-5	250	21	17	5	11	0	54	46	0	0	100	Gordon aquifer	Congaree/Fourmile
C-6	364	20	5	0	9	5	39	61	0	0	100	Gordon aquifer	Congaree/Fourmile
C-10	614	38	39	0	12	0	89	11	0	0	100	Crouch Br. confining unit	Lang Syne/Sawdust
C-10	678	58	4	0	23	4	89	11	0	0	100	Crouch Br. confining unit	Lang Syne/Sawdust
C-10	718	14	30	0	24	0	68	32	0	0	100	Crouch Br. confining unit	Steel Creek
C-2	184	28	57	1	6	2	94	6	0	0	100	Crouch Br. confining unit	Lang Syne/Sawdust
C-3	101	23	54	0	7	3	87	13	0	0	100	Crouch Br. confining unit	Steel Creek
C-5	283	36	24	0	19	7	86	14	0	0	100	Crouch Br. confining unit	Snapp
C-5	311	28	36	0	8	4	76	24	0	0	100	Crouch Br. confining unit	Lang Syne/Sawdust
C-6	430	54	0	0	24	0	78	22	0	0	100	Crouch Br. confining unit	Lang Syne/Sawdust
C-6	501	29	11	0	33	2	75	15	10	0	100	Crouch Br. confining unit	Lang Syne/Sawdust
C-10	775	15	47	0	4	0	66	34	0	0	100	Crouch Br. aquifer	Steel Creek
C-10	887	30	49	0	0	0	79	21	0	0	100	Crouch Br. aquifer	Black Creek

BULK MINERALOGY DETERMINED FROM X-RAY DIFFRACTION ANALYSES (SORTED BY HYDROSTRATIGRAPHIC UNIT)

Well site	Depth (ft)	Illite %	Kaolinite %	Chlorite %	Illite/Smectite %	Smectite %	Total clay %	Quartz %	Feldspar %	Calcite %	Total %	Hydrostratigraphic unit	Stratigraphic unit
C-10	965	34	43	0	4	0	81	19	0	0	100	Crouch Br. aquifer	Black Creek
C-2	288	20	76	0	3	1	100	0	0	0	100	Crouch Br. aquifer	Black Creek
C-3	112	14	48	0	6	0	68	32	0	0	100	Crouch Br. aquifer	Steel Creek
C-3	124	23	59	0	0	3	85	15	0	0	100	Crouch Br. aquifer	Steel Creek
C-3	138	15	69	0	5	3	92	8	0	0	100	Crouch Br. aquifer	Steel Creek
C-3	153	12	55	0	6	4	77	16	7	0	100	Crouch Br. aquifer	Black Creek
C-3	212	9	69	0	8	3	89	7	4	0	100	Crouch Br. aquifer	Black Creek
C-5	364	17	68	0	4	3	92	8	0	0	100	Crouch Br. aquifer	Steel Creek
C-5	441	33	4	26	4	9	76	24	0	0	100	Crouch Br. aquifer	Steel Creek
C-6	598	0	59	0	0	0	59	41	0	0	100	Crouch Br. aquifer	Steel Creek
C-6	619	29	52	0	0	0	81	19	0	0	100	Crouch Br. aquifer	Steel Creek
C-6	678	34	39	0	0	0	73	27	0	0	100	Crouch Br. aquifer	Black Creek
C-6	728	37	15	0	35	3	90	10	0	0	100	Crouch Br. aquifer	Black Creek
C-10	1044	42	0	0	31	0	73	27	0	low	100	McQueen Br. confining unit	Black Creek
C-10	1135	36	14	0	23	0	73	27	0	0	100	McQueen Br. confining unit	Black Creek
C-2	393	8	86	0	0	0	94	6	0	0	100	McQueen Br. confining unit	Black Creek
C-3	284	17	54	0	4	5	80	13	7	0	100	McQueen Br. confining unit	Black Creek
C-3	310	27	59	0	5	0	91	9	0	0	100	McQueen Br. confining unit	Black Creek
C-5	586	37	21	5	14	4	81	19	0	0	100	McQueen Br. confining unit	Black Creek
C-6	770	49	7	0	32	5	93	7	0	0	100	McQueen Br. confining unit	Black Creek
C-6	812	48	6	0	29	0	83	17	0	0	100	McQueen Br. confining unit	Black Creek
C-6	890	34	14	0	34	0	82	18	0	0	100	McQueen Br. confining unit	Black Creek
C-10	1256	14	21	0	8	0	43	57	0	0	100	McQueen Br. aquifer	Middendorf
C-10	1336	0	0	0	0	0	0	100	0	0	100	McQueen Br. aquifer	Middendorf
C-10	1394	0	26	0	0	0	26	74	0	0	100	McQueen Br. aquifer	Middendorf
C-10	1438	8	39	0	0	0	47	53	0	0	100	McQueen Br. aquifer	Middendorf
C-10	1454	12	20	0	6	0	38	49	13	0	100	McQueen Br. aquifer	Middendorf
C-2	425	17	56	0	11	0	84	16	0	0	100	McQueen Br. aquifer	Middendorf
C-2	468	24	35	0	0	0	59	41	0	0	100	McQueen Br. aquifer	Middendorf
C-3	357	18	48	1	3	3	73	17	10	0	100	McQueen Br. aquifer	Middendorf
C-3	404	23	21	5	10	3	62	38	0	0	100	McQueen Br. aquifer	Middendorf
C-3	454	13	8	0	0	0	21	79	0	0	100	McQueen Br. aquifer	Middendorf
C-3	480	13	29	0	0	6	48	52	0	0	100	McQueen Br. aquifer	Middendorf
C-3	499	9	23	0	8	0	40	60	0	0	100	McQueen Br. aquifer	Middendorf
C-5	629	29	7	29	15	4	84	16	0	0	100	McQueen Br. aquifer	Black Creek
C-5	667	32	44	0	5	4	85	15	0	0	100	McQueen Br. aquifer	Black Creek
C-5	684	34	36	3	5	3	81	19	0	0	100	McQueen Br. aquifer	Black Creek

BULK MINERALOGY DETERMINED FROM X-RAY DIFFRACTION ANALYSES (SORTED BY HYDROSTRATIGRAPHIC UNIT)

Well site	Depth (ft)	Illite %	Kaolinite %	Chlorite %	Illite/Smectite %	Smectite %	Total clay %	Quartz %	Feldspar %	Calcite %	Total %	Hydrostratigraphic unit	Stratigraphic unit
C-5	767	30	40	0	7	3	80	20	0	0	100	McQueen Br. aquifer	Middendorf
C-5	785	26	29	6	11	0	72	28	0	0	100	McQueen Br. aquifer	Middendorf
C-5	834	29	40	0	6	6	81	19	0	0	100	McQueen Br. aquifer	Middendorf
C-5	859	35	23	6	9	3	76	24	0	0	100	McQueen Br. aquifer	Middendorf
C-5	875	21	52	0	0	5	78	22	0	0	100	McQueen Br. aquifer	Middendorf
C-5	897	25	54	0	6	2	87	9	4	0	100	McQueen Br. aquifer	Middendorf
C-6	947	28	59	0	0	0	87	13	0	0	100	McQueen Br. aquifer	Black Creek
C-6	971	0	32	0	0	0	32	68	0	0	100	McQueen Br. aquifer	Black Creek
C-6	1002	32	55	0	2	0	89	11	0	0	100	McQueen Br. aquifer	Middendorf
C-6	1100	23	23	0	24	0	70	30	0	0	100	McQueen Br. aquifer	Middendorf
C-6	1127	19	60	0	5	0	84	16	0	0	100	McQueen Br. aquifer	Middendorf
C-6	1187	5	59	0	7	0	71	29	0	0	100	McQueen Br. aquifer	Cape Fear
C-10	1504	8	26	0	0	6	40	47	13	0	100	Appleton confining system	Cape Fear
C-10	1575	9	39	0	0	8	56	44	0	0	100	Appleton confining system	Cape Fear
C-10	1608	0	19	0	0	34	53	47	0	0	100	Appleton confining system	Cape Fear
C-10	1649	0	27	0	0	0	27	35	38	0	100	Appleton confining system	Cape Fear
C-2	552	15	6	3	3	3	30	47	23	0	100	Appleton confining system	Saprolite
C-3	512	20	44	18	2	0	84	16	0	0	100	Appleton confining system	Saprolite
C-5	960	20	8	12	9	7	56	44	0	0	100	Appleton confining system	Cape Fear
C-5	990	25	36	0	14	13	88	12	0	0	100	Appleton confining system	Cape Fear
C-5	1024	12	36	3	16	5	72	18	10	0	100	Appleton confining system	Cape Fear
C-5	1029	19	29	0	22	4	74	15	11	0	100	Appleton confining system	Cape Fear
C-5	1066	29	7	6	36	5	83	3	14	0	100	Appleton confining system	Saprolite
C-5	1082	44	22	7	7	3	83	6	11	medium	100	Appleton confining system	Saprolite
C-5	1085	19	27	4	10	19	79	11	10	low	100	Appleton confining system	Saprolite
C-6	1234	30	23	0	4	9	66	20	14	0	100	Appleton confining system	Cape Fear
C-6	1300	16	31	0	0	25	72	28	0	0	100	Appleton confining system	Cape Fear
C-6	1350	45	11	0	0	44	100	0	0	0	100	Appleton confining system	Saprolite

BULK MINERALOGY DETERMINED FROM X-RAY DIFFRACTION ANALYSES (SORTED BY STRATIGRAPHIC UNIT)													
Well site	Depth (ft)	Illite %	Kaolinite %	Chlorite %	Illite/Smectite %	Smectite %	Total clay %	Quartz %	Feldspar %	Calcite %	Total %	Hydrostratigraphic unit	Stratigraphic unit
C-2	15	19	28	0	9	0	56	44	0	0	100	Steep Pond aquifer	Upland unit
C-10	41	0	33	0	0	0	33	67	0	0	100	Upper Three Runs aquifer	Tobacco Road
C-10	53	38	32	0	21	0	91	9	0	0	100	Upper Three Runs aquifer	Tobacco Road
C-10	87	24	65	0	2	0	91	9	0	0	100	Upper Three Runs aquifer	Tobacco Road
C-10	106	20	36	0	0	0	56	44	0	0	100	Upper Three Runs aquifer	Tobacco Road
C-10	150	24	59	0	5	0	88	12	0	0	100	Upper Three Runs aquifer	Tobacco Road
C-2	40	41	5	1	7	6	60	40	0	0	100	Steep Pond aquifer	Tobacco Road
C-5	48	35	38	0	5	0	78	22	0	0	100	Upper Three Runs aquifer	Tobacco Road
C-10	168	0	28	0	0	0	28	72	0	0	100	Upper Three Runs aquifer	Dry Branch
C-10	293	0	0	0	0	0	0	100	0	low	100	Upper Three Runs aquifer	Dry Branch
C-3	28	25	21	0	15	0	61	39	0	0	100	Steep Pond aquifer	Dry Branch
C-5	94	58	0	0	0	0	58	42	0	0	100	Upper Three Runs aquifer	Dry Branch
C-5	116	49	14	0	12	4	79	21	0	0	100	Upper Three Runs aquifer	Dry Branch
C-6	100	0	0	0	0	0	0	100	0	0	100	Upper Three Runs aquifer	Dry Branch
C-10	430	73	0	0	0	0	73	27	0	high	100	Gordon confining unit	Tinker/Santee
C-5	168	63	10	0	20	0	93	7	0	0	100	Gordon confining unit	Tinker/Santee
C-6	198	32	11	0	21	0	64	36	0	high	100	Gordon confining unit	Tinker/Santee
C-6	236	0	0	0	0	0	50	50	0	high	100	Gordon confining unit	Tinker/Santee
C-10	460	0	0	0	0	0	0	100	0	high	100	Gordon aquifer	Warley Hill
C-10	491	0	0	0	0	0	0	100	0	high	100	Gordon aquifer	Congaree/Fourmile
C-3	54	43	38	0	7	3	91	9	0	0	100	Steep Pond aquifer	Congaree/Fourmile
C-5	250	21	17	5	11	0	54	46	0	0	100	Gordon aquifer	Congaree/Fourmile
C-6	364	20	5	0	9	5	39	61	0	0	100	Gordon aquifer	Congaree/Fourmile
C-10	570	0	0	0	0	0	0	100	0	0	100	Gordon aquifer	Snapp
C-5	283	36	24	0	19	7	86	14	0	0	100	Crouch Br. confining unit	Snapp
C-10	614	38	39	0	12	0	89	11	0	0	100	Crouch Br. confining unit	Lang Syne/Sawdust
C-10	678	58	4	0	23	4	89	11	0	0	100	Crouch Br. confining unit	Lang Syne/Sawdust
C-2	184	28	57	1	6	2	94	6	0	0	100	Crouch Br. confining unit	Lang Syne/Sawdust
C-3	63	45	23	5	18	0	91	9	0	0	100	Steep Pond aquifer	Lang Syne/Sawdust
C-5	311	28	36	0	8	4	76	24	0	0	100	Crouch Br. confining unit	Lang Syne/Sawdust
C-6	430	54	0	0	24	0	78	22	0	0	100	Crouch Br. confining unit	Lang Syne/Sawdust
C-6	501	29	11	0	33	2	75	15	10	0	100	Crouch Br. confining unit	Lang Syne/Sawdust
C-10	718	14	30	0	24	0	68	32	0	0	100	Crouch Br. confining unit	Steel Creek
C-10	775	15	47	0	4	0	66	34	0	0	100	Crouch Br. aquifer	Steel Creek
C-3	101	23	54	0	7	3	87	13	0	0	100	Crouch Br. confining unit	Steel Creek
C-3	112	14	48	0	6	0	68	32	0	0	100	Crouch Br. aquifer	Steel Creek

BULK MINERALOGY DETERMINED FROM X-RAY DIFFRACTION ANALYSES (SORTED BY STRATIGRAPHIC UNIT)													
Well site	Depth (ft)	Illite %	Kaolinite %	Chlorite %	Illite/Smectite %	Smectite %	Total clay %	Quartz %	Feldspar %	Calcite %	Total %	Hydrostratigraphic unit	Stratigraphic unit
C-3	124	23	59	0	0	3	85	15	0	0	100	Crouch Br. aquifer	Steel Creek
C-3	138	15	69	0	5	3	92	8	0	0	100	Crouch Br. aquifer	Steel Creek
C-5	364	17	68	0	4	3	92	8	0	0	100	Crouch Br. aquifer	Steel Creek
C-5	441	33	4	26	4	9	76	24	0	0	100	Crouch Br. aquifer	Steel Creek
C-6	598	0	59	0	0	0	59	41	0	0	100	Crouch Br. aquifer	Steel Creek
C-6	619	29	52	0	0	0	81	19	0	0	100	Crouch Br. aquifer	Steel Creek
C-10	887	30	49	0	0	0	79	21	0	0	100	Crouch Br. aquifer	Black Creek
C-10	965	34	43	0	4	0	81	19	0	0	100	Crouch Br. aquifer	Black Creek
C-10	1044	42	0	0	31	0	73	27	0	low	100	McQueen Br. confining unit	Black Creek
C-10	1135	36	14	0	23	0	73	27	0	0	100	McQueen Br. confining unit	Black Creek
C-2	288	20	76	0	3	1	100	0	0	0	100	Crouch Br. aquifer	Black Creek
C-2	393	8	86	0	0	0	94	6	0	0	100	McQueen Br. confining unit	Black Creek
C-3	153	12	55	0	6	4	77	16	7	0	100	Crouch Br. aquifer	Black Creek
C-3	212	9	69	0	8	3	89	7	4	0	100	Crouch Br. aquifer	Black Creek
C-3	284	17	54	0	4	5	80	13	7	0	100	McQueen Br. confining unit	Black Creek
C-3	310	27	59	0	5	0	91	9	0	0	100	McQueen Br. confining unit	Black Creek
C-5	586	37	21	5	14	4	81	19	0	0	100	McQueen Br. confining unit	Black Creek
C-5	629	29	7	29	15	4	84	16	0	0	100	McQueen Br. aquifer	Black Creek
C-5	667	32	44	0	5	4	85	15	0	0	100	McQueen Br. aquifer	Black Creek
C-5	684	34	36	3	5	3	81	19	0	0	100	McQueen Br. aquifer	Black Creek
C-6	678	34	39	0	0	0	73	27	0	0	100	Crouch Br. aquifer	Black Creek
C-6	728	37	15	0	35	3	90	10	0	0	100	Crouch Br. aquifer	Black Creek
C-6	770	49	7	0	32	5	93	7	0	0	100	McQueen Br. confining unit	Black Creek
C-6	812	48	6	0	29	0	83	17	0	0	100	McQueen Br. confining unit	Black Creek
C-6	890	34	14	0	34	0	82	18	0	0	100	McQueen Br. confining unit	Black Creek
C-6	947	28	59	0	0	0	87	13	0	0	100	McQueen Br. aquifer	Black Creek
C-6	971	0	32	0	0	0	32	68	0	0	100	McQueen Br. aquifer	Black Creek
C-10	1256	14	21	0	8	0	43	57	0	0	100	McQueen Br. aquifer	Middendorf
C-10	1336	0	0	0	0	0	0	100	0	0	100	McQueen Br. aquifer	Middendorf
C-10	1394	0	26	0	0	0	26	74	0	0	100	McQueen Br. aquifer	Middendorf
C-10	1438	8	39	0	0	0	47	53	0	0	100	McQueen Br. aquifer	Middendorf
C-10	1454	12	20	0	6	0	38	49	13	0	100	McQueen Br. aquifer	Middendorf
C-2	425	17	56	0	11	0	84	16	0	0	100	McQueen Br. aquifer	Middendorf
C-2	468	24	35	0	0	0	59	41	0	0	100	McQueen Br. aquifer	Middendorf
C-3	357	18	48	1	3	3	73	17	10	0	100	McQueen Br. aquifer	Middendorf
C-3	404	23	21	5	10	3	62	38	0	0	100	McQueen Br. aquifer	Middendorf
C-3	454	13	8	0	0	0	21	79	0	0	100	McQueen Br. aquifer	Middendorf

BULK MINERALOGY DETERMINED FROM X-RAY DIFFRACTION ANALYSES (SORTED BY STRATIGRAPHIC UNIT)													
Well site	Depth (ft)	Illite %	Kaolinite %	Chlorite %	Illite/Smectite %	Smectite %	Total clay %	Quartz %	Feldspar %	Calcite %	Total %	Hydrostratigraphic unit	Stratigraphic unit
C-3	480	13	29	0	0	6	48	52	0	0	100	McQueen Br. aquifer	Middendorf
C-3	499	9	23	0	8	0	40	60	0	0	100	McQueen Br. aquifer	Middendorf
C-5	767	30	40	0	7	3	80	20	0	0	100	McQueen Br. aquifer	Middendorf
C-5	785	26	29	6	11	0	72	28	0	0	100	McQueen Br. aquifer	Middendorf
C-5	834	29	40	0	6	6	81	19	0	0	100	McQueen Br. aquifer	Middendorf
C-5	859	35	23	6	9	3	76	24	0	0	100	McQueen Br. aquifer	Middendorf
C-5	875	21	52	0	0	5	78	22	0	0	100	McQueen Br. aquifer	Middendorf
C-5	897	25	54	0	6	2	87	9	4	0	100	McQueen Br. aquifer	Middendorf
C-6	1002	32	55	0	2	0	89	11	0	0	100	McQueen Br. aquifer	Middendorf
C-6	1100	23	23	0	24	0	70	30	0	0	100	McQueen Br. aquifer	Middendorf
C-6	1127	19	60	0	5	0	84	16	0	0	100	McQueen Br. aquifer	Middendorf
C-10	1504	8	26	0	0	6	40	47	13	0	100	Appleton confining system	Cape Fear
C-10	1575	9	39	0	0	8	56	44	0	0	100	Appleton confining system	Cape Fear
C-10	1608	0	19	0	0	34	53	47	0	0	100	Appleton confining system	Cape Fear
C-10	1649	0	27	0	0	0	27	35	38	0	100	Appleton confining system	Cape Fear
C-5	960	20	8	12	9	7	56	44	0	0	100	Appleton confining system	Cape Fear
C-5	990	25	36	0	14	13	88	12	0	0	100	Appleton confining system	Cape Fear
C-5	1024	12	36	3	16	5	72	18	10	0	100	Appleton confining system	Cape Fear
C-5	1029	19	29	0	22	4	74	15	11	0	100	Appleton confining system	Cape Fear
C-6	1187	5	59	0	7	0	71	29	0	0	100	McQueen Br. aquifer	Cape Fear
C-6	1234	30	23	0	4	9	66	20	14	0	100	Appleton confining system	Cape Fear
C-6	1300	16	31	0	0	25	72	28	0	0	100	Appleton confining system	Cape Fear
C-2	552	15	6	3	3	3	30	47	23	0	100	Appleton confining system	Saprolite
C-3	512	20	44	18	2	0	84	16	0	0	100	Appleton confining system	Saprolite
C-5	1066	29	7	6	36	5	83	3	14	0	100	Appleton confining system	Saprolite
C-5	1082	44	22	7	7	3	83	6	11	medium	100	Appleton confining system	Saprolite
C-5	1085	19	27	4	10	19	79	11	10	low	100	Appleton confining system	Saprolite
C-6	1350	45	11	0	0	44	100	0	0	0	100	Appleton confining system	Saprolite

APPENDIX 6. Well locations at each cluster site.

Location of wells at site C-1.

Location of wells at site C-3.

Location of wells at site C-2.

Location of wells at site C-5.

Location of wells at site C-6.

Location of wells at site C-7.

Location of wells at site C-10.

APPENDIX 7. Hydrographs.

WATER LEVEL (FEET. MSL)

WATER LEVEL (FEET. MSL)

WATER LEVEL (FEET. LSD)

WATER LEVEL (FEET, MSL)

WATER LEVEL (FEET, MSL)

WATER LEVEL (FEET, LSD)

WATER LEVEL (FEET, LSD)

APPENDIX 8. Pearson's correlation coefficients of hydrographs.

Correlation Analysis

28 'VAR' Variables: DAY AIK817 AIK818 AIK824 AIK825
 AIK826 AIK845 AIK846 AIK847 AIK848
 AIK849 ALL347 ALL348 BRN349 BRN350
 BRN351 BRN352 BRN353 BRN354 BRN355
 BRN356 BRN358 BRN359 BRN360 BRN365
 BRN366 BRN367 BRN368

Simple Statistics

Variable	N	Mean	Std Dev	Sum	Minimum	Maximum
DAY	1826	1005.1	654.7	1835313	1.0000	2192.0
AIK817	1083	236.7	0.7426	256342	235.5	238.3
AIK818	936	238.7	0.8574	223432	237.3	240.3
AIK824	342	239.4	1.1874	81876.9	237.7	240.8
AIK825	536	239.7	1.3859	128463	237.4	241.8
AIK826	1048	272.9	1.6418	285996	270.8	276.4
AIK845	211	275.8	0.2158	58198.1	275.5	276.3
AIK846	212	275.9	0.2138	58500.3	275.5	276.4
AIK847	212	276.0	0.1968	58502.7	275.6	276.3
AIK848	212	268.1	0.3709	56846.7	267.0	268.9
AIK849	211	260.2	0.3589	54907.1	259.5	261.1
ALL347	215	191.8	0.2114	41245.7	191.4	192.2
ALL348	43	198.6	0.0825	8538.0	198.3	198.7
BRN349	1284	195.7	1.4083	251261	193.5	198.7
BRN350	1317	175.4	2.7100	230995	172.4	182.8
BRN351	1119	176.2	2.8627	197146	173.0	183.4
BRN352	796	164.3	1.8303	130788	161.1	168.5
BRN353	1036	172.6	0.8740	178861	170.8	175.4
BRN354	964	164.4	1.6112	158506	161.7	168.7
BRN355	1014	172.5	0.9509	174921	170.7	175.5
BRN356	932	196.4	1.1499	183039	193.8	198.8
BRN358	181	214.8	0.3345	38876.4	214.3	215.7
BRN359	791	215.6	2.1044	170514	213.0	220.6
BRN360	968	243.6	3.1303	235762	237.4	250.1
BRN365	181	210.8	0.5508	38155.9	210.2	212.0
BRN366	181	215.9	0.2975	39069.5	215.4	216.6
BRN367	181	218.3	0.8913	39508.2	217.3	220.2
BRN368	181	210.8	0.5479	38146.3	210.1	211.9

Correlation Analysis

Pearson Correlation Coefficients / Number of Observations

	DAY	AIK817	AIK818	AIK824	AIK825	AIK826
DAY	1.00000 1826	0.40297 1083	0.42415 936	0.92138 342	0.83815 536	0.86807 1048
AIK817	0.40297 1083	1.00000 1083	0.99019 884	0.95021 283	0.96585 484	0.94593 800
AIK818	0.42415 936	0.99019 884	1.00000 936	0.97097 285	0.98485 351	0.96512 624
AIK824	0.92138 342	0.95021 283	0.97097 285	1.00000 342	0.96655 333	0.96294 334
AIK825	0.83815 536	0.96585 484	0.98485 351	0.96655 333	1.00000 536	0.94053 527
AIK826	0.86807 1048	0.94593 800	0.96512 624	0.96294 334	0.94053 527	1.00000 1048
AIK845	0.79137 211	0.44684 209	0.49527 209	-0.44320 209	0.66956 209	0.96757 211
AIK846	0.51093 212	0.27551 210	0.28717 210	-0.28378 210	0.40477 210	0.82198 211
AIK847	0.29012 212	0.21196 210	0.19047 210	-0.25029 210	0.23776 210	0.71350 211
AIK848	0.08584 212	0.57977 210	0.07917 210	-0.49761 210	0.20080 210	0.46636 211
AIK849	-0.49792 211	0.25834 209	-0.29267 209	-0.19722 209	-0.31751 209	-0.05233 211
ALL347	-0.90604 215	-0.18020 213	-0.40910 212	0.43331 213	-0.63406 212	-0.65007 211
ALL348	-0.43121 43	0.20742 43	0.30802 42	0.18741 43	0.12169 42	0.08645 41
BRN349	0.95807 1284	0.33821 1063	0.41172 901	0.95787 335	0.82411 529	0.83117 990
BRN350	0.90138 1317	0.59091 1038	0.64296 891	0.95469 339	0.87232 524	0.88717 1004
BRN351	0.90359 1119	0.61188 906	0.65323 777	0.95710 339	0.88886 487	0.91938 852
BRN352	0.74096 796	0.81711 582	0.85587 505	0.83994 305	0.80911 398	0.82191 784
BRN353	0.37630 1036	0.49736 807	0.60278 610	0.62452 335	0.40799 529	0.44993 1022

Correlation Analysis

Pearson Correlation Coefficients / Number of Observations

	DAY	AIK817	AIK818	AIK824	AIK825	AIK826
BRN354	0.79144 964	0.76219 769	0.82519 590	0.82912 307	0.75764 508	0.80790 950
BRN355	0.41148 1014	0.52881 764	0.64561 588	0.64639 339	0.44802 527	0.50499 1002
BRN356	0.95446 932	0.78797 682	0.81551 569	0.95282 339	0.84780 482	0.86705 920
BRN358	-0.90745 181	-0.04143 179	-0.51674 179	0.27380 179	-0.61659 179	-0.56276 179
BRN359	0.89299 791	0.86741 619	0.90008 491	0.95550 307	0.88239 440	0.88617 785
BRN360	0.71564 968	0.59385 721	0.67152 562	0.75931 287	0.67195 463	0.61428 962
BRN365	-0.94675 181	-0.12589 179	-0.59587 179	0.30799 179	-0.70537 179	-0.60419 179
BRN366	-0.92336 181	-0.07087 179	-0.53563 179	0.30184 179	-0.64263 179	-0.58275 179
BRN367	-0.95042 181	-0.13787 179	-0.62030 179	0.31067 179	-0.71787 179	-0.62247 179
BRN368	-0.94182 181	-0.12979 179	-0.59574 179	0.28805 179	-0.70095 179	-0.59897 179

Correlation Analysis

Pearson Correlation Coefficients / Number of Observations

	AIK845	AIK846	AIK847	AIK848	AIK849	ALL347
DAY	0.79137 211	0.51093 212	0.29012 212	0.08584 212	-0.49792 211	-0.90604 215
AIK817	0.44684 209	0.27551 210	0.21196 210	0.57977 210	0.25834 209	-0.18020 213
AIK818	0.49527 209	0.28717 210	0.19047 210	0.07917 210	-0.29267 209	-0.40910 212
AIK824	-0.44320 209	-0.28378 210	-0.25029 210	-0.49761 210	-0.19722 209	0.43331 213
AIK825	0.66956 209	0.40477 210	0.23776 210	0.20080 210	-0.31751 209	-0.63406 212
AIK826	0.96757 211	0.82198 211	0.71350 211	0.46636 211	-0.05233 211	-0.65007 211
AIK845	1.00000 211	0.80815 211	0.65961 211	0.53292 211	-0.00280 211	-0.71456 211
AIK846	0.80815 211	1.00000 212	0.90164 212	0.47040 212	0.04178 211	-0.38826 212
AIK847	0.65961 211	0.90164 212	1.00000 212	0.44524 212	0.11586 211	-0.15680 212
AIK848	0.53292 211	0.47040 212	0.44524 212	1.00000 212	-0.71141 211	-0.16264 212
AIK849	-0.00280 211	0.04178 211	0.11586 211	0.71141 211	1.00000 211	0.41147 211
ALL347	-0.71456 211	-0.38826 212	-0.15680 212	-0.16264 212	0.41147 211	1.00000 215
ALL348	0.09244 41	0.11863 42	0.09386 42	0.33004 42	0.41192 41	0.63261 43
BRN349	-0.64984 208	-0.38511 209	-0.18431 209	0.10478 209	0.64230 208	0.90181 212
BRN350	-0.81686 208	-0.51110 209	-0.27515 209	-0.14630 209	0.43192 208	0.92714 212
BRN351	-0.81684 208	-0.50070 209	-0.26530 209	-0.15412 209	0.42330 208	0.92807 212
BRN352	-0.54882 208	-0.28697 209	-0.08375 209	0.30363 209	0.74866 208	0.80510 212
BRN353	-0.50626 208	-0.26274 209	-0.06654 209	0.35220 209	0.78041 208	0.77987 212

Correlation Analysis

Pearson Correlation Coefficients / Number of Observations

	AIK845	AIK846	AIK847	AIK848	AIK849	ALL347
BRN354	-0.54838 208	-0.27766 209	-0.06952 209	0.29701 209	0.74423 208	0.81259 212
BRN355	-0.56460 208	-0.31962 209	-0.11283 209	0.28610 209	0.75049 208	0.81618 212
BRN356	-0.66247 208	-0.49006 209	-0.28001 209	0.02957 209	0.52290 208	0.84415 212
BRN358	-0.58627 179	-0.22464 179	0.00967 179	-0.07241 179	0.48016 179	0.88102 181
BRN359	-0.70173 179	-0.29205 179	-0.04349 179	-0.20569 179	0.35893 179	0.90485 181
BRN360	-0.57174 179	-0.18982 179	0.01962 179	-0.01400 179	0.47993 179	0.81730 181
BRN365	-0.64042 179	-0.21224 179	0.03972 179	-0.13934 179	0.41192 179	0.90255 181
BRN366	-0.61233 179	-0.24535 179	-0.00825 179	-0.10677 179	0.45914 179	0.89417 181
BRN367	-0.65403 179	-0.23648 179	0.01053 179	-0.14109 179	0.40691 179	0.88679 181
BRN368	-0.63320 179	-0.20773 179	0.04725 179	-0.12840 179	0.42460 179	0.89965 181

Correlation Analysis

Pearson Correlation Coefficients / Number of Observations

	ALL348	BRN349	BRN350	BRN351	BRN352	BRN353
DAY	-0.43121 43	0.95807 1284	0.90138 1317	0.90359 1119	0.74096 796	0.37630 1036
AIK817	0.20742 43	0.33821 1063	0.59091 1038	0.61188 906	0.81711 582	0.49736 807
AIK818	0.30802 42	0.41172 901	0.64296 891	0.65323 777	0.85587 505	0.60278 610
AIK824	0.18741 43	0.95787 335	0.95469 339	0.95710 339	0.83994 305	0.62452 335
AIK825	0.12169 42	0.82411 529	0.87232 524	0.88886 487	0.80911 398	0.40799 529
AIK826	0.08645 41	0.83117 990	0.88717 1004	0.91938 852	0.82191 784	0.44993 1022
AIK845	0.09244 41	-0.64984 208	-0.81686 208	-0.81684 208	-0.54882 208	-0.50626 208
AIK846	0.11863 42	-0.38511 209	-0.51110 209	-0.50070 209	-0.28697 209	-0.26274 209
AIK847	0.09386 42	-0.18431 209	-0.27515 209	-0.26530 209	-0.08375 209	-0.06654 209
AIK848	0.33004 42	0.10478 209	-0.14630 209	-0.15412 209	0.30363 209	0.35220 209
AIK849	0.41192 41	0.64230 208	0.43192 208	0.42330 208	0.74866 208	0.78041 208
ALL347	0.63261 43	0.90181 212	0.92714 212	0.92807 212	0.80510 212	0.77987 212
ALL348	1.00000 43	0.66009 43	0.73645 43	0.68366 43	0.66176 43	0.52603 43
BRN349	0.66009 43	1.00000 1284	0.91211 1243	0.90432 1080	0.84991 737	0.53582 977
BRN350	0.73645 43	0.91211 1243	1.00000 1317	0.99964 1108	0.89550 788	0.63869 995
BRN351	0.68366 43	0.90432 1080	0.99964 1108	1.00000 1119	0.89230 705	0.62079 838
BRN352	0.66176 43	0.84991 737	0.89550 788	0.89230 705	1.00000 796	0.81432 773
BRN353	0.52603 43	0.53582 977	0.63869 995	0.62079 838	0.81432 773	1.00000 1036

Correlation Analysis

Pearson Correlation Coefficients / Number of Observations

	ALL348	BRN349	BRN350	BRN351	BRN352	BRN353
BRN354	0.68502 43	0.87979 926	0.92112 923	0.91357 787	0.99725 720	0.78689 946
BRN355	0.57177 43	0.59255 955	0.69553 973	0.66424 861	0.84834 783	0.99697 991
BRN356	0.80498 43	0.99720 873	0.96184 905	0.97565 797	0.86069 768	0.56847 909
BRN358	0.52965 12	0.95394 181	0.89256 181	0.88825 181	0.94703 181	0.94988 181
BRN359	-0.26821 12	0.94956 765	0.97761 790	0.97605 690	0.94185 662	0.60148 768
BRN360	-0.39558 12	0.83378 909	0.74719 927	0.74775 808	0.85445 739	0.46543 945
BRN365	0.34119 12	0.95540 181	0.93579 181	0.93431 181	0.95017 181	0.94469 181
BRN366	0.19066 12	0.96282 181	0.90956 181	0.90563 181	0.94178 181	0.94197 181
BRN367	-0.29502 12	0.94691 181	0.93764 181	0.93568 181	0.95065 181	0.94815 181
BRN368	0.17855 12	0.95274 181	0.93033 181	0.92920 181	0.95580 181	0.94739 181

Correlation Analysis

Pearson Correlation Coefficients / Number of Observations

	BRN354	BRN355	BRN356	BRN358	BRN359	BRN360
DAY	0.79144 964	0.41148 1014	0.95446 932	-0.90745 181	0.89299 791	0.71564 968
AIK817	0.76219 769	0.52881 764	0.78797 682	-0.04143 179	0.86741 619	0.59385 721
AIK818	0.82519 590	0.64561 588	0.81551 569	-0.51674 179	0.90008 491	0.67152 562
AIK824	0.82912 307	0.64639 339	0.95282 339	0.27380 179	0.95550 307	0.75931 287
AIK825	0.75764 508	0.44802 527	0.84780 482	-0.61659 179	0.88239 440	0.67195 463
AIK826	0.80790 950	0.50499 1002	0.86705 920	-0.56276 179	0.88617 785	0.61428 962
AIK845	-0.54838 208	-0.56460 208	-0.66247 208	-0.58627 179	-0.70173 179	-0.57174 179
AIK846	-0.27766 209	-0.31962 209	-0.49006 209	-0.22464 179	-0.29205 179	-0.18982 179
AIK847	-0.06952 209	-0.11283 209	-0.28001 209	0.00967 179	-0.04349 179	0.01962 179
AIK848	0.29701 209	0.28610 209	0.02957 209	-0.07241 179	-0.20569 179	-0.01400 179
AIK849	0.74423 208	0.75049 208	0.52290 208	0.48016 179	0.35893 179	0.47993 179
ALL347	0.81259 212	0.81618 212	0.84415 212	0.88102 181	0.90485 181	0.81730 181
ALL348	0.68502 43	0.57177 43	0.80498 43	0.52965 12	-0.26821 12	-0.39558 12
BRN349	0.87979 926	0.59255 955	0.99720 873	0.95394 181	0.94956 765	0.83378 909
BRN350	0.92112 923	0.69553 973	0.96184 905	0.89256 181	0.97761 790	0.74719 927
BRN351	0.91357 787	0.66424 861	0.97565 797	0.88825 181	0.97605 690	0.74775 808
BRN352	0.99725 720	0.84834 783	0.86069 768	0.94703 181	0.94185 662	0.85445 739
BRN353	0.78689 946	0.99697 991	0.56847 909	0.94988 181	0.60148 768	0.46543 945

Correlation Analysis

Pearson Correlation Coefficients / Number of Observations

	BRN354	BRN355	BRN356	BRN358	BRN359	BRN360
BRN354	1.00000 964	0.83097 919	0.88802 839	0.94695 181	0.95012 718	0.86663 874
BRN355	0.83097 919	1.00000 1014	0.61074 925	0.97113 181	0.66515 765	0.54852 931
BRN356	0.88802 839	0.61074 925	1.00000 932	0.85076 181	0.95677 755	0.79137 852
BRN358	0.94695 181	0.97113 181	0.85076 181	1.00000 181	0.97181 181	0.96806 181
BRN359	0.95012 718	0.66515 765	0.95677 755	0.97181 181	1.00000 791	0.86691 747
BRN360	0.86663 874	0.54852 931	0.79137 852	0.96806 181	0.86691 747	1.00000 968
BRN365	0.95304 181	0.97046 181	0.84700 181	0.98100 181	0.99403 181	0.97080 181
BRN366	0.94324 181	0.96712 181	0.86136 181	0.99411 181	0.97910 181	0.96861 181
BRN367	0.95215 181	0.97298 181	0.84762 181	0.97907 181	0.99625 181	0.97840 181
BRN368	0.95848 181	0.97227 181	0.84194 181	0.98149 181	0.99287 181	0.97058 181

Correlation Analysis

Pearson Correlation Coefficients / Number of Observations

	BRN365	BRN366	BRN367	BRN368
DAY	-0.94675 181	-0.92336 181	-0.95042 181	-0.94182 181
AIK817	-0.12589 179	-0.07087 179	-0.13787 179	-0.12979 179
AIK818	-0.59587 179	-0.53563 179	-0.62030 179	-0.59574 179
AIK824	0.30799 179	0.30184 179	0.31067 179	0.28805 179
AIK825	-0.70537 179	-0.64263 179	-0.71787 179	-0.70095 179
AIK826	-0.60419 179	-0.58275 179	-0.62247 179	-0.59897 179
AIK845	-0.64042 179	-0.61233 179	-0.65403 179	-0.63320 179
AIK846	-0.21224 179	-0.24535 179	-0.23648 179	-0.20773 179
AIK847	0.03972 179	-0.00825 179	0.01053 179	0.04725 179
AIK848	-0.13934 179	-0.10677 179	-0.14109 179	-0.12840 179
AIK849	0.41192 179	0.45914 179	0.40691 179	0.42460 179
ALL347	0.90255 181	0.89417 181	0.88679 181	0.89965 181
ALL348	0.34119 12	0.19066 12	-0.29502 12	0.17855 12
BRN349	0.95540 181	0.96282 181	0.94691 181	0.95274 181
BRN350	0.93579 181	0.90956 181	0.93764 181	0.93033 181
BRN351	0.93431 181	0.90563 181	0.93568 181	0.92920 181
BRN352	0.95017 181	0.94178 181	0.95065 181	0.95580 181
BRN353	0.94469 181	0.94197 181	0.94815 181	0.94739 181

Correlation Analysis

Pearson Correlation Coefficients / Number of Observations

	BRN365	BRN366	BRN367	BRN368
BRN354	0.95304 181	0.94324 181	0.95215 181	0.95848 181
BRN355	0.97046 181	0.96712 181	0.97298 181	0.97227 181
BRN356	0.84700 181	0.86136 181	0.84762 181	0.84194 181
BRN358	0.98100 181	0.99411 181	0.97907 181	0.98149 181
BRN359	0.99403 181	0.97910 181	0.99625 181	0.99287 181
BRN360	0.97080 181	0.96861 181	0.97840 181	0.97058 181
BRN365	1.00000 181	0.98434 181	0.99663 181	0.99733 181
BRN366	0.98434 181	1.00000 181	0.98298 181	0.98479 181
BRN367	0.99663 181	0.98298 181	1.00000 181	0.99630 181
BRN368	0.99733 181	0.98479 181	0.99630 181	1.00000 181