Intracompany Correspondence

SOUTHERN COMPANY
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DATE: May 3, 2007

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RE: Vogtle Electric Generating Plant – Units 1&2
Groundwater Monitoring Plan for Radionuclides

JW

FROM: J. G. Aufdenkampe J. G. Aufdenkampe

TO: S. C. Swanson

Request for Engineering Review (RER) C062127201 requested that Vogtle Plant Support (VPS) develop a groundwater monitoring plan for radionuclides, which included:

1. Identify the design basis, commitments and criteria to evaluate potential groundwater contamination.
2. Review industry regulations and commitments on identifying and reporting radioactive contamination in groundwater.
3. Identify potential leakage or spill points for radionuclides.
4. Develop groundwater monitoring strategy including well locations, monitoring plan and reporting schedules.
5. Identify site specific issues.
6. Install groundwater monitoring wells and monitor.

An Engineering Work Order Release (EWOR) was generated (No. V003CT) to allow SCG Earth Sciences & Environmental Engineering to perform the evaluation and provide VPS with the necessary documentation for RER C062127201 (Reference Attachment 1).

<u>Items 1 & 2:</u>
Reference section 1.0 thru 4.3 and section 7.0 of Attachment 1

<u>Item 3:</u>
Section 4.1 of Attachment 1 provides reference to the existing and proposed monitoring well network and their monitoring purpose (Ref. Table 4-1). Section 5.2 of Attachment 1 Identifies several source areas that are common at nuclear power plants for radionuclides (EPRI, 2005).

<u>Item 4:</u>
Section 4.0 (Groundwater Monitoring) of Attachment 1 identifies the existing and planned monitoring wells and their locations for the groundwater monitoring strategy. Section 6.0 (Sampling and Analysis) of Attachment 1 provides parameters, analytical methods, recommended collection, detection limits, frequency, duration, sampling equipment, sampling procedures, sample preservation, chain of custody, laboratory QA/QC, field documentation, water quality monitoring reporting and follow up.

<u>Item 5:</u>
Site specific issues are discussed in section 1.0 (Location), 2.0 (Geology), and 3.0 (Hydrogeology) of Attachment 1.

Item 6:
This item will be covered in a later response to RER C062127201

This response has been discussed with Doug Tamplin and Mary Beth Lloyd and is a partial response to RER C062127201.

This response contains information that has not been verified in accordance with ANSI N45.2.11. Use of this information in a design change process requires verification per ANSI N45.2.11 and applicable site procedures.

If you have any questions, please contact Eric Higgins at extension 205-992-5455.

JGA/EDH/als

Attachments:
Attachment 1- Groundwater Monitoring Plan for Radionuclides prepared by Southern Company Generation Earth Science and Environmental Engineering.

cc: Southern Nuclear Operating Company
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Attachment 1

Groundwater Monitoring Plan for Radionuclides

By

Southern Company Generation
Earth Science and Environmental Engineering

Total Pages for Attachment 1: 98

PLANT ALVIN W. VOGTLE NUCLEAR GENERATING PLANT GROUNDWATER MONITORING PLAN FOR RADIONUCLIDES

Prepared For

Southern Nuclear Operating Company

By

Southern Company Generation
Earth Science and Environmental Engineering

April 2007

PLANT ALVIN W. VOGTLE
NUCLEAR GENERATING PLANT
GROUNDWATER MONITORING PLAN
FOR RADIONUCLIDES

Prepared for
Southern Nuclear Operating Company

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EXECUTIVE SUMMARY

Alvin W. Vogtle Electric Generating Plant, (VEGP), operated by Southern Nuclear Operating Company (SNC) is located in central Burke County located near Waynesboro in eastern Georgia near the South Carolina border. Radionuclide monitoring will be conducted at the existing VEGP under a voluntary implementation program. This plan has been prepared using the VEGP Final Safety Analysis Report (FSAR) as the design basis, but is supplemented with newer information contained in the site's Early Site Permit application package (SNC, 2006).

This groundwater monitoring plan is for a structurally and lithologically complex geologic terrane. This plan will show that detection monitoring adjacent to potential radionuclide sources is appropriate for an aquifer called the Water Table aquifer and that breaching the underlying aquitard (called the Blue Bluff Member or Marl) near potential sources is not necessary due to:

- The Marl's proven ability to restrict vertical groundwater movement and that wells within the aquitard are dry,
- Its intact nature (no interconnected or aerially extensive stress relief fractures), and
- Breaching the aquitard in the area of the plant with a well that is exposed at the ground surface within the power block could create an avenue of very rapid transport for any spilled pollutants.

However, conditions in a deeper aquifer, called the Tertiary aquifer, directly under the Marl confining unit will be monitored to detect cross-river migration of radionuclides and to establish background conditions. Large capacity plant wells and a surface water location will also be monitored for the same reasons.

A total of 29 monitoring wells and one surface water location will be used in the radionuclide detection program. Of the 29 wells, 21 will be monitoring wells in the Water Table aquifer using 13 existing wells and eight new wells (R-series). The Tertiary aquifer will be monitored with eight of the existing monitoring wells, including four existing monitoring wells and the four existing makeup water wells.

Several potential source areas are common at nuclear power plants. These are:

- Spent fuel pools,
- Refueling water storage tanks,
- Water treatment areas,
- Drains and tanks containing liquid waste from on-site analytical laboratories and other waste handling facilities, and
- Cooling water discharge areas from radionuclide leakage into cooling water system, which are diluted with circulating generator cooling water and discharged (this is called the dilution line at VEGP).

In addition to the above, other sources may include:

- Radioactive waste holding areas, and
- Radioactive waste solidification facilities.

The monitoring wells specified in this plan will be able to detect leaked radionuclides from any of the currently unmonitored facilities at VEGP.

The following table lists the groundwater radionuclide parameters to measure in the field and laboratory at VEGP.

Field Parameters

- pH
- Temperature
- Specific conductivity
- Dissolved oxygen (DO)
- Oxidation/reduction potential (ORP)
- Turbidity

Laboratory Parameters

- Tritium
- Gross alpha
- Gross beta
- Gamma emitters
- Bicarbonate alkalinity
- Chloride
- Total phosphate
- Nitrates (total)
- Sulfate
- Aluminum
- Calcium
- Iron
- Magnesium
- Potassium
- Sodium
- Silica

USEPA/State of Georgia guidelines for sampling and documentation will be used.

The groundwater monitoring parameters should include a minimum number of cations, anions and field parameters to characterize the water chemistry of each aquifer in each monitoring well. This will allow correlation of any positive radionuclide results to the proper source aquifer/surface water, or help determine mixing. Both statistical and graphical analysis of the water chemistry results will be used to track monitoring results over time. Examples of statistical and graphical presentations include relative charge balance diagrams called Stiff Diagrams or a percent of charge balance called a Piper Diagram.

The sampling interval will be quarterly for the first year with a statistical comparison of interwell and intrawell techniques to validate the best method for future use. After the first year, sampling will be semi-annual with annual reporting. SNC may change the sampling frequency to provide the appropriate level of monitoring.

There are also naturally occurring radionuclides that could present a source of false positives. The most likely source of natural radionuclides may be the phosphorus compounds that occur in the Lisbon Formation. However, several other sedimentary related radionuclides may be present.

Besides the naturally occurring radionuclides, there are known occurrences of tritium in Burke and Richmond Counties. The tritium is attributed to activities at the Savannah River Site (Summerour, 1997). Historical levels of tritium have been higher than 3,000 pCi/l, but are mostly below 300 pCi/l at the present time.

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1.0 INTRODUCTION

1.1 Location

Alvin W. Vogtle Electric Generating Plant, (VEGP), operated by Southern Nuclear Operating Company (SNC) is located in central Burke County located near Waynesboro in eastern Georgia near the South Carolina border (Figure 1-1). VEGP is jointly owned by Georgia Power (45.7%), Oglethorpe Power Corporation (30%), Municipal Electric Authority of Georgia (22.7%) and the City of Dalton (1.6%). Plant Vogtle's Unit 1 began commercial operation in May 1987. Unit 2 began commercial operation in May 1989. Each unit is capable of generating 1,215 megawatts (Mw) for a total capacity of 2,430 Mw. The plant is powered by pressurized water reactors (PWR) manufactured by Westinghouse.

VEGP is the only nuclear operating plant in eastern Georgia. There is a large nuclear materials processing and manufacturing plant (Savannah River Site, SRS) adjacent to VEGP, across the Savannah River. The SRS is a heavily studied site with known local and regional radiological impacts to soil and groundwater (Summerour, 1997).

1.2 Objectives

Southern Nuclear Operating Company's (SNC's) primary objectives of the groundwater monitoring program are to:

- Detect radionuclides in groundwater,
- Distinguish source of radionuclides on and off site,
- Present a conceptual model of groundwater flow, recharge, and discharge, and
- Establish groundwater 'fingerprint' types based on dissolved major ion associations for discerning areas with normal and anomalous geochemistry.

The plan will look at groundwater in a geologic mass called an aquifer system. An aquifer system can consist of one to several aquifers (high yielding, water-bearing materials) with one or several intervening aquitards (low yield or non yielding geologic materials). At VEGP there are three aquifer designations and several aquitards in the aquifer system directly under the plant. At this time only two aquifers will have detection monitoring for radionuclides. These are the Water Table aquifer and the Tertiary aquifer. The Water Table aquifer will be the most heavily monitored as the first line of detection to the deeper aquifers. Monitoring the next deeper aquifer with well pairs is not recommended at locations proximate to potential leak sources because of the potential for rapid, unintended migration of any pollutants to the next deeper aquifer through the well or borehole.

This groundwater monitoring plan closely follows the recommendations in the *Manual for Groundwater Monitoring*, Georgia Department of Natural Resources, Environmental Protection Division (EPD, 1991) and USEPA (2004). Any deviations from the manual are clearly explained in this groundwater monitoring plan.

1.3 Conceptual Monitoring Plan

This groundwater monitoring plan is for a structurally and lithologically complex geologic terrane. This plan will show that detection monitoring adjacent to potential radionuclide sources is appropriate for an aquifer called the Water Table aquifer and that breaching the underlying aquitard (called the Blue Bluff Member or marl) is not necessary due to:

- The marl's proven ability to restrict vertical groundwater movement and that wells within the aquitard are dry,
- Its intact nature (no interconnected or aerially extensive stress relief fractures), and
- Breaching the aquitard in the area of the plant with a well that is exposed at the ground surface within the power block present an avenue of very rapid transport for any spilled pollutants.

However, conditions in a deeper aquifer directly under the Water Table aquifer's confining clay bottom will be monitored to detect cross-river migration of radionuclides from the SRS and to establish background conditions. Large capacity plant wells will also be monitored for the same reasons.

In order to evaluate the monitoring results at VEGP, fingerprinting parameters will allow discrimination of water derived from the:

- Savannah River,
- The Water Table aquifer,
- The Tertiary aquifer,
- The Cretaceous aquifer,
- A combination of the Tertiary aquifer and the Cretaceous aquifer (from the makeup water wells), and
- Groundwater residing in the backfill area of the power the power block.

The plant's underlying geology varies greatly from one aquifer to another. The geologic variation is described in great detail in the Final Safety Analysis Report (FSAR). Pertinent content is transferred to this plan for supporting documentation of undisturbed geologic conditions and man-made geologic conditions under the power block and after aquifer pumping. In addition, important information discovered since the FSAR are considered in context of the existing plant. All of the known factors (FSAR and new) contributing to the plant's geology, hydrogeology, and aqueous geochemistry are included in this plan.

The radionuclide monitoring list is designed to identify the presence of different types of radioactive emissions (alpha, beta, and gamma emitters) and tritium. If significant radionuclide detection occurs, then SNC will prepare a plan to further characterize the source in the context of the aquifer system and fingerprinted water. A discussion of the data collection, analysis, geochemical/statistical evaluation in the context of the site's hydrogeology for reporting is included.

2.0 GEOLOGY

The bases of this radionuclide groundwater monitoring plan are the investigations for the FSAR. Pertinent geological and hydrogeologic characterizations are presented from the FSAR. In addition, relevant data derived from an Early Site Permit (ESP) are included using correlative terminology of the FSAR. The data in this plan are abbreviated to focus on the factors affecting the radionuclide detection monitoring. Given the abbreviation, this plan should not be used for any other purpose.

2.1 Summary of VEGP FSAR Subsurface Investigation Program

Field investigations included geologic mapping, drilling, geophysical survey, and groundwater studies. During the Preliminary Safety Analysis Report (PSAR) phase of the investigations, 474 holes were drilled for a total of 60,000 ft. A total of 111 holes were drilled subsequent to the PSAR investigations. The exploration program included electric logging, natural gamma, density, neutron, caliper, and three-dimensional velocity logs in selected drill holes. Water pressure tests and Menard pressure meter tests were performed to determine in-situ properties of the marl stratum, which provides bearing for plant structures and Seismic Category 1 backfill. Samples for fossil, mineral, or soluble carbonate analysis were taken in drill holes as required. The geophysical survey provided a total of 28,400 ft of shallow refraction seismic lines, 5000 ft of deep refraction lines, and cross-hole velocities in the upper 290 ft of materials.

2.2 Summary of Geology

The site is located in the Atlantic Coastal Plain physiographic province in central Georgia (Figure 2-1). The portion of the Coastal Plain province in which the site occurs is known as the Tifton Upland, which is characterized by rolling hills ranging in elevation from 80 to 280 ft in the site vicinity (Cooke, 1936; Cooke, 1938; Fenneman, 1938; Smith, 1979).

Figure 2-2 presents a regional geologic map within a 200-mile radius of VEGP. The geology within a 25-mile radius of the site consists of Precambrian and Paleozoic igneous and metamorphic basement rocks (gneisses and granites of the Kiokee Belt and phyllites and greenstones of the Belair Belt) overlain locally by Triassic basin sediments (Dunbarton Basin (Figure 2-3). These are, in turn, overlain by Cretaceous through Miocene Coastal Plain (shallow marine) sediments. Quaternary alluvial deposits occur along the Savannah River and its tributaries. Virtually all tectonic activity occurred prior to the deposition of the Cretaceous and later sediments.

The geology within a 5-mile radius of the site reflects the geology of the region. The contact between the basement complex and Cretaceous sediments occurs more than 1000 ft below the surface. As a result of regional elevation fluctuations following the deposition of the basal Cretaceous sediments (Tuscaloosa formation), overlying Paleocene through Miocene sediments represent marine transgressive and regressive sequences (Figure 2-4). Strata include shallow marine sand, clay, gravel, limestone, and marl. Quaternary deposits of sand, gravel, silt, and clay occur as flood plain deposits in the Savannah River valley and the larger tributaries to the river (Figures 2-4 and 2-5). However, the Quaternary system is principally represented by erosion and weathering rather than deposition.

Figure 2-6 is a lithologic chart that quickly summarized the main distinguishing characteristics of each formation in the aquifer system. Cretaceous and post-Cretaceous formations underlying the site are essentially flat lying or gently dipping to the southeast, reflecting a regional dip of about 30 ft/mi. Localized solution features occur in a shallow formation stratigraphically above the marl. In the area directly under the generating facilities, the solution forming materials have been physically removed and replaced with stable materials.

2.3 Site Geology

2.3.1 Site Physiography and Geomorphology

The site is located near the boundary between two topographic subdivisions of the Atlantic Coastal Plain province. These are the Tifton Upland to the southwest, upon which the site is located, and the older terraces to the northeast. The nearly flat topography of the older terraces is separated from the moderately hilly Tifton Upland by an abrupt 70- to 100-ft-high bluff cut by the Savannah River, which flows along its base (Fenneman,1938).

<u>Tifton Upland</u>. The plant is located on rolling hills at about El.300 ft. Elevations in the area range from 80 ft at the Savannah River to 280 ft at the crest of a knoll near the plant. Surface drainage is primarily northeastward toward the river via a dendritic stream pattern which surrounds the property. The solution and removal of carbonates from shallow underlying beds of calcareous sands and shells have resulted in the formation of local depressions, creating areas of internal drainage. Since these soluble zones occur within nearly horizontal strata resting upon an essentially impervious, hard, clay marl, springs generally have emerged at the top of exposures of the marl, causing erosion along cliff bases and headward erosion of the overlying sands and clays and the formation of amphitheaters and eventually ravines. Where shell deposits are thick, small-scale cavernous conditions occur along preferred percolation paths. The coalescing of the solution depressions or collapse of these small subterranean channels on the top of the clay marl results in ravines with apparently small drainage areas and with amphitheaters at the head (Cooke, 1936; Cooke, 1938; Fenneman, 1938; Smith, 1979).

<u>Older Terraces</u>. The older terrace subdivision of the Atlantic Coastal Plain province is represented principally by the Savannah River alluvial plain, which in the site area is broad and flat and at an elevation of 80 to 90 ft. The river valley is broad and mature and includes

low, dissected, old marine terraces as well as various river plain features, such as cutoff oxbows and natural levees (Cooke, 1936; Cooke, 1938; Fenneman, 1938; Smith, 1979).

2.3.3 *Site Lithology and Stratigraphy*

The site lithology has been determined from the following:

- Geologic and foundation exploration borings,
- Seismic refraction surveys,
- Correlations between holes using spontaneous potential, resistivity, and gamma logs,
- Geological mapping of the surface and foundation excavations for plant structures, and
- Millett fault study of 1982.

Surface distribution of geologic materials is shown on the site geologic map (Figure 2-5). Subsurface geological conditions are shown on the geologic sections (Figure 2-6).

Pre-Tertiary. Cretaceous sediments are known to underlie the site area and crop out a little more than 5 miles northeasterly from the site near the old town site of Ellenton. Approximately 600 ft of Cretaceous sediments rest unconformably upon a truncated and peneplained lithologic complex of Triassic, Paleozoic, and Precambrian age composed of indurated sediments, intrusive and extrusive igneous rocks, and metamorphic rocks. However, no materials identified as Cretaceous crop out within a radius of 5 miles of the site.

Tertiary System. In the site area, all geologic exposures are sediments of Eocene through Miocene age, except for local alluvial cover. Most exploratory drill hole intercepts include sediments of Eocene age and, where drilling started at higher ground surface elevations, sediments of Miocene age. Deep borings, such as TW-1, encountered Paleocene and Cretaceous sediments. The generalized lithology of the site, which is based in part on data obtained from exploratory drilling at the vicinity of the plant site, is presented in Table 2.1.

Eocene Series. The Eocene series in the site area consists of two lithologic units. The older is the Lisbon Formation, which includes the bearing unit for the plant structures; the younger is the Barnwell Group. The local lithologic characteristics and stratigraphy of these formations are summarized in Table 2.1 and discussed above.

Lisbon Formation. The Lisbon Formation of middle Eocene age is exposed only along the Georgia side of the Savannah River. In general, the exposed lithologic unit of this formation is an approximately 60-ft-thick, greenish-gray, fossiliferous clay marl with intercalated limestone lenses. This clay marl unit, which is the bearing bed for the plant structures, is the Blue Bluff Member of the Lisbon Formation.

TABLE 2.1

STRATIGRAPHIC UNITS IN THE VICINITY OF VEGP				
System		Series	Formation	Description
Quaternary	Recent to Pleistocene		Alluvium	Alluvial fill and terrace deposits in stream valleys, consisting of tan to gray sand, clay, slit, and gravel.
Tertiary	Miocene		Hawthorne Formation	Tan, red, and purple sandy clay, interbedded lenses of gravel, and numerous clastic dikes.
Tertiary	Eocene	Jackson Age	Barnwell Group	Red, brown, yellow, and buff, fine to coarse, massive to crossbedded sand and sandy clay.
		Claiborne Age	Lisbon Formation	Yellow-brown to green, fine to coarse, glauconitic quartz sand, interbedded with green, red, yellow, and tan clay, sandy marl or limestone, and lenses of siliceous limestone.
Tertiary	Paleocene		Huber/Ellenton Formation	Dark-gray to black, lignitic, micaceous clay containing disseminated crystals of gypsum. Medium- to dark-gray coarse sand and white kaolin.
Cretaceous	Upper		Tuscaloosa Formation	Tan, buff, red, and white cross- bedded micaceous quartzite and arkosic sand and gravel, interbedded with red, brown, and purple clay and white kaolin.

The lower portion of the Lisbon Formation, which is known in the site area only from exploration drilling, consists of an unnamed, approximately 100-ft-thick bed of fine-grained sand. The lower contact of the Lisbon Formation with the Paleocene Huber and Ellenton Formations is not exposed in the mapping area. Below the Lisbon Formation is the approximately 50-ft-thick lithologic unit comprised of interbedded clay, silty sand, and lignitic beds representing the Huber and Ellenton Formations. The upper contact of the Lisbon Formation with the Barnwell Group is well exposed in the power block excavation for the VEGP and along the Savannah River in the vicinity of the plant.

The best natural exposures of the Lisbon Formation within the mapping area are at Blue Bluff. They are described in detail in the report of investigation of the marl (Bechtel Power Corporation, 1974). Excellent exposure of the Lisbon Formation in the auxiliary building excavation for the VEGP was mapped and described in the reports of the power block excavations (Bechtel, 1978; Bechtel, 1979).

Numerous black shark teeth were found in the interval immediately below the marl, and microfossil analysis of a sample taken from hole 152 just below the base of the Blue Bluff Marl indicates an Eocene age for this material.

The Blue Bluff Marl is a distinct unit that is relatively constant in thickness over many square miles, although variable in lithology. The marl has been eroded from much of the Savannah River flood plain and covered over in part by the higher river terraces. It is completely eroded from the section in hole 36. In hole 45, some 3 miles farther away, a facies change has occurred, with the marl becoming dense gray-green, silty sand and silty clay.

Parallel to the river, however, it is 50 ft thick at Shell Bluff, approximately 1.5 miles northwest of the site, and 65 ft thick at hole 156 on the Griffin Landing Road, nearly 5 miles to the southeast.

Lisbon Formation in the Power Block Excavation. The upper Eocene Lisbon Formation is represented in the site area by the Blue Bluff Member marl, which is the foundation for structures in the power block area. The marl has a total thickness of about 70 ft in the site area. The upper approximately 25 ft of the marl were exposed in excavations and mapped in detail. A vertical section between El.108.6 ft (final excavated grade) and El.132 ft was exposed in the auxiliary building basement excavation. Ten subunits of the marl were recognized and mapped in this vertical section. The subunits, designated A through J are described on Figure 2-7, sheets 1, 2, and 3 and in detail in Appendix A.4.

The upper contact of the Lisbon Formation was exposed around the perimeter of the power block excavation, because it exists at an elevation higher than the top of the more localized auxiliary building excavation. The top of the Lisbon Formation corresponds with the top of the Blue Bluff Marl. This upper contact was examined in detail and surveyed. It varies in elevation from a high of 138.6 ft on the north side of the excavation to a low of 132.0 ft on the south side. The contact is erosional with very minor relief present. The uppermost few feet of the marl are locally weathered to a greenish color, and bioturbations (disturbance of the sediment due to the activity of organisms) were noted locally.

Barnwell Group. Late Eocene beds of the Barnwell Group are present over much of the area within 5 miles of the site. The formation is primarily comprised of tan, yellow, red, and white sands and clayey sands, although exposures of claystone, shelly limestone, and reef deposits are common. The Barnwell Group is comprised of four basic lithologic units which are listed below, from oldest to youngest:

- Utley Limestone,
- Twiggs Clay Member,
- Irwinton Sand Member, and
- Tobacco Road Sand (Upper Sand).

The Barnwell Group rests unconformably upon an erosion surface at the top of the Lisbon Formation. The Barnwell Group is shown as a single lithologic unit on the 5-mile-radius geologic map (Figure 2-5).

The oldest unit of the Barnwell Group is the Utley Limestone Member of the Clinchfield Formation. The Utley Limestone is a white to light-gray fossiliferous limestone, which has been referred to as the shell zone. The limestone was well exposed in the power block excavation for the VEGP and is locally exposed along the Georgia side of the Savannah River. This limestone layer, which is also thought to be of middle Eocene age, exhibits the effects of leaching. Surface topography, losses of drilling fluids during the exploratory drilling, and direct visual observation in the excavation and natural exposures all indicate the presence of solution cavities. The thickness of this unit varies from 0 to 100 ft. In the western area of the former construction city, the Utley may become indistinguishable from the the McBean Limestone, which is the youngest member of the older Lisbon Formation.

Locally overlying the Utley Limestone of the Barnwell Group is the Late Eocene, Twiggs Clay Member. The Twiggs Clay was exposed only in the power block excavation where it was a medium-gray, moderately hard, sandy claystone. The upper 2 to 5 ft are weathered to greenish-gray, reflecting the unconformable relationship with the overlying sand units.

Unconformably overlying the Twiggs Clay is the Irwinton Sand Member. The Irwinton Sand is present through much of the mapped area. Although the Irwinton Sand was well exposed in the power block excavation, it apparently pinches out to the west.

The Irwinton Sand is typically represented by unconsolidated, tan, and white, medium-grained sand and clayey sand. The sands are typically massive, although some cross-bedding is present. Tan clay seams and clayey zones along with scattered shell fragments and carbonaceous zones are present. The upper few feet of this unit in the power block excavation are comprised of shell fragments in a matrix of clay with manganese staining, providing a relatively sharp contact with the overlying sands.

Overlying the Irwinton Sand is the Tobacco Road Sand unit of the Barnwell Group. Tobacco Road Sand is typically red, although yellow, brown, tan, and mottled units are present. The sand is typically medium grained and locally cross-bedded. This sand unit is present throughout much of the mapping area and was particularly well exposed in the power block excavation and near the intersection of River Road and Little Beaver Dam Creek.

The upper portion of the Tobacco Road Sand locally contains lenses of limestone or relic features of limestone which have been leached. This limestone is well exposed near the intersection of Brier Creek and Thomas Bridge Road and near the intersection of the railroad and Newberry Creek. It should be noted that sands of the upper Barnwell Group are affected by surface weathering, forming mottled clayey sands and in many road cuts.

The Barnwell group was also observed in the walls of the power block and auxiliary building excavation. A detailed discussion of this mapping project is included as Appendix A.5.

The Irwinton Sand of the Barnwell Group unconformably overlies the Twiggs Clay in the southeast portion of the power block and overlies the Utley Limestone elsewhere. The Irwinton Sand consists of an approximately 50-ft-thick vertical sequence of sands, clays, and reef deposits. This sand is fine to medium grained and very well sorted, and it exhibits extensive cross-bedding. It is extremely friable and tends to rapidly slump and ravel, assuming its angle of repose soon after excavation.

Above the white sand and reef deposits is a sequence of tan sand and clay. The sand is generally fine to medium and moderately sorted, and it contains thin seams of tan clay having high plasticity. Two continuous marker horizons are present within this sequence. The first, a zone of manganese-straining and shell debris, occurs generally betweenEl.170 and 180 ft and was somewhat higher than this on the west side of the excavation. This zone, called the shell hash horizon, varies in thickness from less than 1 in. to almost 6 ft and could be traced continuously around the excavation slopes. A second shell hash horizon is locally present beneath the first one but is discontinuous. The second marker horizon is a zone of abundant tan clay seams, which varies from approximately 1 to almost 6 ft in thickness, and was found betweenEl.180 and 200 ft. This clay zone marks the top of the Irwinton sand.

Both of the marker horizons undulate along the strike, with flexures in the bedding reflecting underlying reef highs as well as lows due to collapse of cavities in the stratigraphically lower Utley Limestone.

Above the Irwinton Sand is the Tobacco Road Sand of the Barnwell Group. This sand extended up to the top of the excavation slopes and consisted of a thick (up to 40 ft) zone of predominately red sand with zones of lavender, purple, mustard yellow, and orange sand. The color changes are due to weathering effects and are not related to structure or lithology. The sand consists of fine- to medium-quartz grains which are moderately to well sorted and angular to subrounded. Colors are imparted by clay coatings on the individual grains. Differential weathering has produced mottled zones of bright colors, which form an alligator-skin effect near the top of the unit. The sand is dense, well consolidated, and completely uncemented.

At the top of the excavation slopes, recent deposits of buff-colored, alluvial and windblown sand were present locally. These deposits form a thin veneer of fine- to medium-grained, angular to subangular, well-sorted quartz sand which is highly gradational with the underlying sand of the Barnwell Group.

<u>Miocene Series.</u> The Hawthorne Formation of Miocene age caps the ridge and hills aboveEl.200 ft around the site area and lies unconformably upon the eroded surface of the upper sand member of the Eocene Barnwell Group. The Hawthorne Formation is typically red to brown mottled sandy clay and clayey sand. Lateral facies changes, however, result in significant lithologic variations including massive and cross-bedded lavender, purple, red, and brown medium- to coarse-grained sand. Channel deposits and localized lithologic changes are well illustrated in the railroad cut just east of Daniel Grove Baptist Church.

The contact between the Hawthorne Formation and the Barnwell Group is difficult to distinguish in the field. In gross terms, all lithologies present in the upper Barnwell Group occur in the Hawthorne Formation. The only unique distinguishing property of the Hawthorne Formation is the presence of siliceous gravel near the base of the formation.

Quaternary System. The Quaternary sediments in the site area consist of sands, gravels, silts, and clays of Pleistocene and Holocene ages. The Quaternary is largely represented by flood plain deposits in the Savannah River Valley and alluvial trains along the courses of larger streams tributary to the Savannah River. At the plant site elevation, the Quaternary is principally represented by erosion and weathering rather than depositional processes, although deposits of buff-colored, windblown sand are seen on higher ground.

2.3.4 Site Structural Geology

The formations underlying the site area are essentially flat lying or gently dipping to the southeast, reflecting the regional dip. The site area structure is illustrated on Figure 2-8 and Figure 2-9, which show subsurface contours on the top and bottom of the marl. The dip in the plant site area is about 30 ft/mi in a southeasterly direction. This gentle homoclinal structure is unbroken in the area except for a gentle dip reversal, which is of depositional and differential compaction origin. There is, however, a dip reversal of about 3 degrees to the northwest (Figures 2-8 and 2-9).

Solution depressions are apparent on the geologic map of the area (Figure 2-5). These features, which have been investigated and found to be confined and related to lithologic units stratigraphically above the Blue Bluff Member (Marl).

Faults and Lineaments

No faults or lineaments have been found within 5 miles of the site, other than those associated with the Triassic Basin (discussed below). These structures do not extend into the overlying Tertiary deposits. Examination of sediments exposed in the walls of the power block excavation has shown no evidence of faulting. This is particularly important to the groundwater radionuclide monitoring program because it shows major secondary permeability is not present in the most likely leak area.

The only fault found on site is the primary fault controlling the Dunbarton Basin formation, the Pen Branch fault, which bounds the northwest side of the basin (Figures 2-3 and 2-5). ESP-related field activities found evidence of faulting near the western extent of the former construction city area of VEGP. This has been interpreted to be part of the Pen Branch Fault. Barnwell Group sediments are not offset by the fault which demonstrates its noncapable history since the early Tertiary time. The fault appears to have been an earlier Paleozoic reverse fault that was re-activated as an extensional normal fault during Mesozoic continental rifting. The fault was subsequently reactivated in the very early Cenozoic as a reverse fault or right-oblique slip fault (Price et al., 1989; Snipes et al. 1993a; Stieve and Stephenson, 1995). The Pen Branch fault dips to the southeast. This structure does not extend into the younger Cenozoic sediments.

Detailed mapping of the Lisbon Formation in excavations at the plant site has demonstrated rapid lithologic changes laterally and rapid changes in the thickness of mappable units within the formation. The upper boundary of the bearing stratum, the Blue Bluff Marl, is basically established by the contact between it and an overlying shell bed, the Utley Limestone. The base is generally established by the presence of an underlying sand bed. In the excavation and in investigative borings, similar lithologic sequences are repeated vertically. The principal difference is one of scale. It can be shown within the excavation that thickness changes of 12 to 15 ft in a horizontal distance of less than 200 ft can occur in the Utley Limestone and in the Twiggs Clay, which is practically indistinguishable from the Blue Bluff Marl. It seems that over a distance of 1000 ft, the magnitude of change of thickness, the pinching out of key units, and the appearance of similar key units at lower elevations could create the appearance of a flexure.

<u>Prior Earthquake Effects</u>. There is no evidence to suggest that surficial or subsurface materials have been affected by prior earthquake activity. No evidence of texture faults were found from any of the site exploration borings or in the power block excavations.

<u>Deformational Zones</u>. Examination of outcrops, excavation exposures, and subsurface samples have revealed that there are no deformational zones within the Blue Bluff Marl, which is the foundation material for the major plant structures. Approximately 1000 ft northwest of the major structures, there is, however, a dip reversal of about 3 degrees to the northwest (Figures 2-8 and 2-9). This gentle dip reversal in the otherwise very gently southeasterly dipping (approximately 30 ft/mi southeasterly) homocline of Tertiary sediments is of depositional origin and does not represent a structural (tectonic) deformation.

During the construction phase at VEGP, a comprehensive inspection program was carried out to continuously monitor and assess the condition and character of all excavated marl throughout the power block area. A total of four joints were found in the uppermost strata of the marl. Two were found during routine inspection of the exposed marl surface prior to backfilling, and two were found during inspection of the radioactive waste solidification building caisson foundation. Each joint was independently investigated and found to be of limited depth and aerial extent and of nontectonic origin. Evidence produced by the investigations suggests that the joints were formed either during or immediately following late-stage diagenesis of the marl. Depositional loading from overlying sediments may have been a contributing factor. This is particularly important to the groundwater radionuclide monitoring program because it shows more minor secondary permeability is not present in the most likely leak area.

With the exception of the joints described above, no other fractures, partings, or anomalous features were found in the marl.

2.4 EXCAVATION BACKFILL

The natural ground surface in the plant area varied between elevation 200 and 230 ft MSL. The power block area was excavated and graded to an elevation of approximately 130 to 135 feet MSL near the top of the marl bearing stratum which is the clayey marl of the Blue Bluff Member of the Lisbon Formation. The excavation for the power block structures at the VEGP site is roughly square in shape; with three access ramps, one each in the northwest, southeast, and southwest corners of the excavation. It measures approximately 1400 ft on an edge at the top and 1000 ft on an edge at the toe. The side slopes were cut at a gradient of two horizontal to one vertical. The total excavated volume in the power block was approximately 5,000,000 yd^3 including the access ramp. Figures 2-10, sheets 1 through 3 present geologic maps of the excavation in 1977, before access roads were completed. The dominant backfill material is sand with minor amounts of clay and silt.

3.0 HYDROGEOLOGY

3.1 Site Ground Water

The first groundwater body encountered beneath the VEGP site is the Water Table aquifer (unconfined) in the Barnwell sands and Utley limestone. It overlies the Blue Bluff Marl. The site is on an interfluvial ridge that is nearly surrounded by streams that have cut down through the Barnwell sands and Utley limestone to the marl. This has isolated the Water Table aquifer beneath the site from adjacent areas. Groundwater discharges from the Water Table aquifer to the surrounding streams. The streams discharge to the Savannah River.

Underlying the Water Table aquifer is the Blue Bluff Marl, the upper member of the Lisbon Formation. The marl layer, approximately 70 ft thick, is a near-impermeable layer called an aquitard that effectively confines the underlying Tertiary and Cretaceous aquifers.

There are two confined aquifers beneath the site. The overlying Tertiary aquifer is represented beneath the site by the "unnamed sands" member of the Lisbon Formation. These Tertiary sands are the local, minor equivalent of the regional principal artesian aquifer, which consists primarily of permeable sands and limestones of several Tertiary formations extending throughout the Atlantic Coastal Plain.

The Cretaceous aquifer is the lowermost, and it consists primarily of the sands and gravels of the Tuscaloosa formation. It is often referred to as the Tuscaloosa aquifer. The Cretaceous aquifer and Tertiary aquifer are believed to be hydraulically connected beneath the plant site. The beds that normally separate the Tertiary aquifer from the underlying Cretaceous aquifer are somewhat more permeable than they are elsewhere.

Replenishment of the Water table Aquifer is by infiltration of precipitation. After percolation to the water table, groundwater moves laterally to the bordering interceptor streams. Potentiometric contours of the water table for 2005 and half of 2006 are shown in Figures 3-1 through 3-5. The water table is, in general, a subdued reflection of the ground surface, and movement is from the central portions of topographical highs (interfluve in FSAR) toward the bordering interceptor streams, which are topographically-low boundaries.

Power block structures are designed to accommodate groundwater levels of El.165 ft; hence, no permanent dewatering system is required. Figures 3-1 through 3-5 show a finer contour interval in the power block area. In the power block area, groundwater flow is moving to the north and northwest, except in its southeastern corner where groundwater flow is to the northeast toward the cooling towers.

Foundation design for the power-block facilities required excavation of the materials comprising the Water Table aquifer overlying the Blue Bluff Marl. To construct and maintain the excavation, the materials were dewatered by a series of ditches oriented in an east-west direction. They were connected by a north-south ditch, which drained to a sump in the southwest corner of the excavation. The sump was equipped with four pumps with a capacity of 500 gal/min each to remove inflows from groundwater. Additional capacity was provided for the removal of inflows of storm water into the excavation. Dewatering for construction was terminated, in March 1983, and the water levels and flow pattern of the Water Table aquifer have returned near the preconstruction pattern.

Upon completion of construction, recharge in the plant area returned more or less to the pre-construction levels with some change due to the structures, pavements, and surface drainage systems. However, the future recharge conditions was not expected to rise as high as the preconstruction conditions. Power block structures are designed to accommodate groundwater levels of El.165 ft; hence, no permanent dewatering system is required.

At the VEGP site the potentiometric surface of the Tertiary aquifer, determined from observation wells set in the unnamed sands below the confining (marl) layer, slopes to the northeast toward the Savannah River (Figures 3-6 through 3-10). The river has cut through the marl in the vicinity of VEGP, and it is in hydraulic contact with the underlying Tertiary aquifer. This allows the aquifer to discharge to the river in this area (especially well shown by Tertiary aquifer monitoring well number 27). This is a relatively local condition, as downstream of the VEGP site, the confining layer is intact below the river. Off the VEGP site, the confining layer allows the gross direction of groundwater movement to change in the confined aquifers to the southeast, the regional direction of migration of the aquifer.

Permeabilities of the aquifers and the confining layer were measured by field and laboratory methods for the PSAR, FSAR and the ESP. Permeability of Barnwell sands and clayey sands (Water Table aquifer) was measured *in situ* at two exploratory holes at the plant site and in the laboratory on three undisturbed samples. The results ranged from 10 to 302 ft/year (9.6×10^{-7} to 2.91×10^{-4} cm/second). SNC (2006) reported slug test results ranging from 27 to 96 feet per year (2.6×10^{-5} to 9.3×10^{-5} cm/second) in wells screened 5 to 15 feet above the Blue Bluff Member (marl) but in the lower half of the Water Table aquifer. One disturbed sample of Barnwell sands (considered for use as backfill) and two grab samples of backfill material were measured at different densities. Their permeability results ranged from 430 to 20,000 ft/year (4×10^{-4} to 1.9×10^{-2} cm/second). Two test wells, each with an array of 4 observation wells, were used to conduct field tests in the Utley limestone, which is at the base of Water Table aquifer. Data from the tests indicated that the permeability of the Utley limestone varies considerably from place to place. Calculated permeabilities range from 96 to 125,400 ft/year (1.6×10^{-5} to 1.2×10^{-1} cm/second).

In situ permeability tests in the Blue Bluff Member (the confining layer of Marl) were conducted in 95 intervals at different depths in 28 exploratory holes. In 90 percent of the intervals tested, no measurable water inflow occurred. In only three holes was any inflow confirmed: two of these were in near-surface, weathered marl. The range of laboratory permeability measurements is from 5.2×10^{-3} ft/year to 8.8 ft/year (5×10^{-6} to 8.5×10^{-6} cm/second). All of the permeability data are summarized in Table 3-1.

Table 3-1 Summary of Water Table aquifer and Blue Bluff Permeabilities

Aquifer	Test Type	Range
Water Table aquifer	*In situ*	0 to 302 ft/year (9.6 x 10^{-7} to 2.91 x 10^{-4} cm/second)
Water Table aquifer	Slug test	27 to 96 feet per year (2.6 x 10^{-5} to 9.3 x 10^{-5} cm/second)
Utley limestone	Pumping test	96 to 125,400 ft/year (1.6 x 10^{-5} to 1.2 x 10^{-1} cm/sec)
Blue Bluff Member (Marl)	*In situ*	5.2 x 10^{-3} ft/year to 8.8 ft/year (5 x 10^{-6} to 8.5 x 10^{-6} cm/second)

A groundwater level monitoring program has been implemented at the VEGP. This program has been designed to monitor potentiometric levels in the Water Table aquifer, the confined aquifers (Tertiary and Cretaceous), and hydrostatic pore pressure in the confining layer (marl). The program consists of various wells monitoring the unconfined aquifer, the Tertiary aquifer, the Cretaceous aquifer, and the confining layer.

3.2 Groundwater Users in the Area Surrounding VEGP

Large quantities of groundwater are stored in the confined aquifers underlying the region of the VEGP site, and relatively small withdrawals have occurred to date. Although many small communities derive water from wells, the draft on the aquifers is low because of the low population density, limited industrial development, abundant surface waters, and abundant rainfall (agricultural crops of the area do not require significant quantities of applied water). Future use of groundwater for industrial and domestic use is expected to increase to some degree, but withdrawals from the confined aquifers are estimated to be small (Leeth et al, 2005). Permitted municipal and industrial wells within 25 miles of VEGP are listed Table 3-2. Permitted agricultural wells are listed in Table 3-3 (Lewis, 2006). Permitted drinking water wells are listed in Table 3-4 (USEPA, 2006). All non-Southern Nuclear-owned wells are hydraulically upgradient from VEGP. The Savannah River forms a sink for groundwater on both sides of the river, although water may move from one side to the other (a relatively short distance) and in some areas, river water may actually recharge the underlying aquifers. Table 3-4 lists all of the wells associated with VEGP.

Present groundwater uses within 25 mi of the VEGP site are primarily municipal, industrial, and agricultural . Most of the groundwater wells withdraw water from the Cretaceous aquifer. Apart from water withdrawals for VEGP Units 1 and 2, the immediate area near the VEGP site has mainly domestic users, with no other large users nearby. The nearest domestic well is located west of the VEGP site across River Road.

The Georgia Environmental Protection Division (EPD) issues permits for wells having average daily withdrawals that exceed 100,000 gpd during any single month. These data indicate the nearest permitted agricultural well (William Hatcher, A-28) to be about 3.4 mi northwest of the VEGP site, while the nearest permitted industrial well (International Paper, I-1) is about 8.5 mi northwest of the site. The nearest municipal well (City of Waynesboro, M-1) is about 14.5 mi west-southwest of the VEGP site. The nearest SDWIS-listed well (Dealigle Mobile Home Park, C-6) is about 4.9 mi southwest of the VEGP site. These wells are sufficiently distant from the VEGP site such that pumping these wells would have no effect on groundwater levels at the VEGP site. The recharge areas for the source aquifers for the nearest Georgia EPD-permitted wells are in their outcrop areas located up-gradient of the VEGP site and beyond the influence of the VEGP.

Regionally, projected overall water use is expected to increase through 2035 for Burke County. Surface water usage is increasing; however, it is increasing at a much slower rate than groundwater usage, approximately 5 percent versus 17 percent. Burke County's water usage, including both surface and groundwater, is projected as 100 to 120 mgpd for 2035 (Fanning et al. 2003). Projections for Burke County total water use in 2050 are provided in the Comprehensive Water Supply Management Plan for Burke County and its Municipalities (Rutherford 2000). Assuming the same water usage patterns, groundwater demand with the population increasing to 43,420 people is projected to be 10.94 mgpd for domestic use, 14.73 mgpd for industrial use, and 40.96 mgpd for agricultural use, which totals 66.63 mgpd (Rutherford 2000).

Local groundwater use includes domestic wells and wells supplying water to existing VEGP Units 1 and 2. Uses include makeup process water, utility water, potable water, and supply for the fire protection system (Table 3-5). Current permitted withdrawal rates are a monthly average of 6 mgpd and an annual average of 5.5 mgpd, as permitted by the Georgia EPD. Three of the wells are in the Cretaceous aquifer at depths varying from 851 to 884 ft, with design yields of 1,000 to 2,000 gpm. These wells provide makeup water for the plant processes. The remaining six wells extend into the Tertiary aquifer, range in depth from 200 to 370 ft, and have design yields of 20 to 150 gpm. Average annual usage levels for 1999 to 2004 from all wells excluding SEC are from 0.79 to 1.44 mgpd (SNC 2005).

Table 3-2 Georgia EPD Permitted Municipal and Industrial Groundwater Users within 25 miles of the VEGP Site

Well ID	Permit Holder	County	Aquifer	Year	Permitted Monthly Average, gpm (mgpd)	Permitted Annual Average, gpm (mgpd)	Average Annual Water Use, gpm (mgpd)
C-2	City of Sardis	Burke	Floridan	2004	278 (0.40)	278 (0.40)	63 (0.09)
				2005	278 (0.40)	278 (0.40)	NA
C-12	East Central Regional Hospital - Gracewood Campus	Richmond	Cretaceous Sand	2004	347 (0.50)	278 (0.40)	146 (0.21)
				2005	NA	NA	76 (0.11)
C-13	City of Hephzibah	Richmond	Cretaceous Sand	2004	833 (1.20)	833 (1.20)	160 (0.23)
				2005	NA	NA	236 (0.34)
C-19	Olin Corporation	Richmond	Cretaceous Sand	2004	847 (1.22)	847 (1.22)	514 (0.74)
				2005	NA	NA	486 (0.70)
C-19	Olin Corporation - Corrective Action Wells	Richmond	Cretaceous Sand	2004	632 (0.91)	632 (0.91)	229 (0.33)
				2005	NA	NA	250 (0.36)
I-1	International Paper	Burke	Cretaceous Sand	2004	660 (0.95)	660 (0.95)	181 (0.26)
				2005	660 (0.95)	660 (0.95)	35 (0.05)
I-2	Prayon, Inc	Richmond	Cretaceous Sand	2004	292 (0.42)	264 (0.38)	35 (0.05)
				2005	NA	NA	63 (0.09)
I-3	Thermal Ceramics, Inc.	Richmond	Cretaceous Sand	2004	625 (0.90)	625 (0.90)	313 (0.45)
				2005	NA	NA	208 (0.30)
I-4	Procter & Gamble Manufacturing Company	Richmond	Cretaceous Sand	2004	486 (0.70)	486 (0.70)	278 (0.40)
				2005	NA	NA	243 (0.35)
I-5	Southern Wood Piedmont Company	Richmond	Cretaceous Sand	2004	451 (0.65)	451 (0.65)	188 (0.27)
				2005	NA	NA	174 (0.25)
M-1	City of Waynesboro	Burke	Cretaceous Sand	2004	2778 (4.00)	2431 (3.50)	NA
				2005	2778 (4.00)	2431 (3.50)	NA
M-2	Augusta-Richmond Utilities Department	Richmond	Cretaceous Sand	2004	12778 (18.40)	12083 (17.40)	8285 (11.93)
				2005	NA	NA	8.40
	Southern Nuclear Operating Co.	Burke	Cretaceous Sand	2004	4167 (6.00)	3819 (5.50)	556 (0.80)
				2005	4167 (6.00)	3819 (5.50)	583 (0.84)

Table 3-3 Georgia EPD Permitted Agricultural Groundwater Users within 25 miles of the VEGP Site

Well ID	Permit Holder	County	Depth (ft)	Permit (gpm)
A-1	ANDERSON JOHN	Burke	363	1500
A-2	BLANCHARD HENRY	Burke	500	1200
A-3	BLANCHARD HENRY	Burke	450	1400
A-4	BOLLWEEVIL PLANATION	Burke	300	190
A-5	Chance Bill	Burke	500	450
A-6	CHANDLER FARM	Burke	580	1600
A-7	Chandler Michael	Burke	556	2400
A-8	Chandler Randall	Burke	579	2500
A-9	COCHRAN IRBY	Burke	420	1350
A-10	COLLINS ROBERT	Burke	430	1350
A-11	COLLINS ROBERT	Burke	530	1200
A-12	COLLINS ROBERT	Burke	480	1100
A-13	COLLINS ROBERT	Burke	440	1100
A-14	Collins Robert	Burke	490	1700
A-15	DIXON CARL	Burke	600	2000
A-16	DIXON JAMES	Burke	210	400
A-17	DIXON JAMES	Burke	200	200
A-18	DIXON JOANNE	Burke	640	1150
A-19	DIXON PERCY	Screven	560	2000
A-20	DIXON PERCY	Burke	560	2000
A-21	DIXON PERCY	Burke	350	115
A-22	DIXON PERCY	Burke	350	115
A-23	DIXON PERCY	Burke	550	3400
A-24	DIXON PERCY	Burke	350	200
A-25	DIXON PERCY	Burke	575	2500
A-26	DIXON PERCY	Burke	550	2500
A-27	GWR Partnership LLP	Burke	360	200
A-28	Hatcher William	Burke	300	500
A-29	HEATH CLAXTON	Burke	300	150
A-30	HEATH CLAXTON	Burke	400	250
A-31	HEATWOLE BYARD	Burke	325	200
A-32	HOPKINS HENRY	Burke	363	350
A-33	Horst Isaac	Burke	260	250
A-34	MALLARD CLYDE	Burke	320	400
A-35	MALLARD CLYDE MALLARD FARMS	Burke	210	250
A-36	MALLARD J.	Burke	200	150
A-37	McGregor Charles	Burke	430	350
A-38	MOBLEY DANNY	Burke	396	350
A-39	Mobley Danny	Burke	424	650
A-40	MOBLEY HERBERT	Burke	465	1100
A-41	MOBLEY HERBERT	Burke	500	1250
A-42	MOBLEY JAMES F.	Burke	572	2000
A-43	PENNINGTON FARMS- INC.	Burke	240	250
A-44	RAYMOND NEIL	Burke	430	1350

Table 3-3 (Cont.) Georgia EPD Permitted Agricultural Groundwater Users within 25 miles of the VEGP Site

Well ID	Permit Holder	County	Depth (ft)	Permit (gpm)
A-45	Shepherd Joseph	Burke	421	1500
A-46	SMART DARRELL	Burke	300	350
A-47	SMART DARRELL	Burke	300	350
A-48	SMART DARRELL	Burke	300	350
A-49	SMART DARRELL	Burke	300	400
A-50	MIMS JOHN	Jenkins	445	1500
A-51	MIMS JOHN	Jenkins	460	1500
A-52	MULKEY A.	Jenkins	300	1000
A-53	MULKEY A.	Jenkins	400	500
A-54	PARKER GEORGE	Jenkins	450	700
A-55	PARKER GEORGE	Jenkins	300	450
A-56	PARKER GEORGE	Jenkins	300	450
A-57	Parker George	Jenkins	450	450
A-58	POINTE SOUTH GOLF CLUB- INC.	Richmond	311	400
A-59	BRAGG SOL	Screven	380	240
A-60	BRIAR CREEK COUNTRY CLUB	Screven	180	300
A-61	CAIN BRIAN	Screven	390	600
A-62	Cain Brian	Screven	493	1100
A-63	CLEMENT INVESTMENTS	Screven	282	1250
A-64	FOREHAND FARMS	Screven	160	250
A-65	Lee Mike	Screven	480	1800
A-66	Mill Haven Company Inc.	Screven	600	1200
A-67	MILLHAVEN CO.- INC.	Screven	553	1900
A-68	MILLHAVEN CO.- INC.	Screven	565	1400
A-69	NEWTON JAMES	Screven	350	400
A-70	SOWELL CAROLYN	Screven	275	300
A-71	STEPONGZI FRANK & PEARL	Screven	225	300
A-72	THOMPSON JAMES	Screven	475	750
A-73	THOMPSON ROGER	Screven	500	1000
A-74	WADE PLANTATION	Screven	215	200
A-75	WADE PLANTATION	Screven	250	190
A-76	WADE PLANTATION	Screven	460	1200
A-77	WADE PLANTATION	Screven	119	1000
A-78	WADE PLANTATION	Screven	750	1800
A-79	WADE PLANTATION	Screven	494	900
A-80	WADE PLANTATION	Screven	475	1200
A-81	WADE PLANTATION	Screven	672	1100
A-82	WADE PLANTATION	Screven	475	1100
A-83	WADE PLANTATION	Screven	525	1400
A-84	Wade Plantation	Screven	467	1100

Table 3-4 SDWIS Listed Public Water Systems Supplied from Groundwater within 25 miles of the VEGP Site

Well ID	Water System ID	Water System Name	County Served	Type	System Status
C-1	GA0330000	Girard	Burke	Community	Active
C-2	GA0330002	Sardis	Burke	Community	Active
C-3	GA0330013	Mamie Joe Rhodes Harrison Subdivision	Burke	Community	Closed
C-4	GA0330006	Burke Academy	Burke	Non-Transient Non-Community	Active
C-5	GA0330022	Burke County Training Center	Burke	Non-Transient Non-Community	Active
C-6	GA0330020	Delaigle Mobile Home Park	Burke	Transient Non-Community	Closed
C-7	GA1650000	Millen	Jenkins	Community	Active
C-8	GA1650001	Perkins Water Authority	Jenkins	Community	Active
C-9	GA1650006	Jockey International, Inc.	Jenkins	Non-Transient Non-Community	Active
C-10	GA1650005	DNR - Magnolia Springs State Pk.	Jenkins	Transient Non-Community	Active
C-11	GA1650008	National Fish Hatchery	Jenkins	Transient Non-Community	Closed
C-12	GA2450023	East Central Regional Hospital	Richmond	Community	Active
C-13	GA2450002	Hephzibah	Richmond	Community	Active
C-14	GA2450017	Hephzibah - Oakridge	Richmond	Community	Active
C-15	GA2450014	Mars Trailer Park	Richmond	Community	Active
C-16	GA2450016	Mobile Home Country Club MHP	Richmond	Community	Active
C-17	GA2450004	Richmond County	Richmond	Community	Closed
C-18	GA2450159	Albion Kaolin Company	Richmond	Non-Transient Non-Community	Closed
C-19	GA2450152	Olin Chemicals	Richmond	Non-Transient Non-Community	Closed
C-20	GA2510000	Hiltonia	Screven	Community	Active
C-21	GA2510015	Buck Creek M.H.P.	Screven	Community	Closed
C-22	GA2510052	Millhaven Plantation	Screven	Community	Closed
C-23	GA2510011	DOT - Georgia Welcome Center	Screven	Transient Non-Community	Active
C-24	GA2510057	Savannah River Challenge Program	Screven	Transient Non-Community	Active
	GA0330035	Southern Nuclear - Simulator Bld	Burke	Non-Transient Non-Community	Active
	GA0330017	Southern Nuclear - Vogtle Makeup	Burke	Non-Transient Non-Community	Active
	GA0330036	Southern Nuclear - Vogtle Rec	Burke	Transient Non-Community	Active

Table 3-5 Water-Supply Wells for the Existing VEGP Plant

Water Supply Well No.	Well Depth (ft)	Aquifer	Design Yield (gpm)	Water Use
MU-1	851	Cretaceous	2000	Make-up water for plant use (nuclear service water system; make-up to the water treatment plant demineralizer, and potable water source).
MU-2A	884	Cretaceous	1000	Make-up water for plant use (nuclear service water system; make-up to the water treatment plant demineralizer, and potable water source).
TW-1	860	Cretaceous	1000	Back-up water for the production make-up well system.
SW-5	200	Tertiary	20	Water supply for old security tactical training area.
IW-4	370	Tertiary	120	Irrigation water for ornamental vegetation.
CW-3	220	Tertiary	NA	Water supply for nuclear operations garage.
REC	265	Tertiary	150	Potable water supply for recreation area.
SB	340	Tertiary	50	Potable water supply for simulator training building.
SEC	320	Tertiary	10	Non-potable water for lavatory use at a new plant entrance security building

Notes: NA – not available

3.3 Post VEGP FSAR Tritium Studies in Burke County, Georgia

A consortium of investigators have re-examined the geology, hydrogeology, and occurrence of tritium in Burke County, Georgia (Summerour et al, 1994; Huddleston & Summerour, 1996; Summerour, 1997; and Summerour et al, 1998). Their geologic and hydrogeologic analyses are similar enough to the VEGP FSAR and ESP to not warrant further discussion. Tritium in the VEGP's Water Table aquifer wells, as well in surrounding Burke County, Georgia is attributed to atmospheric deposition of tritium from rain events. However, Summerour et al, 1998 put forth seven hypotheses (paraphrased below) regarding the mode of tritium occurrence in the deeper confined aquifers:

- Downward leakage of tritium containing water from the Upper Three Runs aquifer (South Carolina correlative to VEGP Water Table aquifer) such as the more permeable McBean Limestone member or the Lisbon Formation sand,
- Leakage through the Pen Branch fault,
- Leakage through the grouted annular spaces of monitoring wells,
- Leakage from the Three Runs aquifer to lower aquifers during drilling,
- Tritium contaminated drilling muds used in monitoring wells,
- Tritium contaminated condensate may have formed and traveled along the casing of wells in the deep aquifers, and
- Sample contact with atmospheric tritium.

Huddleston et al (1998) also identified two of these scenarios as being the most likely routes of occurrence -bullets 1 and 2. Both of these hypotheses are purely hydrogeologic and likely related to the brittle failure of then existent rocks during late Dunbarton Basin formation. These movements have been shown to predate deposition of the Barnwell Group and younger sediments. However, a salient point is that well drilling can present unintended consequences such as allowing leakage through fully confining layers. Their study did not disprove the potential for leakage through cross aquifer wells.

Clarke and West (1997) characterized regional flow into areas of net downward flow and upward flow in addition to horizontal flow. This included differential downward and upward flow near features like the Pen Branch Fault. Areas where the Blue Bluff Marl have been eroded away by the Savannah River area also susceptible to vertical movement of shallow and deeper groundwater depending on the groundwater/river water head differentials. VEGP's may have exposure to offsite radionuclides through the Pen Branch Fault or Quaternary alluvium/bedload from one or more of the following unproven path ways:

- Natural gradients under flowing the Savannah River,
- Savannah River water loss through incised strata of Tertiary/Cretaceous age, or

- Induced cross river migration through the Pen Branch Fault from use of VEGP's larger capacity wells (MU-1, MW-2, MU-2A or TW-1) that are screened in multiple water-producing zones.

VEGP site data suggest groundwater flow may be downward from the Water Table aquifer, through brittle fractures related to the Pen Branch Fault, into the Tertiary aquifer. This geologic feature is located sufficiently far from and upgradient from the existing VEGP Units 1 and 2 that tritium is not expected to migrate in to the deeper aquifer. The excellent confining characteristics of the Blue Bluff Marl will also protect the deeper confined aquifers from potential leakage of radionuclide containing water. Monitoring wells installed through the Blue Bluff Marl should be avoided in areas that have radionuclide leakage potential. This will provide the best protection for the underlying aquifer from unintentional rapid transfer through the well as postulated as a pathway for radionuclide migration.

4.0 GROUNDWATER MONITORING

A comprehensive groundwater level monitoring program is part of a VEGP site soil settlement monitoring. This program has been designed to monitor potentiometric levels in the Water Table aquifer, the confined aquifers (Tertiary and Cretaceous), and hydrostatic pore pressure in the confining layer (marl). The program consists of various wells monitoring the unconfined aquifer, the Tertiary aquifer, the Cretaceous aquifer, and the confining layer. SNC (2006) has also installed another additional 15 wells as part of a Nuclear Regulatory Commission (NRC) Early Site Permit application program.

Groundwater monitoring for the VEGP site is also taking place through programs implemented for the existing units and as part of the ESP effort by SNC. Current groundwater monitoring programs for the existing units are addressed in VEGP Procedure Number 30140-C, Revision 22 (VEGP, 2006). The results of these existing programs are reported semi-annually.

To date, environmental monitoring for radionuclides in the monitoring wells has not been required. The existing network has been examined with respect to the site geology, hydrogeology, and geochemistry. This examination has identified several existing wells, which can be used for detection studies. These gaps in detection capability will be addressed with additional Water Table aquifer monitoring wells.

The objective of all monitoring wells, both upgradient and downgradient, is to monitor groundwater immediately beneath or as near to potential sources of radionuclides as site conditions allow. According to the *Manual for Groundwater Monitoring, Georgia EPD, September 1991*:

"Upgradient monitoring wells provide background groundwater quality data. Upgradient wells should be (1) located beyond the upgradient limit of potential sources so that they reflect backgroundwater quality, (2) screened at the same stratigraphic horizon(s) as the downgradient wells to ensure comparability of data, and (3) of sufficient number to account for natural variations in background groundwater quality. Down gradient monitoring wells will be spaced to assure that contaminated leakage will be immediately detected."

4.1 Monitoring Well Network and Potential Sources

Figures 3-1 through 3-10 show the locations for all of the existing monitoring wells at VEGP. Figure 4-1 is an aerial photograph showing the proposed conceptual monitoring well network composed of existing and planned wells. A total of 29 monitoring wells and one surface water location will be used in the radionuclide detection program. Of the 29 wells, 21 will be monitoring wells in the Water Table aquifer using 13 existing wells and 8 new wells (R-series). The Tertiary aquifer will be monitored with eight of the existing monitoring wells, including four existing monitoring wells and the four existing makeup water wells. The other water supply wells at VEGP are not included because they are either inactive, up gradient, or cross gradient to potential migration paths. The surface water location will be included for comparison to the groundwater geochemistry (it will coincide with an existing location of SNC's choosing).

Table 4-1 is a list of the monitoring wells for the radionuclide-detection groundwater-monitoring program. In addition, plant supply wells and an upstream Savannah River sample are included in this list. In addition, Table 4-1 identifies particular plant features that are potential sources. The piping network, reactor vessel cooling water, and spent fuel pools are in interior areas with existing leak detection monitoring.

The monitoring wells will provide site background conditions using hydraulically upgradient wells in the Water Table aquifer and the Tertiary aquifer directly beneath the Blue Bluff Member (Marl). Detection monitoring wells installed in the Water Table aquifer are near potential leak sources. Wells installed into the Tertiary aquifer are not recommended in the Power Block area or other areas that could leak radionuclides because of the potential for rapid movement through wells installed through the Blue Bluff Marl. Two Tertiary aquifer monitoring wells are included to monitor aquifer conditions that could indicate intra- and trans-river leakage. These are of concern because of VEGP's high capacity wells could draw water from these areas, especially during times of drought.

4.2 Geochemical Considerations - Sources of Tritium and Naturally Occurring Radionuclides

VEGP's groundwater occurs in several very distinct geologic formations containing one or more of the following major chemical components:

- Silicate sand,
- Aluminosilicate clay/silt/sand,
- Carbonates,
- Phosphatic sand/silt/clay material,
- Lignitic mixtures,
- Ferruginous sands/clays, and
- Natural and manmade mixtures from backfill composed of the above.

In addition, due to plant operations, there can be intermingling of water chemistry due to irrigation, maintenance, cleaning operations, and/or leaking pipes. However, most water will occur on site due to rainfall infiltration. In the Water Table aquifer, there is an expectation that the groundwater chemistry will be different because of the absence of carbonate and phosphatic materials in the power block backfill consisting of:

- Siliceous sand,
- Aluminosilicate sand/clay/silt mixtures, and
- Ferruginous sand.

Table 4-1 List of Radionuclide Monitoring Wells, Aquifer, Status and Purpose

Well	Aquifer	Status	Monitoring Purpose
LT-1B	Water Table	Existing	NSCW related tank
LT-7A	Water Table	Existing	NSCW related tank
LT-12	Water Table	Existing	NSCW related tank
LT-13	Water Table	Existing	NSCW related tank
802A	Water Table	Existing	Southeastern radioactive waste leakage
803A	Water Table	Existing	Upgradient to radioactive waste building
805A	Water Table	Existing	Intermittently down gradient from radioactive waste building and NSCW related facilities.
806B	Water Table	Existing	Dilution line
808	Water Table	Existing	Upgradient/leakage along Pen Branch Fault
R1	Water Table	To be installed	NSCW related tank, western radioactive waste leakage
R2	Water Table	To be installed	Southern radioactive waste leakage
R3	Water Table	To be installed	Eastern radioactive waste leakage
R4	Water Table	To be installed	Dilution line
R5	Water Table	To be installed	Dilution line
R6	Water Table	To be installed	Dilution line
R7	Water Table	To be installed	Dilution line
R8	Water Table	To be installed	Dilution line
1013	Water Table	To be installed	Low level radioactive waste storage
1014	Tertiary	Existing	Upgradient Tertiary well
1015	Water Table	Existing	Vertically upgradient to Tertiary well
1003	Tertiary	Existing	Upgradient Tertiary well
1004	Water Table	Existing	Vertically upgradient to Tertiary well
27	Tertiary	Existing	Down gradient Tertiary
29	Tertiary	Existing	Down gradient Tertiary
MU-1	Tertiary/Cretaceous	Existing	Facility Water Supply
MU-2	Tertiary/Cretaceous	Existing	Facility Water Supply
MU-2A	Tertiary/Cretaceous	Existing	Facility Water Supply
TW-1	Tertiary/Cretaceous	Existing	Facility Water Supply
River	NA	NA	Part of existing program for comparison

NSCW – Nuclear service cooling water.

The lower Lisbon Formation that forms the upper part of the Tertiary aquifer is mixed calcareous, phosphatic sand. Its groundwater chemistry is expected to reflect the Lisbon Formation chemistry.

The formations composing the lower portion of the Tertiary aquifer and the whole Cretaceous aquifer system are mostly silica sands with interspersed aluminosilicate feldspars and clays. Water in this aquifer is expected to be different from the upper portion of the Tertiary aquifer and the Water Table aquifer.

The groundwater monitoring parameters should include a minimum number of cations, anions and field parameters to characterize the water chemistry of each aquifer in each monitoring well. This will allow correlation of any positive radionuclide results to the proper source aquifer/surface water, or help determine mixing. Both statistical and graphical analysis of the water chemistry results will be used to track monitoring results over time. Examples of statistical and graphical presentations include relative charge balance diagrams called Stiff Diagrams or a percent of charge balance called a Piper Diagram.

There are also naturally occurring radionuclides that could present a source of false positives. The most likely source of natural radionuclides may be the phosphorus compounds that occur in the Lisbon Formation. However, several other sedimentary related radionuclides may be present.

Besides the naturally occurring radionuclides, there are known occurrences of tritium in Burke and Richmond Counties. The tritium is attributed to activities at the Savannah River Site (Summerour, 1997). Historical levels of tritium have been higher than 3,000 pCi/l, but are mostly below 300 pCi/l at the present time.

4.3 Monitoring Well Design and Construction

4.3.1 Introduction

Monitoring wells will be installed under the direction of a geologist or geotechnical engineer registered in the state of Georgia and who will certify to the EPD that the installation complies with the *Manual for Groundwater Monitoring*, 1991. A signed certification statement will be included with documentation for the construction of the monitoring wells within 30 days of installation.

4.3.2 Drilling Method

Sonic, hollow-stem continuous auger drilling and/or rock coring can be used to advance borings. Care will be taken so that the drilling methods minimize the disturbance of subsurface materials, and do not allow contamination of the groundwater. Drilling equipment will be steam-cleaned between each well.

4.3.3 Soil Sampling

Soil sampling will be performed using the best method available to the driller to help determine the soil stratigraphy and geology in the vicinity of the monitoring well. Acceptable soil samples include continuous and split spoons. Soil samples will be logged under the supervision of a geologist or geotechnical engineer registered in the state of Georgia. Well installation documentation will be included as part of the first monitoring report. Soil samples should be screened in at the time of collection with alpha, beta, and gamma radiation detector suitable for prospecting/health and safety purposes, whichever is more sensitive.

4.3.4 Screened Interval

Reasonable efforts will be made to ensure that upgradient and downgradient wells are screened at the same water-bearing unit. The Water Table aquifer monitoring wells to be installed for this detection program will be drilled to the top of the Blue Bluff Member (Marl) and the screen bottom set five feet above the Blue Bluff Member (Marl). A longer tail pipe may be used to facilitate this operation. All other monitoring well locations will use existing screen intervals.

4.3.5 Well Casings and Screens

Well construction materials are sufficiently durable to resist chemical and physical degradation and yet not interfere with the quality of groundwater samples. Materials used for well casings, well screens, filter packs, and annular seals are discussed in this section. Wells will be constructed as shown in Figure 4-2.

ASTM, NSF-rated, Schedule 40, 2-inch PVC will be used for casing pipe and for screens at the site. Compounds which cause PVC to deteriorate will not be present in, or expected to be in the monitoring area. If drilling activities find solvents to PVC or excessive heat, then alternative well materials will be necessary.

Plastic pipe sections are flush-threaded. No solvents or glues will be used in well construction. The casings and screens arrive pre-cleaned and packaged to prevent contamination. If wells are significantly deeper than 100 feet, then the well material wall thickness will be changed to Schedule 80.

Well centralizers are required to properly center the screen in the middle of the boring. Two centralizers, one above and one below the screened interval will be permanently installed. Centralizer materials shall be stainless steel in entirety.

4.3.6 Well Intake Design

The monitoring wells are designed and constructed to: (1) allow sufficient groundwater flow to the well for sampling; (2) minimize the passage of formation materials (turbidity) into the wells; and (3) ensure sufficient structural integrity to prevent the collapse of the intake structure. Due to the extreme depth of the monitoring wells, centralizers will be required above and below the screened sections to allow adequate annular space for placement of the filter sand.

The annular space between the face of the formation and the screen or slotted casing will be filled to minimize passage of formation materials into the wells. A filter pack of clean, well-rounded, quartz sand will be installed in each monitoring well. In order to ensure discrete sample horizons, the filter pack will extend no more than two feet above the well screen.

4.3.6.1 Screen Slot Size

A 0.01-inch slot size will be used for the well screens. This screen size will retain 100% of size 20/30 filter sand.

4.3.6.2 Filter Pack

The filter pack will be a well-graded, well-rounded 20/30-type quartz (silica) sand. Fabric filters will not be used as a filter pack. Volume of the annular space after drilling will be computed in the field, and sufficient filter material placed in the hole to ensure that no bridging occurs.

4.3.7 Annular Sealant

The materials used to seal the annular space must prevent cross contamination between strata. The materials used are chemically resistant to ensure seal integrity during the life of the monitoring well and chemically inert so they do not affect the quality of the groundwater samples. A minimum of two feet of certified sodium bentonite will overly the filter pack. A cement and bentonite grout will be used as the annular sealant in the vadose zone above the bentonite seal and below the frost line. The cement and bentonite grout will be placed in the borehole using the tremie method. A concrete seal will extend from a little below the frost line to the surface and blends into a sloping, cement-apron extending outward from the edge of the borehole to direct precipitation run-off away from the well. The apron should be at least one-foot diameter if round or be at least two-feet per side if square.

4.3.8 Cap and Protective Casing

The well riser will be fitted with a PVC cap and a protective stainless-steel or anodized aluminum cover and lock (Figure 4-2). A one-quarter inch vent hole provides an avenue for the escape of gas and barometric equalization. The protective cap guards the casing from damage and the locking cover serves as a security device to prevent well tampering. These construction details will be field verified.

Wells will be clearly marked with reflective tape and proper well identification number will be installed on the stand-up casing. Access to the wells will need to be possible by vehicle outside the protected area.

4.3.9 Well Development

After completion of construction of the monitoring wells, every effort is made to:

- Restore the natural hydraulic conductivity of the formation, and
- Remove sediment to ensure turbidity-free groundwater samples.

These two items are accomplished by proper well development. Existing wells will need redevelopment if they have not been pumped in the past 2 years.

Proper well development requires reversals or surges in flow to avoid bridging, which commonly occurs when flow is continuous in one direction. In these wells, development will be accomplished by pumping and surging. A visual comparative test to gauge turbidity will be performed to ensure that the well is fully developed. All equipment will be decontaminated with laboratory grade soap wash externally and rinsed with site water prior to well development, and between wells.

All wells will be purged by the sampler(s) when the groundwater monitoring plan is implemented. The sampler(s) will use a purging method approved by the USEPA. Field turbidity will be recorded to ensure that the proper development has occurred. In the event purging does not yield acceptable turbidity levels, field or laboratory filtering will be required using 0.45 micron disposable filter cartridges.

4.3.10 Documentation of Well Design and Construction

Information on drilling, design, and construction of the monitoring wells will be compiled by a geologist or geotechnical engineer registered in Georgia, who is overseeing the operation in the field. Such information typically includes the items shown in Table 4-1. All new holes should be drilled to identify the top of the Blue Bluff Member (Marl) and then the well screen top designed to occur approximately ten feet below the water table surface to allow for natural fluctuations without exposing the screen area to aerating conditions. VEGP site water level monitoring shows that fluctuations are typically less than five feet.

Table 4-1 Typical Items To Document Well Construction

Name of drillers, identification of drill rig
Date and time of construction
Drilling method
Well location (±0.5 ft.)
Borehole diameter and well casing diameter
Well depth (±0.1 ft.)
Drilling and lithologic logs
Casing materials
Screen materials and design
Casing and screen joint type
Screen slot size and length
Filter pack material and size
Filter pack volume
Filter pack placement method
Sealant materials
Sealant volume
Sealant placement methods
Surface seal design construction
Well development procedure
Type of protective well cap
Ground surface elevation (±0.01 ft.)
Depth to top of screen
Depth to bottom of screen
Tailpipe section length
Top of casing elevation (±0.01 ft.)
Detailed drawing of well (including dimensions)

4.3.11 Well Plugging and Abandonment

Should it become necessary to abandon a monitoring well during this groundwater monitoring program, the well will be plugged and abandoned following the guidelines in the *Georgia Water Well Standards Act of 1985.* The well or wells will be plugged and abandoned under the direction of a geologist or geotechnical engineer registered in Georgia. The basic abandonment procedure will be to tremie cement/bentonite grout into the borehole from the bottom to the ground surface with bentonite grout.

5.0 TYPES OF RADIONUCLIDES AND SOURCE AREAS

5.1 Radionuclides

The Electric Power Research Institute (EPRI, 2005) and the NRC (2006) have compiled leak and detection scenarios for several nuclear power plants in the United States. Detection methods in water usually look for types of radiation emissions such as alpha, beta, and gamma. These readings may be gross readings in the case of alpha and beta. However, gamma emitters may be differentiated based on emission power.

5.2 Source Areas

EPRI (2005) identified several source areas that are common at nuclear power plants. These are:

- Spent fuel pools,
- Refueling water storage tanks,
- Water treatment areas,
- Drains and tanks containing liquid waste from on-site analytical laboratories and other waste handling facilities, and
- Cooling water discharge areas from radionuclide leakage into cooling water system, which are diluted with circulating generator cooling water and discharged (this is called the dilution line at VEGP).

In addition to the above, other sources may include:

- Radioactive waste holding areas, and
- Radioactive waste solidification facilities.

The monitoring wells specified in Section 4 will be able to detect leaked radionuclides from any of the currently unmonitored facilities at VEGP.

6.0 SAMPLING AND ANALYSIS

6.1 Introduction

Southern Nuclear is conducting voluntary radionuclide monitoring at Plant Vogtle. A groundwater monitoring network to detect tritium and other radionuclides at Plant Vogtle has been designed to check likely pathways and differentiate water sources. This plan will define the parameters for analysis, frequency of collection, procedures and techniques for sample collection, sample preservation and shipment, analytical procedures, chain-of-custody control, and statistical analysis of groundwater quality data. This plan generally conforms to the Environmental Protection Agency (EPA) *Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures* (EPA/540-S-95/504), and with *Sample Collection Procedures for Radiochemical Analytes in Environmental Matrices* (EPA/600/S-07/001).

If, during the detection monitoring phase, substantial levels of radionuclides are found in groundwater, the NRC will be notified immediately and a plan for assessing the potential effects will be developed in cooperation with the NRC.

Collection of groundwater samples requires the use of equipment and sample handling in the field that might increase the potential for inadvertent sample contamination if not performed properly. Typically, the potential for field sampling error exceeds laboratory error. Contamination from the ground surface can pass to hands, to the bottle, and to the sample. Cleanliness and attention to detail will hold these errors to a minimum.

6.2 Parameters and Analytical Methods

Table 6-1 lists all of the field and laboratory parameters to be measured as part of the radionuclide monitoring program.

Table 6-1 Field and Laboratory Included in Radionuclide Monitoring Program

Field Parameters	Laboratory Parameters	
• pH	• Tritium	• Sulfate
• Temperature	• Gross alpha	• Aluminum
• Specific conductivity	• Gross beta	• Calcium
• Dissolved oxygen (DO)	• Gamma emitters	• Iron
• Oxidation/reduction potential (ORP)	• Bicarbonate alkalinity	• Magnesium
• Turbidity	• Chloride	• Potassium
	• Total phosphate	• Sodium
	• Nitrates (total)	• Silica

Temperature, specific conductance, pH, DO, ORP, and turbidity will be measured and recorded in the field during well evacuation procedures. All other parameters will be analyzed by a certified laboratory.

The recommended collection containers, preservatives, and holding times are summarized in the Table 6-2 below. Collection container type and size may vary depending upon the laboratory selected to perform sample analyses.

Table 6-2 Recommended Collection Containers, Preservatives, and Holding Times

Analyte	Collection Containers/Amounts	Preservative	Holding Time/ Temperature
Gross alpha	Plastic 2 L	HNO_3	6 months
Gross Beta	Plastic 2 L	HNO_3	6 months
Tritium	Glass or Plastic 2 L	None	1 month
Gamma emitters	Plastic 2 L	HNO_3	6 months
Bicarbonate Alkalinity	Plastic 100 mL	None	28 days/ 4°C
Chloride	Plastic 100 mL	None	28 days/ 4°C
Total Phosphate	Plastic 500 mL	H_2SO_4	24 hours/ 4°C
Aluminum	Plastic 500 mL	HNO_3	28 days/ 4°C
Silica	Plastic 500 mL	HNO_3	28 days/ 4°C
Calcium	Plastic 500 mL	HNO_3	28 days/ 4°C
Nitrates (total)	Plastic 500 mL	H_2SO_4	14 days/ 4°C
Sulfate	Plastic 250 mL	None	28 days/ 4°C
Iron	Plastic 500 mL	HNO_3	6 months/ 4°C
Magnesium	Plastic 500 mL	HNO_3	6 months/ 4°C
Sodium	Plastic 500 mL	HNO_3	6 months/ 4°C
Potassium	Plastic 500 mL	HNO_3	6 months/ 4°C

According to EPA procedures, all lids should be lined with polytetrafluoroethylene (PFTE, commonly called Teflon®). Lids should not be able to absorb water, and should not contain glue or adhesives.

Once samples have been collected and delivered to the laboratory, the following analytical methods and detection limits will be utilized (Table 6-3). Laboratory records of groundwater analyses will include the methods used (by number), the extraction date, and date of actual analysis. Data from samples that are not analyzed within recommended holding times will be considered suspect. Any deviation from an EPA approved method will be adequately tested to ensure that the quality of the results meets the performance specifications (e.g., detection limit, sensitivity, precision, accuracy) of the reference method. A planned deviation will be justified and submitted for approval by the NRC prior to use.

Table 6-3 Analytical Methods and Detection Limits

Analyte	EPA Analytical Method	Required Detection Limit*
Gross alpha	900.0	3 pCi/L
Gross beta	900.0	4 pCi/L
Tritium	906.0	1,000 pCi/L
Gamma emitters	901.0, 901.1, and/or 902.0	sample
Bicarbonate alkalinity	2320B	None
Chloride[1]	325.3	250 mg/L
Total phosphate	365.2	None
Aluminum[1]	200.7	0.05 mg/L
Silica	200.7	None
Calcium	200.7	None
Nitrates (total)	353.2	10 mg/L
Sulfate[1]	9030B	250 mg/L
Iron[1]	6010B	0.3 mg/L
Magnesium	6010B	None
Sodium	6010B	None
Potassium	6010B	None

*The required detection limit is equal to the drinking water MCL as regulated by EPA. If the drinking water MCL changes in the future, the required detection limit will change equal to the MCL.

[1] These constituents are on the EPA list of secondary national drinking water regulations.

6.3 Frequency and Duration

Sampling will commence once the plan has been approved, and will be performed at least quarterly for the first year of monitoring. The quarterly sampling events will be performed to develop and establish a statistical base. Background data will be determined from the upgradient wells and downgradient wells. After the statistical base has been developed, sampling frequency will change to a semi-annual basis. Reporting will be on an annual basis from the initiation of sampling.

Once a baseline has been established for all parameters, SNC may reduce the number or type of parameters monitored.

6.4 Water Levels

Water level elevations will be measured during each sampling event to determine if horizontal and vertical flow gradients have changed since initial site characterization. A change in hydrologic conditions may require modification of the design of the groundwater monitoring system.

Field measurements will include depth to standing water and total depth of the well. The measurements will be taken to the nearest 0.01 foot. An electronic water level indicator will be used to collect the depths.

Each well will have a surveyed reference point, generally a notch cut in the casing, from which its water level measurement is taken, preferably the top of the casing. The reference point elevation will be established in relation to a permanent benchmark and the survey will also note the well location.

Electronic water level equipment should be decontaminated between each well.

6.5 Monitoring Well Sampling Equipment

In order to minimize the introduction of contamination into the well, positive pressure bladder pumps are recommended for purging wells. Where these devices cannot be used, peristaltic pumps, or venturi pumps may be used. Some of these pumps produce volatilization and high pressure differentials, causing variability in the analysis of pH, specific conductance, metals, and volatile organic samples. Using low-flow sampling techniques will minimize this variability.

When purging equipment must be reused, it will be decontaminated with a water wash and distilled de-ionized water rinse between wells. Should purging equipment become heavily contaminated, it should be cleaned with a nonphosphate detergent wash followed by rinsing with isopropanol and de-ionized or distilled water.

Clean, powder-free Nitrile gloves will be worn over cotton gloves by the sampling personnel. A clean pair of new, disposable gloves will be worn each time a different location is sampled and gloves should be donned immediately prior to sampling. Gloves will be discarded after sampling one well and before sampling the next well.

Sampling equipment should be constructed of inert material. Equipment with neoprene fittings, PVC, Tygon® tubing, silicone rubber bladders, neoprene impellers, polyethylene, and Viton® should be used with caution if wells are known to have organic contaminants or if they will be decontaminated for reuse.

6.6 Well Preparation, Purging and Sampling Procedures

The greatest source of inadvertent sample contamination is through incorrect handling by field personnel. The levels of concern are minute, as compared to a waste sample, and extreme care is needed. The necessary care will usually slow down the speed of sample collection, but the reliability of test results is increased proportionally.

Any item coming in contact with the inside of the well casing or the well water will be kept in a clean container and handled only with gloved hands. Always start with the least contaminated well, or wells expected to be uncontaminated, such as upgradient wells.

Water standing in a well may not be a true representation of water quality in the aquifer. Changes in temperature and pressure, contact with air, and prolonged contact with well casing materials can all affect the chemical quality of the water.

Wells will be purged until turbidity, pH, specific conductance, DO, ORP, and temperature stabilize. The values for these field parameters will be recorded during the evacuation procedures.

Sampling personnel will follow this procedure to ensure that a representative sample is collected. The recommended procedure for monitoring well sampling, using low flow sampling techniques, is described below:

Pre-Sampling Activities:

1. Start at the well known or believed to have the least contaminated groundwater and proceed systematically to the well with the most contaminated groundwater. Check the well, the lock, and the locking cap for damage or evidence of tampering. Record observations.

2. If necessary to maintain cleanliness, lay out sheet of polyethylene for placement of monitoring and sampling equipment.

3. Remove well cap.

4. If the well casing does not have a reference point (usually a V-cut or indelible mark in the well casing), make one. Note that the reference point should be surveyed for correction of groundwater elevations to the mean geodesic datum (MSL).

5. Measure and record the depth to water (to 0.01 ft) in all wells to be sampled prior to purging. The device used for water level measurements will be an electronic water level reader permanently marked in 0.01 of a foot. The device will be cleaned between wells and gloves will be used during sampling. Care should be taken to minimize disturbance in the water column and dislodging of any particulate matter attached to the sides or settled at the bottom of the well.

Sampling Procedures:

6. Install Pump: Slowly lower the pump, safety cable, tubing and any lines into the well to the depth specified for that well approved by the hydrogeologist or project scientist. These procedures will comply with *Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures, EPA/540/S-95/504* (Puls and Barcelona, 1996). The pump intake

must be kept at least two (2) feet above the bottom of the well to prevent disturbance and re-suspension of any sediment.

If using a peristaltic pump, slowly lower the tubing into the well to the specified depth.

7. Measure Water Level: Before starting the pump, measure the water level again with the pump in the well. Leave the water level measuring device in the well.

8. Purge Well: Start pumping the well at 200 to 500 milliliters per minute (mL/min). The water level should be monitored every three to five minutes. Ideally, a steady flow rate should be maintained that results in a stabilized water level (drawdown of 0.3 ft or less). Pumping rates should, if needed, be reduced to the minimum capabilities of the pump to ensure stabilization of the water level. As noted above, care should be taken to maintain pump suction and to avoid entrainment of air in the tubing. Record each adjustment made to the pumping rate and the water level measured immediately after each adjustment.

9. Monitor Indicator Parameters: During purging of the well, monitor and record the field indicator parameters (turbidity, temperature, specific conductivity, pH, ORP, and DO) every three to five minutes. The well is considered stabilized and ready for sample collection when the indicator parameters have stabilized for three consecutive readings as follows:

   ±0.1 for pH
   ±10% for specific conductance (conductivity)
   ±10 mv for redox potential, ORP
   ±10% for DO
   <5 NTU if possible, or ±10% if other parameters are stable, for turbidity

   Dissolved oxygen and turbidity usually require the longest time to achieve stabilization. The pump must not be removed from the well between purging and sampling.

10. Collect Samples: Collect samples at a flow rate between 100 and 250 ml/min and such that drawdown of the water level within the well does not exceed the maximum allowable drawdown of 0.3 ft. All sample containers should be filled with minimal turbulence by allowing the groundwater to flow from the tubing gently down the inside of the container.

11. Remove Pump and Tubing: After collection of the samples, the tubing, unless permanently installed, must be properly discarded or dedicated to the well for re-sampling by hanging the tubing inside the well.

12. Measure and record well depth.

13. All remaining sample bottles should now be carried to the ice chest where they are labeled, placed in Zip-loc® bags, and iced down. The labels can be filled out prior to beginning sampling to avoid delay at the site. The label must include the following:

    Name of facility
    Date and time of sampling
    Sample description (well id number)
    Sampler's name

    The sample label should also contain information on: 1) whether or not the sample was filtered; 2) what preservatives were added; 3) how the sample should be stored prior to laboratory analysis (e.g., cool to 4° C); and 4) what analyses are to be performed for that particular sample bottle. Each sample bottle should also have a chain-of-custody label for the names of all persons handling the sample.

    Additionally, mark each sample bottle with an identification number using a red glass-marking crayon which is resistant to water. Bottle caps are good places to add identification. This is a precaution in case labels get wet or come off during transport.

14. The well cap is replaced and locked. Lock the protective well casing.

15. Proceed to the next well. Repeat.

    NOTE: It is good practice to take an extra set of sample bottles to the field in case of breakage or accidental contamination.

6.7 Decontamination

Non-disposable sampling equipment, including the pump and support cable and electrical wires which contact the sample, must be decontaminated thoroughly each day before use, after each well is sampled, and at the end of each day. Dedicated, in-place pumps and tubing should be certified clean prior to their initial use. For submersible pumps, all non-disposable sampling equipment, including the pump and support cable and electrical wires in contact with sample water, will be decontaminated thoroughly each day before use, after each well is sampled, and at the end of the day. When using peristaltic pumps, the tubing should be disposed of after each well, and the body of the pump decontaminated at the end of each day. Water level indicators are cleaned and rinsed with deionized water between each well. Any water or detritus from sampling and decontamination activities should be considered contaminated unless proved otherwise. Dry waste may be stored in a heavy-duty plastic garbage bag. Wet or damp waste must be drummed for disposal. The plant site where sampling takes place will be responsible for disposal of all waste produced during sampling.

Before any equipment or supplies are removed from the site, all should be checked for radionuclide contamination before leaving a controlled area. Items will be considered contaminated if radiation is detected at 2x the background level in the area. Any item registering 2x the background radiation level must be decontaminated thoroughly and rechecked before being removed from the site.

6.8 Decontamination Procedures

At the beginning and end of each day, the following procedures should be used for decontamination.

A. Pre-rinse: Operate pump in a deep basin containing 8 to 10 gallons of potable water for 5 minutes and flush other equipment with potable water for 5 minutes.

B. Wash: Operate pump in a deep basin containing 8 to 10 gallons of a non-phosphate detergent solution, such as Alconox®, for 5 minutes and flush other equipment with fresh detergent solution for 5 minutes. Pre-packaged half-ounce packages of detergent are recommended to avoid over-use.

C. Rinse: Operate pump in a deep basin of potable water for 5 minutes and flush other equipment with potable water for 5 minutes.

D. Disassemble pump.

E. Wash pump parts: Place the disassembled parts of the pump into a deep basin containing 8 to 10 gallons of non-phosphate detergent solution. Scrub all pump parts with a test tube brush or clean cloth, as appropriate.

F. Rinse pump parts with distilled/deionized water.

G. Dry equipment with clean, dry paper towels.

6.9 Between-Well Decontamination

A. Pre-rinse: Operate pump in a deep basin containing 8 to 10 gallons of potable water for 5 minutes and flush other equipment with potable water for 5 minutes.

B. Wash: Operate pump in a deep basin containing 8 to 10 gallons of a non-phosphate detergent solution, such as Alconox, for 5 minutes and flush other equipment with fresh detergent solution for 5 minutes. Use the detergent sparingly.

C. Rinse: Operate pump in a deep basin of potable water for 5 minutes and flush other equipment with potable water for 5 minutes.

D. Final Rinse: Operate pump in a deep basin of distilled/deionized water to pump out 1 to 2 gallons of this final rinse water.

6.10 Sample Handling and Preservation

All sample bottles will be filled to the top, capped with a Teflon® seal, and be placed on ice immediately after sampling except alpha, beta, and gamma containers. Gross alpha and beta and gamma samples do not require cooling.

Following collection, all sample jars should be wiped with a clean, dry paper towel and placed in plastic bags. Double-bagging samples will help prevent cross-contamination. Potential cross contamination from shipping containers or other samples will be checked by analyzing trip blanks.

Sample delivery to the laboratory will be in the shortest possible time after collection. If delay is incurred, this will be entered in the field log book along with the time increment and reason for delay. Sample transport by the collector or other individuals is prohibited. A certified handler must take custody of the samples for delivery.

All samples should be considered radioactive until proven otherwise. Therefore, sampling personnel should wear all relevant PPE while packing and loading samples for shipment. Care should be taken to use the required type of shipping container; hard plastic coolers are appropriate for low-level radioactive samples. Additionally, transport packaging must contain 3x the amount of absorbent material necessary to absorb all available fluid. If appropriate, DOT and/or NRC labeling will be used on shipping containers.

6.11 Chain of Custody

Custody and protection of samples is an important legal consideration. As few people as possible should handle the samples. The sampler is personally responsible for collected samples, and should be able to attest to the integrity of samples until transfer. If the samples are placed in a vehicle, it will be kept locked. Any ice chest will be locked, or located in a place which is locked, and having access only by responsible officials. If the samples are to be shipped, they must be sealed such that any access to the shipping container will be obvious to the person receiving the container. If appropriate, shipped sample containers must use the appropriate Department of Transportation (DOT) and/or Nuclear Regulatory Commission (NRC) radioactive/radiation labels.

A chain-of-custody (COC) form will be used to document the handling of samples from the moment of collection until testing. The ID number of each sampling point will be entered in a sampling log book along with a word description of the sample. Note that several bottles collected for different parameters will have the same ID number if they come from one sampling point.

The chain-of-custody form should contain the facility name, date of sampling, and name of the collector. Each transfer of custody is recorded with an appropriate signature, date, and time. Every COC shall be filled out in its entirety, with no information left blank.

6.12 Field and Laboratory Quality Assurance/Quality Control

It is the responsibility of SNC to ensure the reliability of the analytical data being gathered during the monitoring program.

Quality control samples must be collected to determine if sample collection and handling procedures have adversely affected the quality of the groundwater samples. The appropriate EPA Program Guidance should be consulted in preparing the field QC sample requirements.

All field quality control samples must be prepared exactly as regular investigation samples with regard to sample volume, containers, and preservation. The following quality control samples should be collected during the sampling event:

- Sample duplicates every 10 samples,
- Equipment blank (not necessary if equipment is dedicated to the well) each day per piece of non-dedicated sampling equipment, and
- Rinsate blank each day per piece of non-dedicated equipment.

As noted above, groundwater samples should be collected systematically from wells with the lowest level of contamination through to wells with highest level of contamination.

6.13 Field Documentation

A field log book must be kept each time groundwater monitoring activities are conducted in the field. The field log book should document the following:

- Well identification number and physical condition,
- Well depth,
- Static water level depth, date, and time,
- Pumping rate, drawdown, indicator parameters values, and clock time, at three to five minute intervals,
- Total volume pumped, for the interval and the total amount,
- Number of samples collected and time of sample collection,
- Field observations of sampling event,
- Name of sample collector(s),
- Weather conditions, and
- Make, model, and QA/QC (i.e. calibration) data for field instruments.

If corrections are needed in the field book, incorrect information should be crossed out with a single line, initialed, and dated. Correct information should be written as close as possible to the cross-out.

In selecting a laboratory to conduct analyses of groundwater samples, SNC will ensure that the laboratory of choice is exercising a proper QA/QC program as described in this sampling and analysis plan. The approved EPA test methods contain requirements to run a spiked sample to determine percent recovery. This will be a part of the lab report. Additional quality control such as method blanks and duplicates are also described in the test method and will be included in the laboratory work agreement. The laboratory QA program will be considered a part of this plan. Quality assurance procedures are time-consuming and increase the cost of testing, but the plant will be regulated based on the results.

Any field instruments that SNC or its contractors use will be calibrated prior to field use. Field logs of the procedures will be maintained and included with the reporting.

6.14 Water Quality Monitoring Reporting, Analysis, and Follow-Up

Water quality monitoring reports will be prepared annually. The report will include:

- Facility name sample collection dates and analysis dates,
- All analytical results, including peaks even if below maximum contaminant levels,
- Identification number and designation of all surface water and groundwater monitoring points,
- Quality assurance, quality control notations,
- Method detection limits,
- Water levels recorded prior to evaluating wells or sample collection. Elevation reference will include the top of well casing and land surface at each well site at a precision of plus or minus 0.01 foot (NGVD),
- An updated groundwater table or potentiometric surface contour map (to be signed and sealed by a Georgia Professional Geologist or Geotechnical Engineer) with contours at no greater than one-foot intervals unless site-specific conditions dictate otherwise, which indicates groundwater elevations and flow direction, and
- Any appropriate discussion of the monitoring results.

In addition, the report, including contour maps, is to be signed and sealed by a Georgia Professional Geologist or Geotechnical Engineer with experience in hydrogeologic investigations. The report will summarize and interpret the water quality monitoring results and water level measurements. At the discretion of the Professional Geologist or Engineer, the report may contain the following information (if meaningful):

- Tabular displays of any data which shows that a monitoring parameter has been detected, and graphical displays of any key indicator parameters (such as pH, specific

conductance, TDS, TOC, sulfate, chloride, sodium, iron, and possibly well hydrographs);
- Trend analyses of any monitoring parameters consistently detected;
- Comparisons among each aquifer's wells;
- Comparisons between background water quality and water quality in detection and compliance wells;
- Correlations between related parameters, for example, total dissolved solids and specific conductance;
- Discussion of erratic and/or poorly correlated data;
- An interpretation of the groundwater contour maps, including an evaluation of groundwater flow rates; and
- An evaluation of the adequacy of the water quality monitoring frequency and sampling locations based upon site conditions (at least 3 years will be allowed for evaluation).

All field and laboratory records will be included as a paper or digital appendix. A complete sampling record on appropriate forms will be provided with each well's characterization and quarterly analyses. This record will include water level; total depth of the well; volume of water in the well; volume of water removed; stabilization documentation including pH, specific conductivity, dissolved oxygen, oxidation-reduction potential (ORP), turbidity, temperature, time interval of purging; time sample is taken; and devices(s) used for purging (including discharge rate if available) and sampling.

Random exceedances of groundwater standards are common in large water quality data sets. Predicting the appropriate statistical test prior to sampling can have unintended results. SNC will use either the intrawell or interwell prediction limits (Gibbons, 1994) to minimize site-wide false positive rates while maintaining a low-level site-wide false negative rate. Prediction limits compare the data of a certain well to its own and/or a group's history (for example, all of the Water Table aquifer wells or other geochemically derived subset), with the prediction limit itself coming from the background data. So even if the distribution, mean, and variance of a down gradient well are different from that of an upgradient or background well, it will only trigger an exceedance if it is significantly different from that of an upgradient or background well and from its own history. This significantly lowers the false negative rate for the site, because only one well is considered (and that one well's history) at a time, instead of considering all the data at once. The first annual report will contain a statistical summary of the intrawell versus the interwell comparison.

An integral part of refuting or accepting beyond-limit results is a re-sampling program, where affected wells are re-sampled according to the process discussed in this plan. In the event that groundwater sample results show an exceedance of the prediction limits, SNC will arrange for a confirmation re-sampling within 30 days of receipt of laboratory results. If the re-sampling and additional testing confirm the exceedance, SNC will prepare an appropriate assessment plan for NRC approval.

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APPENDIX

REGIONAL GEOLOGIC HISTORY AND ROCK DESCRIPTIONS OF STRATA COMPOSING THE AQUIFER SYSTEM

A. REGIONAL GEOLOGIC HISTORY AND ROCK DESCRIPTION OF STRATA COMPOSING AQUIFER SYSTEM

Usually geologic history is not pertinent to groundwater monitoring programs. However, there are important events which will affect the correct conclusions of the groundwater monitoring program. The events that formed and deformed the materials comprising the all inclusive aquifer system at VEGP are presented. Figure 2-2 presents a regional geologic area within a 200-mile radius of VEGP.

A.1.1 Mesozoic Era

A.1.1.1 *Triassic and Jurassic Periods* - The tectonic model which best explains the stratigraphic distribution of lower Mesozoic rocks on the eastern coast of North America includes the following sequence: (1) Permian to Late Triassic uplift and crustal thinning along the axis of the future Atlantic Ocean, (2) Middle to Late Triassic strike-slip faulting and volcanism along east-trending fracture zones, and (3) Late Triassic rifting along the axis of the proto-Atlantic Ocean and shearing along east-west fracture zones (Manspeizer and others, 1978).

On the eastern seaboard of the United States many of the Triassic basins are exposed at the surface in the Piedmont province (Wentworth and Mergner-Keefer, 1981). Most, however, are covered by Coastal Plain sediments and have been delineated on the basis of core holes and wells (Plate 1 of Chowns and Williams, 1983), aeromagnetic and gravity anomalies, (Daniels and others, 1983; Behrendt et al, 1983; Klitgord and Behrendt, 1979) and seismic reflection and refraction studies (Cook et al, 1981; Cook et al, 1983).

Triassic basins occur along the eastern seaboard from Connecticut south to Florida. Basins north of South Carolina are exposed in Piedmont crystalline rocks, while those south of North Carolina are overlain by Cretaceous and Cenozoic sediments. The sediments within these basins have been tentatively correlated with the Newark Supergroup of Late Triassic through Early Jurassic age (Manspeizer and others, 1978; Siple, 1967; Olsen and Galton, 1977; Van Houten, 1977; Gohn et al, 1978). It is difficult to obtain an accurate age for the sedimentary rocks within these basins due to their time-transgressive nature (Manspeizer and others, 1978).

The plant site is underlain by the buried Dunbarton Triassic Basin. The sediments within this basin have been identified as Triassic, based on stratigraphic position and lithology. Marine and Siple (1974) have presented a complete lithologic description of the Triassic rocks of the Dunbarton Basin based on drill cores. In the central northwest portion of the basin, sediments consist of red-brown breccias in a matrix of claystone and siltstone. The central part of the basin is composed of alternating layers of sandstone and mudstone. Rocks from what may be the southeastern part of the basin include siltstones, claystones, and fine-grained sandstones which contain calcareous nodules.

The primary fault controlling basin formation, the Pen Branch fault, bounds the northwest side of the basin. The fault appears to have been an earlier Paleozoic reverse fault that was reactivated as an extensional normal fault during Mesozoic continental rifting. The fault was subsequently reactivated in the Cenozoic as a reverse fault or right-oblique slip fault (Price et al. 1989; Snipes et al., 1993a; Stieve and Stephenson 1995). The Pen Branch fault dips to the southeast. The master fault to the Riddleville Basin in Georgia also dips to the southeast (Peterson et al. 1984). The southeast boundary of the basin is poorly constrained but is interpreted as fault bounded (Faye and Prowell 1982; Snipes et al., 1993b).

A.1.1.2 *Cretaceous Period* - Both Cretaceous and Tertiary sediments of the Coastal Plain Province accumulated on the trailing eastern margin of the continent. The composition of these sediments and their gentle dip away from the Appalachian Mountains implies that the Appalachians have stood as an eroding structural high for over 200 million years (Hack, 1979).

Following a period of uplift and erosion during the Late Jurassic and Early Cretaceous, there was a transgression of Late Cretaceous seas over part of the Coastal Plain (Vail and Mitchum, 1979). The basal clastic formation in the vicinity of the plant site is the subaerial Tuscaloosa Formation.

Rocks deposited during the close of the Cretaceous are not present in Georgia or South Carolina (Cramer and Arden, 1980; Gohn et al, 1982; Rankin, 1977). The Cretaceous-Tertiary boundary is marked by an erosional surface which would be due, in part, to a fall in sea level (Vail and Mitchum, 1979).

The Upper Cretaceous Tuscaloosa Formation consists of fluvial and estuarine deposits of cross-bedded arkosic sand and minor gravel intercalated with lenses of variegated white, pink, red, brown, and purple silt and clay (Cramer and Arden, 1980; Gohn et al., 1982; Siple, 1967). Coarse and fine sediments are interbedded in an irregular sequence and grade laterally into one another or pinch out within short distances. Abundant kaolin is present along with other clay minerals.

A.1.2 Cenozoic Era

A.1.2.1 *Tertiary Period*

Paleocene Epoch - Sediments deposited during the early Paleocene are thickest in the southwest, indicating that seas transgressed from that direction. No upper Paleocene sediments are interpreted to exist in the plant site area.

The lower Paleocene series in the vicinity of the site consists of the Ellenton and the Huber Formations. The Ellenton Formation is a dark-gray to black sandy lignitic micaceous clay interbedded with medium- to coarse-grained quartz sand. Authigenic gypsum is commonly associated. The lower part of the Ellenton is sandy lignitic clay with the sand portion becoming very coarse and gravelly. The Ellenton is unconformable with the underlying

Tuscaloosa Formation. The contact is characterized by a change in the color of the clay and in the composition of the sand. The Ellenton grades into the overlying Huber Formation in the vicinity of the plant site (Bechtel Power Corporation, 1982).

The Huber Formation lies between the top of the Ellenton Formation and base of the overlying sands and limestones of middle Eocene age. The lithology of the Huber Formation is diverse, ranging from beds of multicolored clays, high-purity and sandy kaolin, to thick cross-bedded members of coarse, pebbly sand and conglomerate composed of boulders of pisolitic kaolin (Buie, 1978). In drill cores the uppermost part of the Huber Formation shows signs of weathering and chemical reduction.

Eocene Epoch - Following a period of erosion during the early Eocene, the sea again transgressed over the Georgia Coastal Plain during the middle Eocene. The bulk of the middle Eocene sediments are carbonates, with up to 10 percent chert and evaporite. Toward the Fall Line all of the carbonate rocks become coarser and grade into calcareous sands, indicating a higher energy environment. Following the transgression of the middle Eocene seas, regression again occurred and erosion of the middle Eocene deposits began.

Late Eocene deposition is a relatively thin, uniform blanket of shelf limestones and calcareous sands, which unconformably overlie deposits of middle Eocene age. Northeastward along the Fall Line the fluctuating strandline of the middle Eocene sea is apparent in the inter-tonguing of carbonate and clastic formations. A period of regression is apparent, and deposits of late Eocene age are overlain by upper Oligocene deposits.

The Eocene series consists of the middle Eocene Lisbon Formation and the upper Eocene Barnwell Group.

The Lisbon Formation occurs between the top of the Huber Formation and an unconformity at the base of the Barnwell Group. In east-central Georgia the Lisbon Formation is subdivided into three members: an unnamed basal sand and limestone member, the Blue Bluff Member, and the McBean Limestone Member.

The lowermost portion consists of quartz sand which grades both up section and downdip into calcareous sand. Overlying these sands is a limestone. The Blue Bluff Member is a greenish- to bluish-gray, moderately hard calcareous siltstone or marl. In core-holes drilled near the plant site, the marl is thinly interbedded to laminated with isolated limestone nodules and shell fragments (Bechtel Power Corporation, 1982). Updip, the McBean Limestone Member is composed of soft, gray limestone and calcareous sand. Downdip, the Blue Bluff Member interfingers with an unnamed gray calcareous sand and fossiliferous limestone. At the plant site, the Blue Bluff Member is a bluish-gray marl. This marl forms the foundation for critical plant structures and structural backfill.

In east-central Georgia the Barnwell Group consists of the

- Clinchfield Formation which contains the Utley Limestone Member, a sandy, glauconitic slightly argillaceous and locally cavernous limestone (Huddleston and Hetrick, 1979)

- Dry Branch Formation which contains:
  - the Irwinton Sand, a distinctly bedded sand
  - Griffins Landing, a indistinctly to massively bedded , calcareous fossiliferous sand, and
  - Twiggs Clay Member, a montmorillonite clay.

- Tobacco Road Sand which is predominantly a massively bedded and bioturbated quartz sand (Huddleston and Hetrick, 1979; Huddleston and Hetrick, 1978).

Oligocene Epoch. - At least two transgression/regression cycles occurred during the Oligocene. Only the late Oligocene transgression deposited material in the site area. The Suwannee rocks that remain are shelf deposits, with none of the updip clastic facies preserved. The basal part of the Suwannee consists of a sandy limestone that contains few fossils. Above this is a layer of predominately cream-colored, relatively soft, somewhat chalky, fossiliferous limestone. The upper part is a light-gray to cream color, dense nodular, cherty, and somewhat sandy limestone (Cramer and Arden, 1980). This unit is absent on the VEGP site due to down-cutting of the Savannah River (Miller, 1990).

Miocene Epoch - The deposits of Miocene age appear to be a sequence of predominantly clastic sediments deposited during and following the regression of the coastline. In some places (VEGP site included) erosion has continued from the Miocene to the present.

The Miocene Hawthorne Formation has been assigned to earliest Miocene, 25 to 23 million years before present (Huddleston, 1982). Hawthorne sediments include poorly sorted clayey sands and gravels, containing cross-bedded stringers of limonite-goethite pebbles. The sediments are variegated, orange through violet, with mottled or alligator-skin appearance due to weathering. The Hawthorne Formation has been removed from much of the site as part of the building activities (SNC, 2006).

Exposures of Hawthorne and Barnwell Formation sediments in the region commonly contain patterned weathering structures. The weathering has produced an upper zone, commonly 2 to 3 ft thick, of mottled blotches and horizontal planes of off white bleached zones within the deep red sediments. Below this zone a series of vertical weathered fractures is found. The vertical features normally taper downward and pinch out within 10 ft of the upper Tertiary sediment surface. These features have been described as clastic dikes by various authors.

The occurrence of clastic dikes in Coastal Plain sediments has resulted primarily from alteration along near vertical fractures during a paleosol development. The material within the dikes consists of the same material as the host sediments, with some dikes containing high proportions of clay. Large exposures of dikes show polygon development associated with desiccation. In several locations the near vertical dike faults are offset by low angle reverse faults. These thrust faults are interpreted to result from later settlement and collapse, although the timing and exact relationship is unknown.

The geographic distribution of clastic dikes is the result of the paleoenvironment, which caused the desiccation and alteration. The grain size and conduit geometry of the liquefaction feature studied by Cox (1984) is very different from the clastic dikes found in the site area. It is concluded that clastic dikes near the site cannot be attributed to tectonic activity.

A.1.2.2 Quaternary Period

Pleistocene Epoch – During Pleistocene time the sea transgressed over the eastern part of the Coastal Plain several times. Each transgression/regression cycle left a distinct terrace as evidence of its occurrence. Surface uplift and subsidence of the Coastal Plain of Georgia and surrounding states continued through the Pleistocene (Winker and Howard, 1977). Sediments have accumulated and related geomorphic features such as erosional scarps, and terraces have continued to develop over the last 1.8 million years.

The Quaternary system is represented by alluvial deposits consisting of coarse gravel and poorly sorted sand, which occur irregularly and discontinuously in the tributary and main channels of the Savannah River.

A.2 Regional Structural Geology

Major structural and tectonic features in Georgia and South Carolina are shown on drawing Figure 2-3. The major structural trend affecting the region is the pre-Mesozoic southern Appalachian Mountain system, exposed west of the Fall Line. Virtually all compressional tectonic activity occurred prior to the deposition of the Cretaceous sediments east of the Fall Line. The complex folding, faulting, and shear structures that developed in the Piedmont, Blue Ridge, and Valley and Ridge Fold belts originated in the Precambrian and Paleozoic eras during one or more of the orogenic episodes associated with the development of the southern Appalachians.

The crystalline basement underlying the Georgia Coastal Plain dips toward the southeast at approximately 36 ft/mi. This regional dip is interrupted by several local structures.

A.2.1 Tectonic Framework of the Georgia Coastal Plain

Triassic Features - The Dunbarton Basin is one of several elongated basins filled with Triassic (and in some other cases Jurassic) rocks found buried beneath the Cretaceous and Cenozoic age sediments of the Georgia Coastal Plain. The most probable origin of the Dunbarton Basin is the formation of a graben by normal faulting. Early evidence of a northwestern border fault of unknown displacement, and hypothesized faulting for the southeastern margin are discussed by Marine (1976). Substantial evidence for a southeastern border fault is lacking, however, and the nature and extent of this margin of the Dunbarton Basin is derived from gravity and aeromagnetic surveys (Marine, 1976; Marine and Siple, 1974). The basin is oriented northeast-southwest and is about 31 miles long and 6 miles wide based on an aeromagnetic survey.

FSAR era geophysical studies indicate the possibility of intrabasinal faulting, but an attempt to verify this by analyzing drill cores was inconclusive (Marine, 1976; Marine and Siple, 1974). Because of stratigraphic thickness and the nature of the gravity and magnetic data, faulting is a likely explanation for the southeastern boundary of the Dunbarton Basin. The VEGP ESP (2006) presented additional information including 4 additional government studies conducted in the mid to late 1990's (Summerour et al, 1994; Huddleston & Summerour, 1996; Summerour, 1997; and Summerour et al, 1998) and additional site information was observed during the installation of some exploratory water level observation wells (OW-1001A, 1001B, and 1001C; SNC, 2006).

<u>Cretaceous and Cenozoic Features</u> - The dominant structural features of the Georgia Coastal Plain are two large sedimentary basins. The southeast Georgia Embayment (Toulmin, 1955) includes an area of downwarping and sediment thickening which formed during Cretaceous and Cenozoic time (Cramer and Arden, 1980; Cramer, 1969). A second sedimentary basin, the Appalachicola Embayment, is an area of thickened Tertiary sediments into the southwest corner of Georgia. Between these two embayments is a positive feature called the Central Georgia Uplift (Pressler, 1947) which is defined as a southeast-northwest striking upwarped feature between the two flanking downwarped areas. The southern extension of the Central Georgia Uplift is the Peninsular Arch (Applin, 1951) which also forms the spine of Florida. The Yamacraw Ridge is a basement feature trending parallel to the coastlines of Georgia and South Carolina which may have had some influence on Upper Cretaceous sedimentation (Cramer, 1969).

A.2.2 Faulting

During the Cretaceous Period and continuing into the Cenozoic Era, structural deformations in the form of mild regional warping and faulting, or reactivation of older faults, occurred. The Southeast Georgia Embayment of Toulmin (1955) includes an area of down warping and sediment thickening which formed during Cretaceous and Cenozoic time (Cramer and Arden, 1980; Cramer, 1969). This feature has also been called the Okefenokee Embayment (Pressler, 1947) and the Atlantic Embayment of Georgia (Herrick and Vorhis, 1963). A second sedimentary basin, the Appalachicola Embayment, is an area of thickened Tertiary sediments extending into the southwest corner of Georgia. This feature has also been called the Southwest Georgia Basin (LeGrand, 1961; Murray, 1961). Between these two embayments is a positive feature called the Central Georgia Uplift which is defined as a southeast-northwest striking upwarped feature between the two flanking down warped areas (Pressler, 1947). The southern extension of the Central Georgia Uplift is the Peninsula Arch which also forms the spine of Florida (Applin, 1951).

Faults with minor displacement of Cretaceous and Cenozoic deposits are present in the southeastern United States (York and Oliver, 1976). Detailed work has indicated that northeast-trending faults with Later Cretaceous and Cenozoic displacements such as the Belair, Cooke, and Stafford fault zones exist in the Atlantic Coastal Plain and Piedmont (Behrendt and others, 1981; Mixon and Newell, 1977; Prowell and O'Conner, 1978). Wentworth and Mergner-Keefer (1983) propose that many of these faults may be reactivated Mesozoic and older high angle normal faults. Other isolated instances of Cretaceous and Cenozoic faulting in the coastal plain region have been listed by Prowell (1983).

One of these faults is the old inactive and noncapable Pen Branch Fault (Figure 2-4). It is located on site, but not under the generating facilities. The age of the fault's activity is not entirely known but it does cross cut Mesozoic and Early Cenozoic strata and may be related to a mild warping of carbonate clays and rocks of the Lisbon Formation while not affecting younger strata at all (ESP, 2006).

<u>Belair Fault Zone</u> - The Belair fault zone is a structural feature extending along the inner margin of the Atlantic Coastal Plain. This fault is located a few miles west of Augusta and extends for about 29 miles from Fort Gordon Military Reservation on the south to a quarry just west of the Savannah River on the north (O'Conner and Prowell, 1976; Prowell and O'Conner, 1978; Prowell and others, 1975). The most recent documentable movement along the Belair fault zone occurred about 40 million years ago (Wentworth and Mergener-Keefer, 1981; Wentworth and Mergener-Keefer, 1983).

A.3 Site Geologic History

The site area is located upon a seaward-thickening wedge of sediments 950 ft thick at the plant, deposited upon the truncated and peneplained roots of the ancestral southern Appalachian Mountain system. Igneous and metamorphic rocks of Precambrian through Paleozoic age and early Mesozoic Triassic sediments comprise the basement rock at the site. These deformed and faulted basement rocks reflect the complex geologic history of the Appalachian Mountain system, which has been essentially quiescent since the late Mesozoic. This period of tectonic stability during and following deposition of the sediments is evidenced by their nearly flat-lying and relatively undeformed nature. The seaward thickening of the sedimentary mantle indicates a progressive downwarping of the continental margin. Regional uplift of the Coastal Plain is the latest and current stage of the geologic history of the site area.

The stratigraphic and structural relationships of the lithologic units at the site reflect the geologic history of the region. The site area was relatively stable following the deposition of the nonmarine Cretaceous Tuscaloosa Formation and the overlying Ellenton Formation of Early Paleocene age. Unconformably overlying the Ellenton Formation in the site area are the Lisbon Formation and Barnwell Group of Eocene age, which are in turn unconformably overlain by the Hawthorne Formation of Miocene age. The Hawthorne Formation is the youngest deposit of formation status exposed in the site area. These formations are also shown on the site geologic map as presented in Figure 2-4.

The Tertiary shallow marine deposits represent periods of marine transgressions and regressions from Eocene through Miocene times, most likely the result of periods of minor regional uplift and subsidence. For example, the Barnwell Group includes lithologic units varying from coarse sand to clay and marl, zones of weathering and variations in fossil abundances indicative of variable near-shore and tidal conditions.

The current stage of regional uplift is evidenced in the site area by exposures of the Miocene marine Hawthorne Formation at elevations above 250 ft. The mature geomorphic expression and deep weathering of the Hawthorne Formation and exposures of the underlying Barnwell Group indicate an extended period of orderly erosion on a stable surface of emergence.

A.4 Detailed Discussion of Lisbon Formation Observations in the Power Block Excavation

Unit A, near the top of the excavation walls, is generally above 128 ft to the upper contact of the marl with the Utley Limestone Member of the Barnwell Group. It consists of dark- gray, silty to clayey marl with very fine light-gray to white, fine, sandy laminations, which are undulatory and discontinuous.

Scattered shell fragments and well-cemented lenses of sand up to 0.1 ft thick are present locally. The laminations are oriented parallel to the lower contact of the unit, and parting along the laminations is common. Unit A is dense and well consolidated. Surfaces exposed to the atmosphere tend to desiccate rapidly. Unit A interfingers with the underlying unit B. The contact with unit B is everywhere gradational.

Unit B, directly beneath unit A, was continuous around the auxiliary building-basement excavation walls and varies from 1 to over 4 ft in thickness. It consists of massive to faintly laminated gray, sandy marl. It has a sugary texture and does not tend to desiccate as readily as does unit A. This property provides an easy means for differentiating the units after exposure to the atmosphere. Unit B is dense but poorly cemented and contains widely scattered shell fragments.

A subunit of **B**, designated $\mathbf{B_1}$, has been identified and is present locally within **B**. This subunit consists of laminated sandy marl that is locally fossiliferous. The contacts between **B** and $\mathbf{B_1}$ are highly gradational.

Unit B is in turn underlain by a thin, relatively discontinuous but laterally extensive limestone, designated as unit C. This limestone is light gray and well indurated, and it exhibits conchoidal fracturing. It averaged about 1 ft in thickness and dipped slightly to the east, being present at about El.127 to 128 ft at the west end of the auxiliary building and 125 ft at the east end.

The irregularity of portions of **unit C** led to a special study to determine whether the irregularities could be related to fault offset. The concern was that lenses and pods of the limestone occurring at slightly different elevations might have been offset from one another. As both excavation and mapping of stratigraphically lower units progressed, it became very evident that the irregularities of **unit C** were due to processes other than faulting. The continuity of the lower units in the areas of interest precluded the possibility of fault offset. A report prepared by Bechtel (1978) concluded that the only plausible explanation for the observed irregularities was a combination of erosional and depositional processes.

Underlying the limestone of **unit C** is medium-gray, highly fossiliferous, sandy to silty marl, designated as **unit D**. This zone, averaging 8 ft in thickness, was continuous around the walls of the auxiliary building excavation. The lithology of **unit D** is very uniform, and its upper and lower contacts are quite sharp. An abundance of pelecypods retaining both valves characterizes this unit. Near the base, a number of very hard, lime-cemented pods and lenses are present at roughly equivalent elevations and have highly gradational contacts with the surrounding marl. These pods and lenses are believed to represent accumulations of calcium carbonate cement leached from the surrounding fossiliferous marl. They are collectively considered to be a subunit of **D**, designated $\mathbf{D_1}$.

Unit **E** underlies **D** and is thin, relatively continuous, impure limestone. It is light gray, very well indurated, and fossiliferous. It averages 1 ft in thickness and varies in elevation from 121 ft in the northwest corner of the auxiliary building to 116 ft in the southeast corner. Locally, **unit E** is difficult to distinguish from $\mathbf{D_1}$. In these cases, **unit E** is arbitrarily selected as the unit displaying the sharpest contacts with surrounding units and the one stratigraphically between the overlying **unit D** and underlying **unit F**. The similarity between portions of **E** and $\mathbf{D_1}$ suggests that both may be cemented deposits resulting from leaching and redeposition of calcium carbonate from the overlying fossiliferous deposits. The relative continuity of **E** indicates a basic permeability change occurring at the horizon in the geologic past. This is a basis for differentiating the overlying **unit D** and underlying **unit F**.

Unit F, like **D**, is a fossiliferous marl which was seen to be continuous around the basement excavation walls. It is medium gray and sandy to silty; it varies in thickness from 1 to 4 ft. It is dense and well consolidated but poorly cemented and tends to desiccate upon exposure to the atmosphere. **Unit F** includes some cemented limey pods similar to $\mathbf{D_1}$. These have gradational contacts with surrounding material and appear to be secondary in origin.
Unit G is light-to-dark gray laminated marl, which is present locally as lenses interfingering with **units F** and **H**. It was present in portions of the west and north walls and was absent in the east wall. The unit is characterized by very fine, sinuous, and discontinuous sandy laminations; scattered shell fragments; and small, lenticular clay pods. It contains scattered carbonaceous lenses and is well consolidated.

Unit H underlies **G** and consists of massive gray marl which was continuous around the excavation. It is dense, well consolidated, and poorly cemented. Shell fragments are sparse in the upper part of the unit but become increasingly abundant toward the base. **Unit H** varies in thickness from 1 to 6 ft.

Unit I underlies **H** and is very similar to **unit E**. It is a thin, relatively continuous, light-gray, impure limestone which is generally less than 1 ft thick. It was continuous around the excavation walls, with the exception of the east wall between station 0+79 and the south end of the wall, where it was absent.

Unit J, the deepest marl unit exposed in the auxiliary building excavation, consists of medium gray, massive, fossiliferous marl similar to the stratigraphically higher **units D** and **F**. It was continuous around the excavation walls, with the exception of the east end of the excavation, where the upper contact of the unit dipped beneath the base of the excavation.

From the preceding descriptions, it is seen that the portion of the marl section exposed in the auxiliary building excavation represents cycles of fossil abundance and absence, interspersed with periods of formation of secondary limestone pods and lenses as a result of leaching of calcium carbonate from fossiliferous zones. Erosional and depositional processes have combined to create some of the interfingering of units as well as the irregularity of some of the limestone layers.

A.5 Barnwell Group in the Power Block Excavation

All of the sediments that were exposed in the sidewalls of the power block excavation are of Eocene age. Above the Blue Bluff Marl of the Lisbon Formation, the exposures were comprised entirely of sedimentary beds of the Barnwell Group.

Although examined and described in detail, the deposits between the top of the Blue Bluff Marl and approximately El.170 ft could not be mapped in detail. This was due to extensive slumping of the slopes when excavation and dewatering were suspended during the period between September 1974 and June 1976. Extensive regrading obscured the contacts between units in this zone. Several portions of the slopes were covered with riprap in order to control seepage and improve stability, further obscuring contacts. Since seepage from the slopes was creating local stability problems, it was decided not to excavate back into the slopes to expose contacts and risk large slope stability problems. Detailed mapping of the units above and below this zone demonstrated the continuity of the strata and the absence of faulting.

The lowermost exposed unit within the Barnwell Group in the power block excavation is the Utley Limestone. The lower part of the limestone is grayish yellow, well indurated, and fossiliferous, grading locally into coquina. It was continuous around the power block excavation and varies in thickness from 0.5 to 3 ft. The upper part of the limestone is white to light gray and varies from 0 to 12 ft in thickness, present only in the north and northwest portions of the power block excavations. Although well indurated, this thicker limestone has been subjected to extensive leaching, producing a honeycomb network of cavities. Some individual cavities had mean diameters of several feet before being removed by excavation or filled in place. Within the cavities, the limestone typically displayed a weathered and soft zone immediately adjacent to the cavity walls, which graded within a few inches to hard, unweathered limestone. Locally, extensive leaching of the limestone had left a residue of silt and clay impurities forming a soft mottled blackish material. Included in the Utley

Limestone is a highly fossiliferous clay deposit, which varies in color from tan to dark gray. The difference in colors appears to be due primarily to weathering effects. Prior to its removal, this clay was present mainly in the northwest portion of the power block excavation.

Unconformably overlying the Utley Limestone is the Twiggs Clay. This consists primarily of medium-gray, moderately indurated, laminated sandy claystone, which is quite similar to the underlying Blue Bluff Marl of the Lisbon Formation. The Twiggs Clay was exposed only in the southeast portion of the power block excavation and varies in thickness from 0 to 13 ft. The upper 2 to 5 ft are weathered to a distinctive greenish-yellow color. The Twiggs Clay has alternating thin and thick beds (from less than 1 in. to greater than 1 ft), with gradational contacts between beds. No joints, fractures, or discontinuities were observed in the clay.

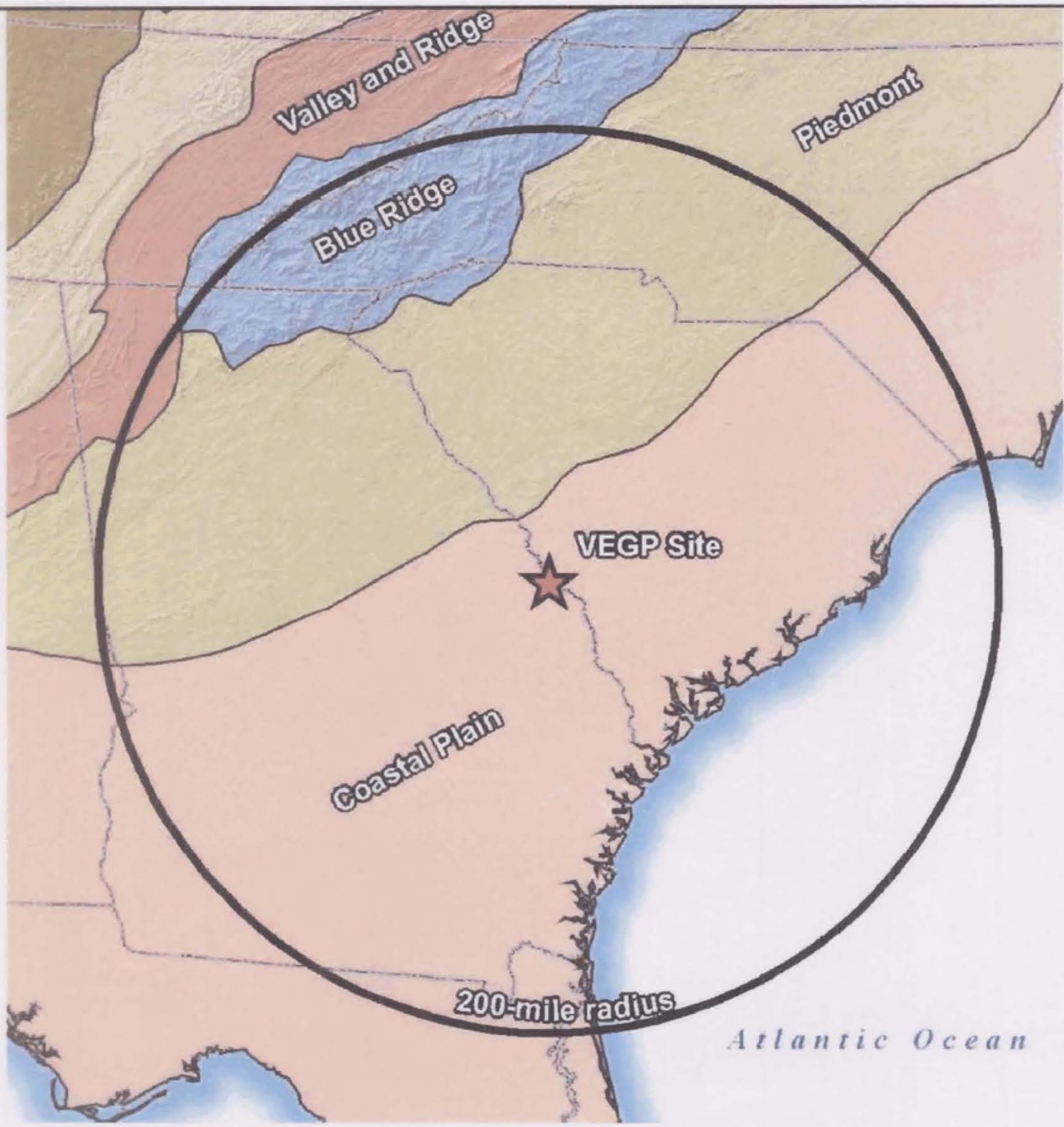

FIGURE 1-1

Southern Company Generation
Engineering and Construction Services
FOR

Southern Nuclear

ALVIN W. VOGTLE NUCLEAR PLANT
LOCATION MAP

SCALE	PROJ I.D.	DRAWING NUMBER	SH	CONT'D
NONE		ES1537S1-1	1	FINAL

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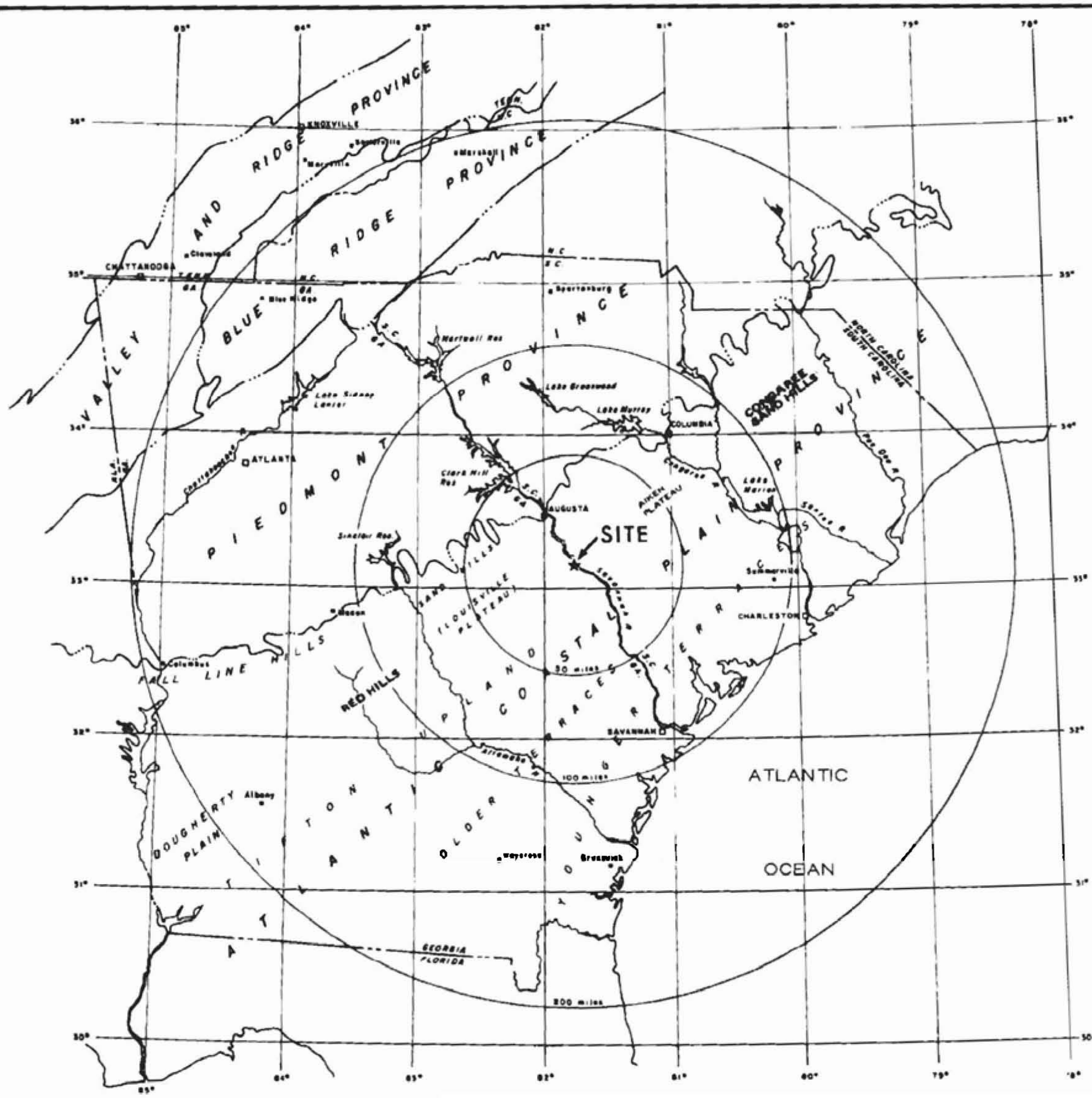

EXPLANATION:

Tectonic Province Boundary

REFERENCE: VOGTLE FSAR

10 0 10 20 30 40 50
SCALE IN MILES

FIGURE 2-1

Southern Company Generation
Engineering and Construction Services
FOR

Southern Nuclear

ALVIN W. VOGTLE NUCLEAR PLANT
PHYSIOGRAPHIC PROVINCES
OF THE SOUTHEAST

SCALE	PROJ I.D.	DRAWING NUMBER	SH	CONT'D
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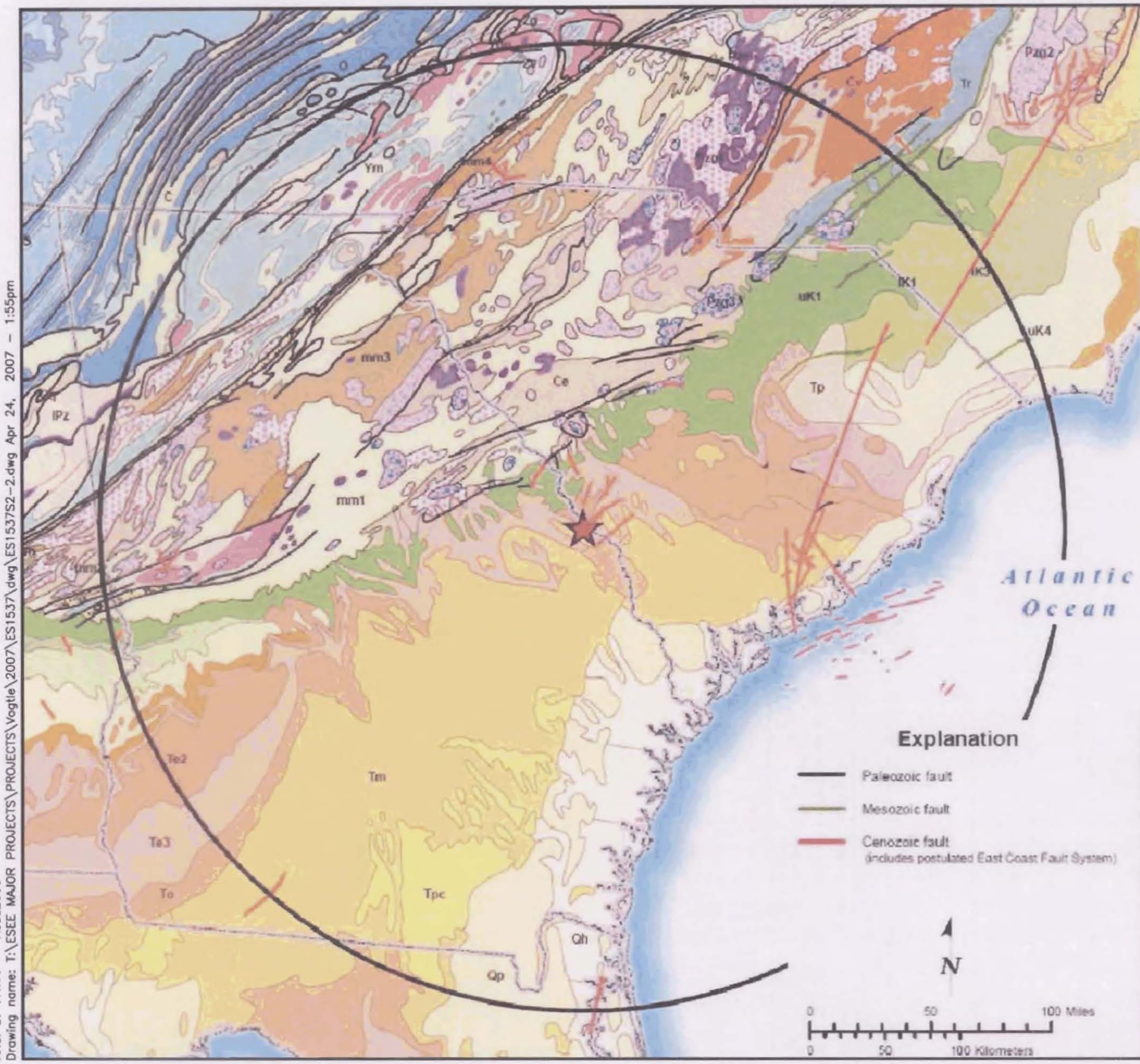

REFERENCE: SNC 2006

FIGURE 2-2

Southern Company Generation
Engineering and Construction Services

FOR

Southern Nuclear

ALVIN W. VOGTLE NUCLEAR PLANT
REGIONAL GEOLOGIC MAP
(200 MILE RADIUS)

SCALE	PROJ I.D.	DRAWING NUMBER	SH	CONT'D
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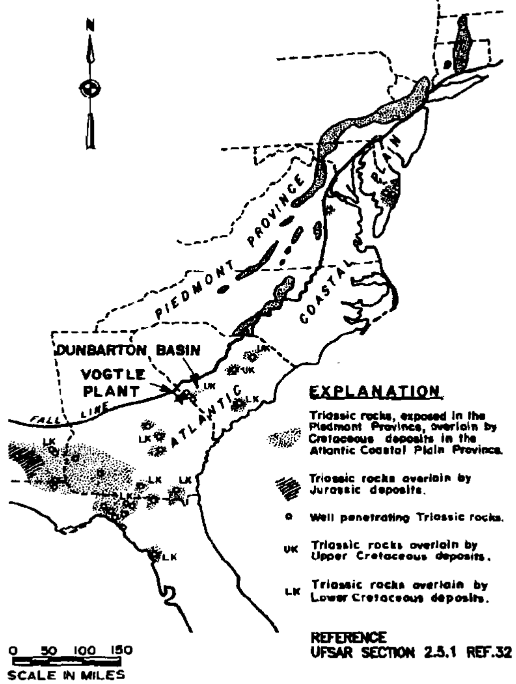
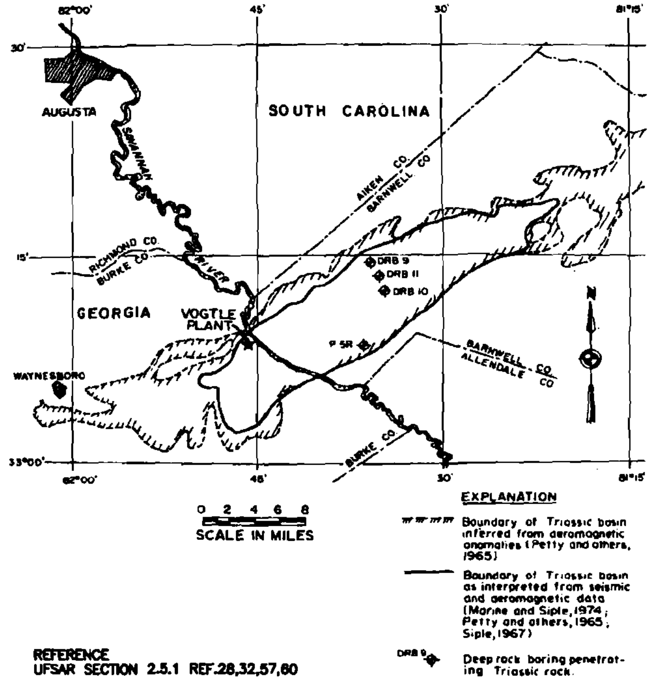


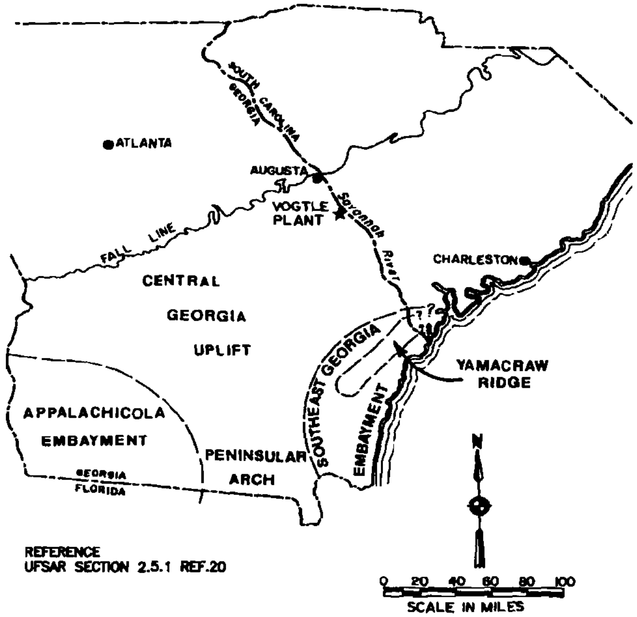
REFERENCE
UFSAR SECTION 2.5.1 REF.32

TRIASSIC ROCKS ALONG THE EASTERN SEABOARD



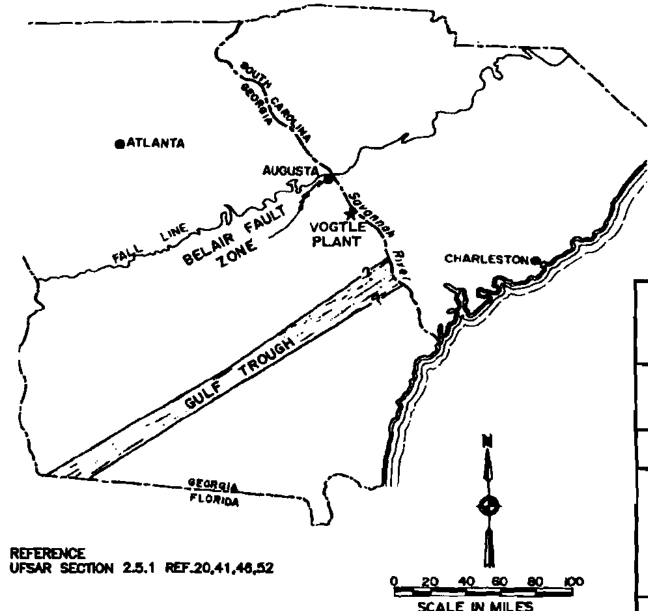
REFERENCE
UFSAR SECTION 2.5.1 REF.28,32,57,60

BOUNDARIES OF THE TRIASSIC DUNBARTON BASIN



REFERENCE
UFSAR SECTION 2.5.1 REF.20

BASEMENT FEATURES GEORGIA COASTAL PLAIN



REFERENCE
UFSAR SECTION 2.5.1 REF.20,41,46,52

APPROXIMATE LOCATIONS OF BELAIR FAULT ZONE AND GULF TROUGH

FIGURE 2-3

Southern Company Generation
Engineering and Construction Services
FOR
Southern Nuclear

ALVIN W. VOGTLE NUCLEAR PLANT
REGIONAL STRUCTURAL GEOLOGY

SCALE	PROJ I.D.	DRAWING NUMBER	SH	CONT'D
NONE		ES1537S2-3	1	FINAL

Drawing name: T:\ESEE MAJOR PROJECTS\PROJECTS\Vogtle\2007\ES1537\dwg\ES1537S2-3.dwg Apr 30, 2007 – 1:08pm

ANSI C: 22x17 Acad2004

ERA	SYSTEM	SERIES	AGE	UNIT	DESCRIPTION
CENOZOIC	QUATERNARY	PLEIS. & RECENT		ALLUVIUM	ALLUVIAL FILL AND TERRACE DEPOSITS IN STREAM VALLEYS, CONSISTING OF TAN TO GRAY SAND, CLAY SILT AND GRAVEL
	TERTIARY	MIOCENE	EARLY	HAWTHORN (ALTAMAHA) FORMATION	POORLY SORTED CLAYEY SAND AND GRAVEL, TAN, RED AND PURPLE IN COLOR CONTAINS SOME CROSS-BEDDED STRINGERS OF LIMONITE-GOETHITE PEBBLES
		OLIGOCENE	LATE	SUWANNEE LIMESTONE	LIGHT-GRAY TO CREAM COLOR, FOSSILIFEROUS LIMESTONE BASAL LAYER IS SANDY
		EOCENE	LATE	BARNWELL GROUP: TOBACCO ROAD SAND; DRY BRANCH FM: IRWINTON SAND MBR, TWIGGS, GRIFFINS LANDING MEMBER, TWIGGS CLAY MBR; CLINCHFIELD FM, UTLEY LIMESTONE MBR; OCALA GROUP: OCMULGEE FM, CRYSTAL RIVER FM, WILLISTON FM	TOBACCO ROAD SAND FINE-GRAINED AND WELL SORTED TO COARSE AND POORLY-SORTED SAND OCMULGEE FM FORAMINIFERAL MARL AND LIMESTONE CRYSTAL RIVER FM COARSE, FOSSILIFEROUS LIMESTONE IRWINTON SAND MBR FINE-TO MEDIUM-GRAINED QUARTZ SAND GRIFFINS LANDING MBR WELL-SORTED CALCAREOUS SAND TWIGGS CLAY MBR GREENISH BLUISH GRAY SILTY SAND WILLISTON FM NON FOSSILIFEROUS SANDY LIMESTONE UTLEY LIMESTONE MBR SANDY, GLAUCONITIC, FOSSILIFEROUS LIMESTONE
			MIDDLE	LISBON FM: McBEAN LIMESTONE MEMBER, BLUE BLUFF MEMBER; UNNAMED LIMESTONE; UNNAMED SANDS AND LIMESTONE	BLUE BLUFF MBR GREENISH TO BLUISH-GRAY MARL McBEAN LIMESTONE MBR SOFT, GRAY SANDY LIMESTONE WITH SOME SHELL FRAGMENTS UNNAMED LIMESTONE GRAY, FOSSILIFEROUS LIMESTONE UNNAMED SAND AND LIMESTONE QUARTZ SAND, CALCAREOUS SAND AND FOSSILIFEROUS LIMESTONE
		PALEOCENE	EARLY	HUBER FORMATION; ELLENTON FORMATION	HUBER FM MULTI-COLORED CLAY, CONTAINS BEDS OF SANDY KAOLIN TO COARSE BEDDED SAND ELLENTON FM DARK-GRAY TO BLACK SANDY LIGNITIC MICACEOUS CLAY, MEDIUM-TO DARK-GRAY COARSE SAND.
MESOZOIC	CRETACEOUS	LATE		TUSCALOOSA FORMATION	TAN, BUFF, LIGHT-GRAY AND WHITE CROSS BEDDED MICACEOUS QUARTZITE AND ARKOSIC SAND AND GRAVEL, INTERBEDDED WITH RED, BROWN AND PURPLE CLAY AND WHITE KAOLIN
	TRIASSIC	LATE		NEWARK (?) SUPERGROUP	GRAY, DARK BROWN AND BRICK RED SANDSTONE, SILTSTONE AND CLAYSTONE WITH SECTIONS OF CONGLOMERATE AND FAN GLOMERATE
PRECAMBRIAN & PALEOZOIC				BASEMENT ROCK OF THE KIOKEE BELT AND BELAIR BELT	GRANITE, GNEISS, PHYLLITE AND GREENSTONE

NOTE:

FORMATION AGES ARE GIVEN ON DRAWING AX6DD339 AND IN UFSAR SECTION 2.5.1 TEXT

REFERENCES:

VEGP, FSAR

FIGURE 2-4

Southern Company Generation
Engineering and Construction Services
FOR
Southern Nuclear

ALVIN W. VOGTLE NUCLEAR PLANT
LITHOLOGIC CHART

SCALE	PROJ I.D.	DRAWING NUMBER	SH	CONT'D
NONE		ES1537S2-4	1	FINAL

ANSI B: 17x11 Acad2006
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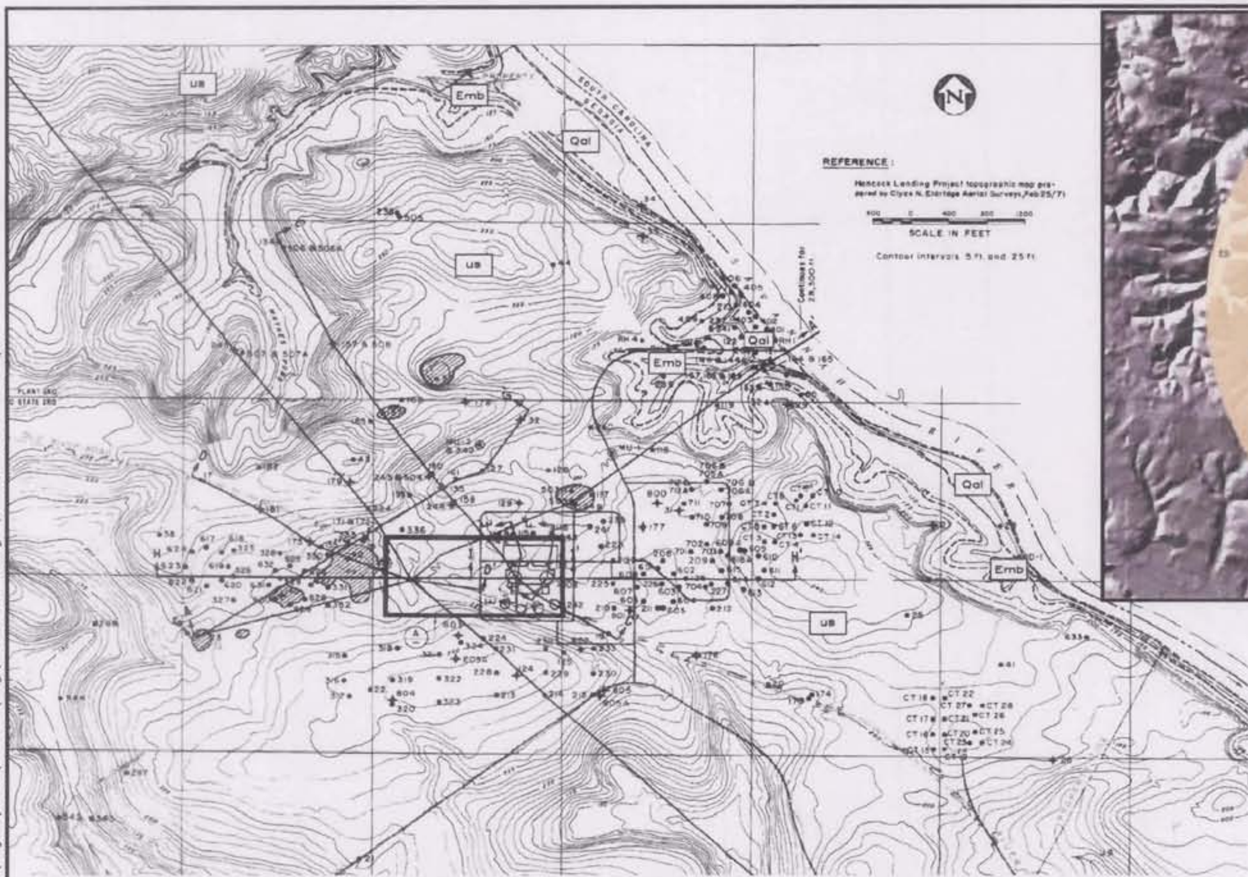
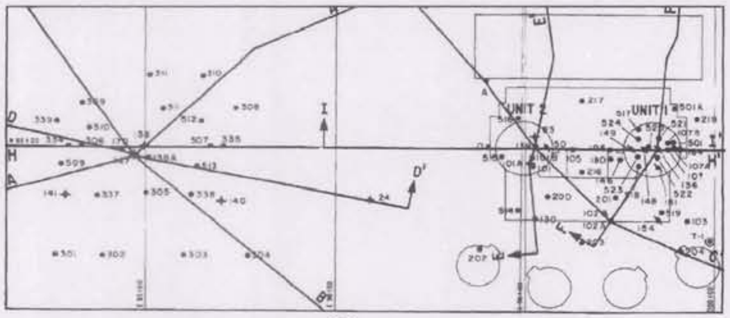


REFERENCE: VEGP, FSAR

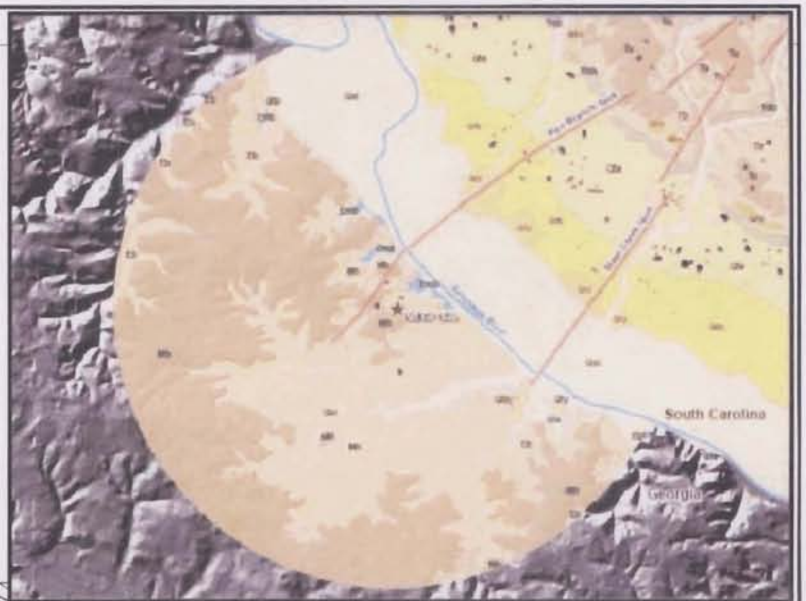


DETAIL (A) PLANT SITE

SCALE IN FEET

EXPLANATION

- Exploration hole
- Seismic survey hole
- Ground water observation hole
- Make up well
- Qal — Recent alluvium
- us — UPPER SANDS: Undifferentiated, uncemented, red-brown, yellow, silty sand. Occasionally typified by many clay seams, loose sands and shell deposits. (Hawthorne Formation and Barnwell Group)
- Emb — BEARING UNIT: (Blue Bluff Marl) Hard gray-green true marl, fossiliferous and concretionary
- Geologic contact, approximated
- A A' — Geologic section
- Surface depression



PEN BRANCH FAULT INSET
NOT TO SCALE
REFERENCE: SNC, 2006

FIGURE 2-5

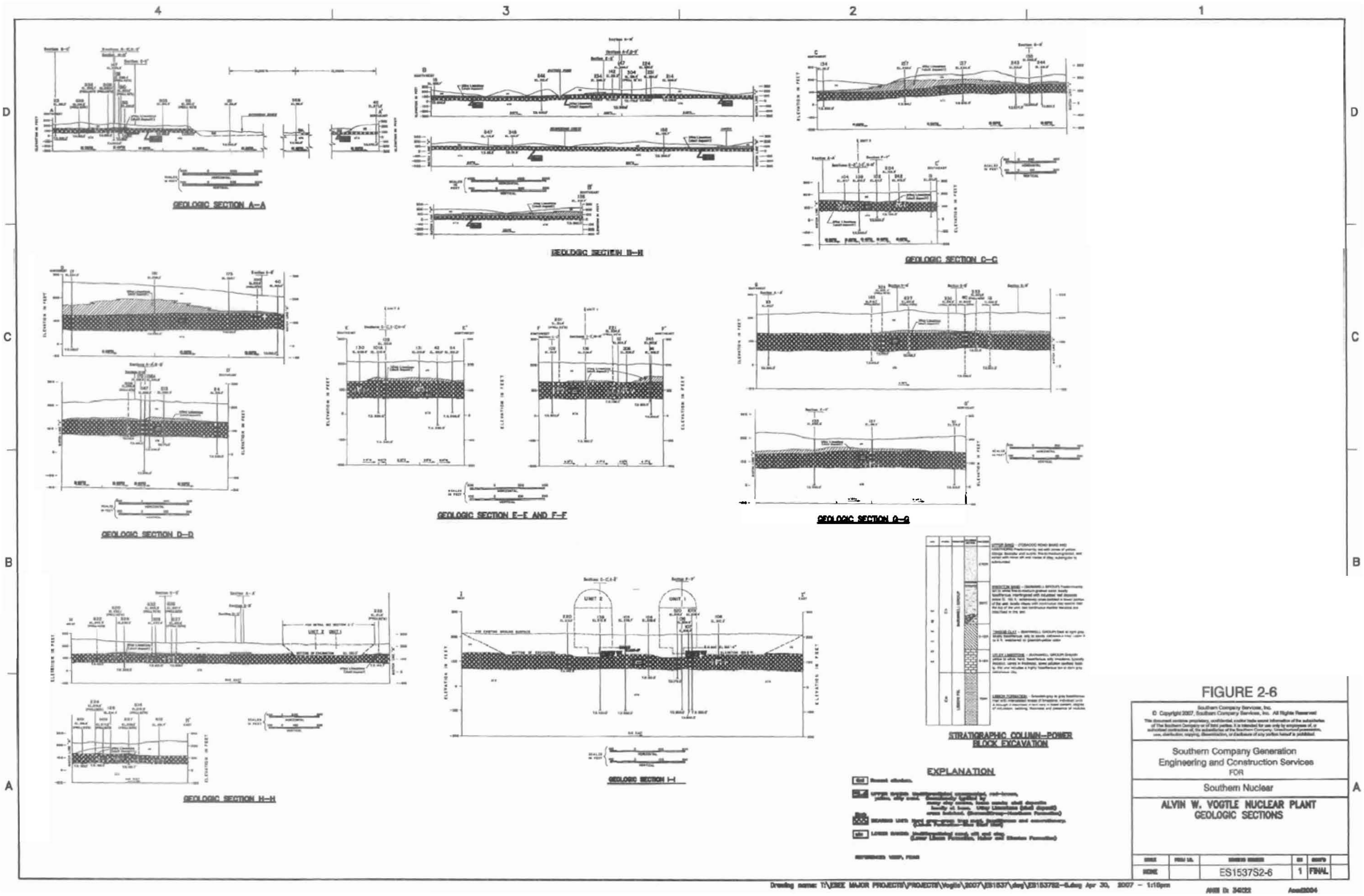
Southern Company Generation
Engineering and Construction Services
FOR

Southern Nuclear

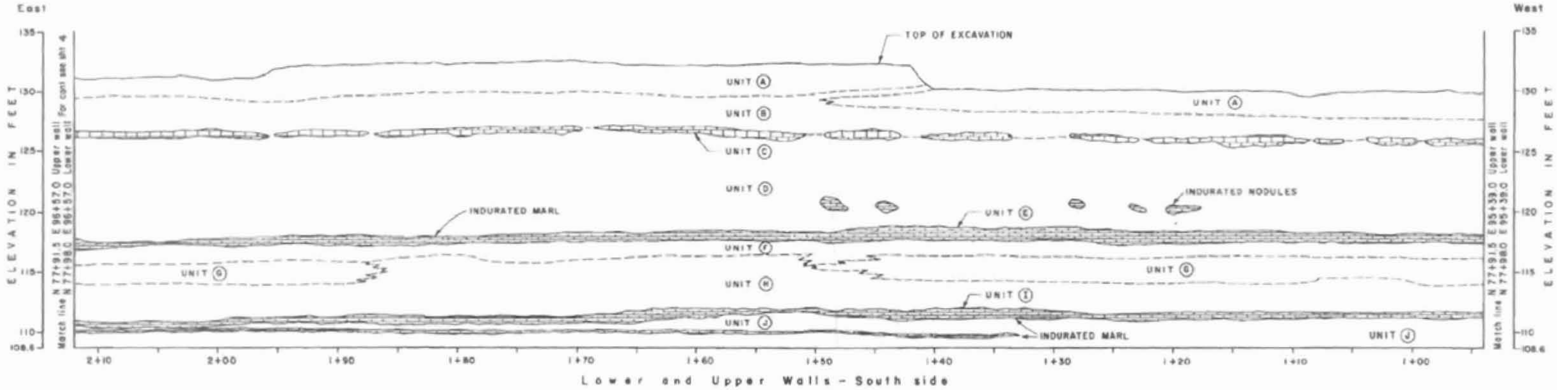
ALVIN W. VOGTLE NUCLEAR PLANT
SITE GEOLOGIC MAP

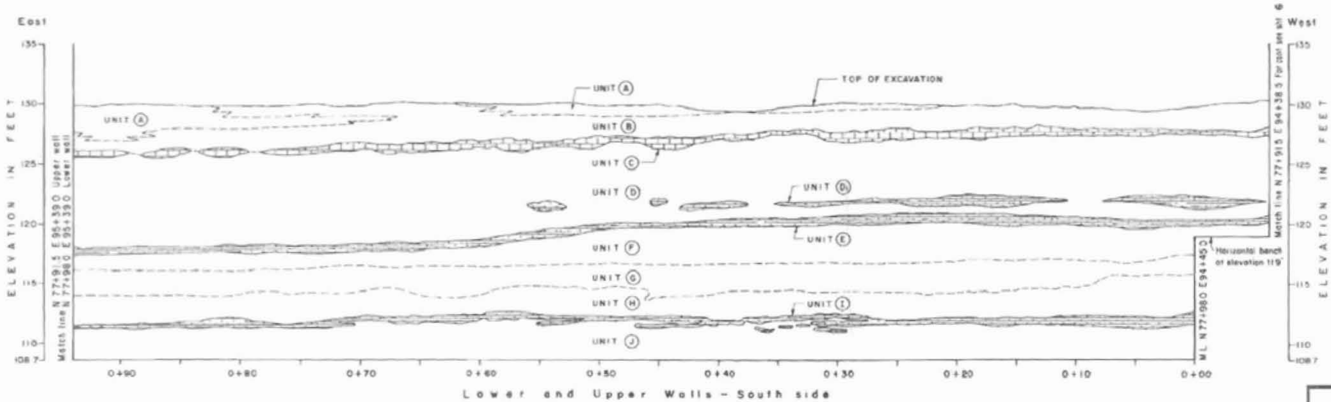
SCALE	PROJ I.D.	DRAWING NUMBER	SH	CONT'D
NONE		ES1537S2-5	1	FINAL

ANSI B: 17x11 Acad2006
Drawing name: T:\ESEE MAJOR PROJECTS\PROJECTS\Vogtle\2007\ES1537\dwg\ES1537S2-5.dwg Apr 24, 2007 - 2:08pm



GEOLOGIC SECTION A–A
GEOLOGIC SECTION B–B
GEOLOGIC SECTION C–C
GEOLOGIC SECTION D–D
GEOLOGIC SECTION E–E AND F–F
GEOLOGIC SECTION G–G
GEOLOGIC SECTION H–H
GEOLOGIC SECTION I–I
UNIT 2
UNIT 1
STRATIGRAPHIC COLUMN—POWER BLOCK EXCAVATION
EXPLANATION
FIGURE 2-6
Southern Company Generation
Engineering and Construction Services
FOR
Southern Nuclear
ALVIN W. VOGTLE NUCLEAR PLANT
GEOLOGIC SECTIONS
ES1537S2-6
1
FINAL





REFERENCE: VEGP, FSAR

FIGURE 2-7 Sh.1

NOTES:

1. FOR EXPLANATION OF GEOLOGIC UNITS SEE FIGURE 2-7, Sh.2.
2. STATIONING KEY AND SECTION LOCATION SHOWN ON DRAWING AX6DD374
3. SECTION CONSISTS OF UPPER AND LOWER WELLS SEPARATED BY HORIZONTAL BENCH AT ELEVATION 119 ft. (SEE DRAWING AX6DD374).

Southern Company Generation
Engineering and Construction Services
FOR
Southern Nuclear

ALVIN W. VOGTLE NUCLEAR PLANT
GEOLOGIC SECTION SHOWING MARL SUBUNITS

SCALE	PROJ I.D.	DRAWING NUMBER	SH	CONT'D
NONE		ES1537S2-7	1	2

UNIT (A) MARL - Silty to clayey dark gray marl; thin light gray laminations which are discontinuous and undulating; parting along laminations common; laminations are conformable with overall attitude of unit; scattered shell fragments; cemented or indurated lenses of sand (up to 0.1' thick) occur locally; appears dessicated at surface after exposure to the atmosphere.

UNIT (A1) INDURATED MARL - Indurated light gray sandy marl, massive, conchoidal fracture, few fossil fragments, moderately hard (can be scratched with a knife); contacts gradational, few dessication cracks develop on exposure to atmosphere, small mica flakes observed without aid of magnification device. Thickness varies from 0.0 to 0.5'.

UNIT (B) SANDY MARL - Very fine-grained sand and silt with widely scattered shell fragments, typically massive although faintly laminated zones are present, sugary texture, dessication cracks poorly developed, moderately soft, medium gray to dark gray.

UNIT (B1) LAMINATED MARL - Dark gray to white alternating discontinuous bands of clay and very fine-grained sand and mixtures of the above; the bands are lenticular and undulatory; few fossils present, locally well indurated, dessication cracks appear upon exposure to atmosphere, gradational contacts except with Unit (C) ; typically moderately soft, can be deformed under finger pressure but hardens upon drying.

UNIT (C) LIMESTONE - Light gray, hard, limestone; conchoidal fracture, no fossils, discontinuous with lenticular pods, up to 1.0-foot thick, sharp contacts.

UNIT (D) FOSSILIFEROUS MARL - Medium gray (lightens upon drying), highly fossiliferous, sandy (very fine-grained) to silty, massive, uniform lithology throughout auxiliary building foundation, many pelecypod fossils retain both valves, discontinuous limestone-like indurated seams occur in the upper portion, large lime-cemented nodules and seams occur near the base of the unit which have gradational contacts with the surrounding material; unit varies from moderately hard to moderately soft.

UNIT (D1) LIMESTONE PODS - Impure limestone to well-cemented marl, discontinuous highly irregular pods and lenses, generally at the same elevation, highly gradational contacts, resembles caliche-like deposit in places, light gray, hard, fossiliferous, silty, massive, no jointing or fractures.

UNIT (E) IMPURE LIMESTONE - Gray, impure limestone appears to be indurated or lime-cemented marl material, fossiliferous, hard, sharp to highly gradational and uneven contacts.

UNIT (F) FOSSILIFEROUS MARL - Very similar to Unit (D) ; medium gray, highly fossiliferous sandy (very fine-grained) to silty, massive gradational contacts in places with both overlying and underlying units, moderately soft, unit forms dessication cracks upon exposure to the atmosphere.

UNIT (G) LAMINATED MARL - Laminated, dark gray to light gray, unit is characterized by sinuous, undulatory, discontinuous laminations, silty to extremely fine sand, scattered shell fragments, small lenticular clay pods, well consolidated, moderately soft (cannot be deformed by finger pressure), no joints or bedding planes, scattered carbonaceous lenses.

UNIT (H) MASSIVE MARL - Massive, silty, firm, uncemented,well consolidated,upper portion of this unit has only sparse fossils but fossils become more numerous near the base, no bedding joints or fractures, medium gray to light gray when dry, moderately soft, cannot be deformed by finger pressure.

UNIT (I) IMPURE LIMESTONE - Fossiliferous, massive, silty limestone, locally discontinuous, hard, light gray to white, locally interbedded with Unit (H) , small carbonaceous inclusions.

UNIT (J) FOSSILIFEROUS MARL - Medium gray, massive fossiliferous silty, marl, scattered shell fragments, numerous limestone pods occur about 3' below the top of the unit; a thin indurated zone is present about 1' below the top of the unit; moderately hard.

NOTE:

FOR GEOLOGIC SECTIONS SEE DRAWINGS AX6DD364 THRU AX6DD369.

REFERENCE: VEGP, FSAR

FIGURE 2-7 Sh.2

Southern Company Generation
Engineering and Construction Services
FOR
Southern Nuclear

ALVIN W. VOGTLE NUCLEAR PLANT
DESCRIPTION OF MARL SUBUNITS

SCALE	PROJ I.D.	DRAWING NUMBER	SH	CONT'D	
NONE		ES1537S2-7	2	FINAL	

ANSI B: 17x11 Acad2006
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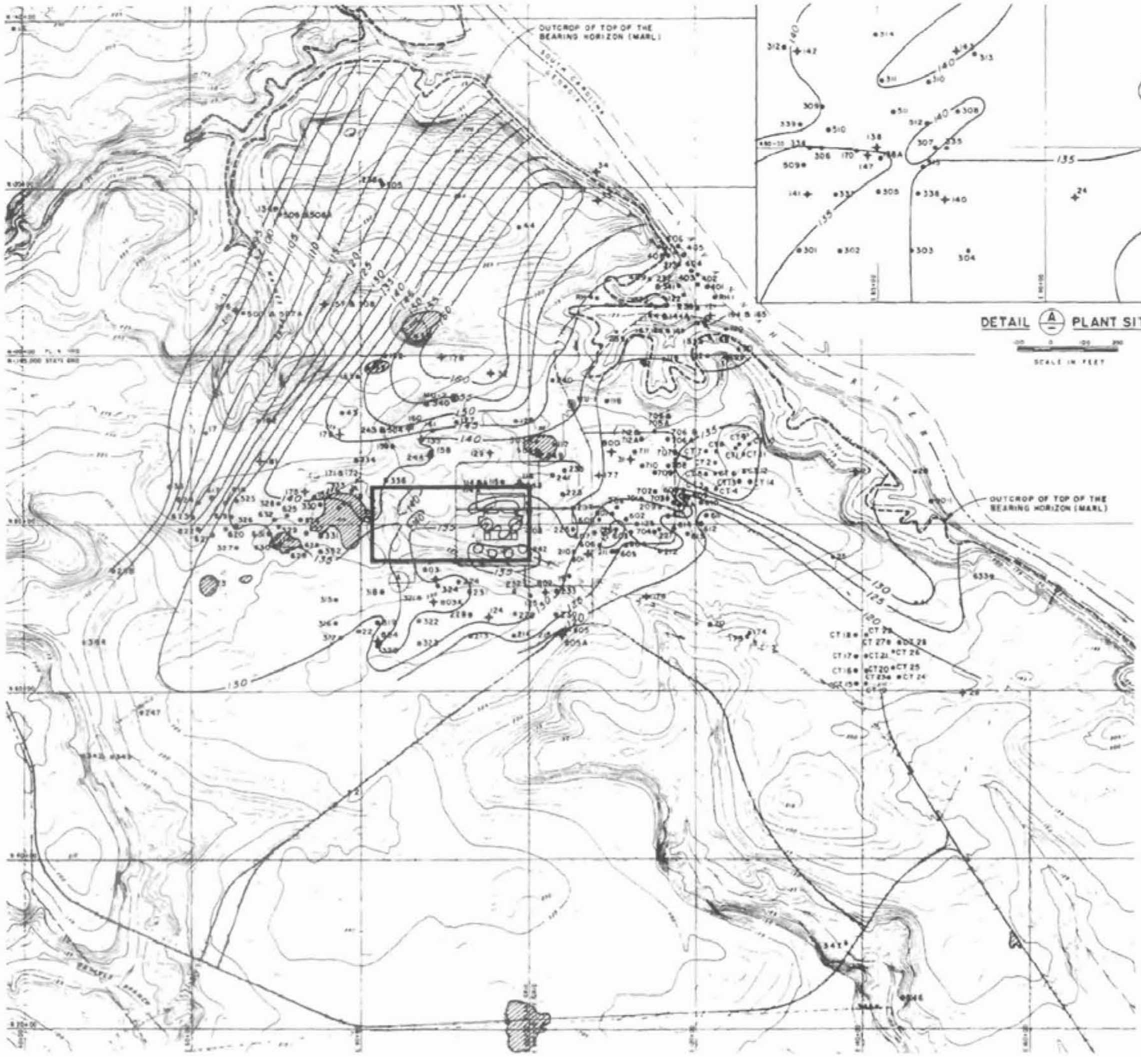

EXPLANATION

- EXPLORATION HOLE
- SEISMIC SURVEY HOLE
- GROUND WATER OBSERVATION HOLE
- MAKE-UP WELL
- SURFACE DEPRESSION
- CONTOURS OF THE TOP OF THE BEARING HORIZON IN FEET ABOVE SEA LEVEL

REFERENCE:

Hancock Landing Project topographic map prepared by Clyde N. Eldridge Aerial Surveys, Feb 25/71

SCALE IN FEET

Contour intervals 5 ft and 25 ft

FIGURE 2-8

Southern Company Generation
Engineering and Construction Services
FOR

Southern Nuclear

ALVIN W. VOGTLE NUCLEAR PLANT
TOP OF THE BLUE BLUFF MARL

SCALE	PROJ I.D.	DRAWING NUMBER	SH	CONT'D
NONE		ES1537S2-8	1	FINAL

ANSI B: 17x11 Acad2006
Drawing name: T:\ESEE MAJOR PROJECTS\PROJECTS\Vogtle\2007\ES1537\dwg\ES1537S2-8.dwg Apr 24, 2007 - 2:18pm

ANSI B: 17x11 Acad2006
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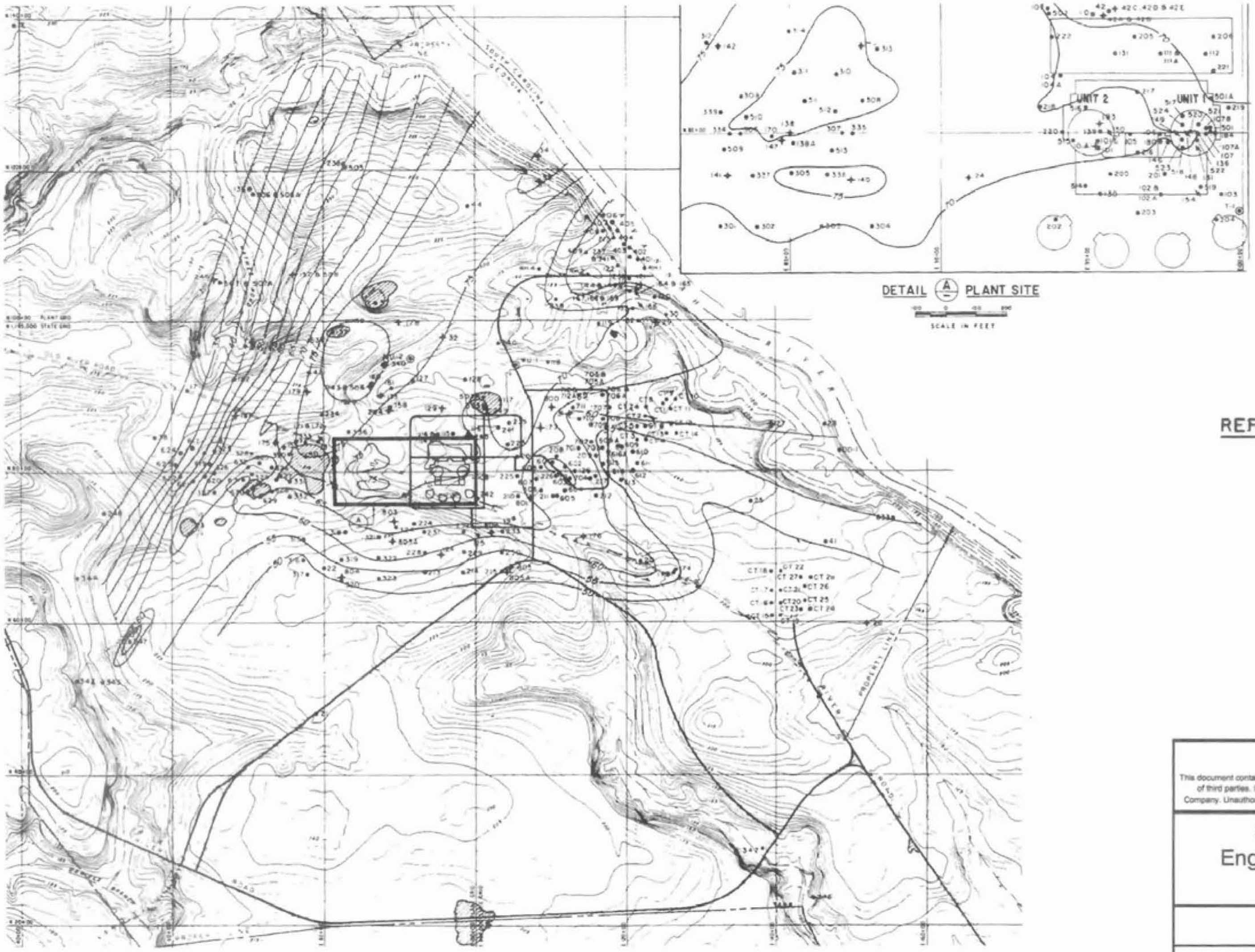


EXPLANATION

●17 EXPLORATION HOLE

15 SEISMIC SURVEY HOLE

✚31 GROUND WATER OBSERVATION HOLE

◉71 MAKE-UP WELL

SURFACE DEPRESSION

70 CONTOURS OF THE TOP OF THE BEARING HORIZON IN FEET ABOVE SEA LEVEL

REFERENCE:

Hancock Landing Project topographic map prepared by Clyde N. Eldridge Aerial Surveys, Feb 25/71

SCALE IN FEET

Contour intervals 5 ft. and 25 ft.

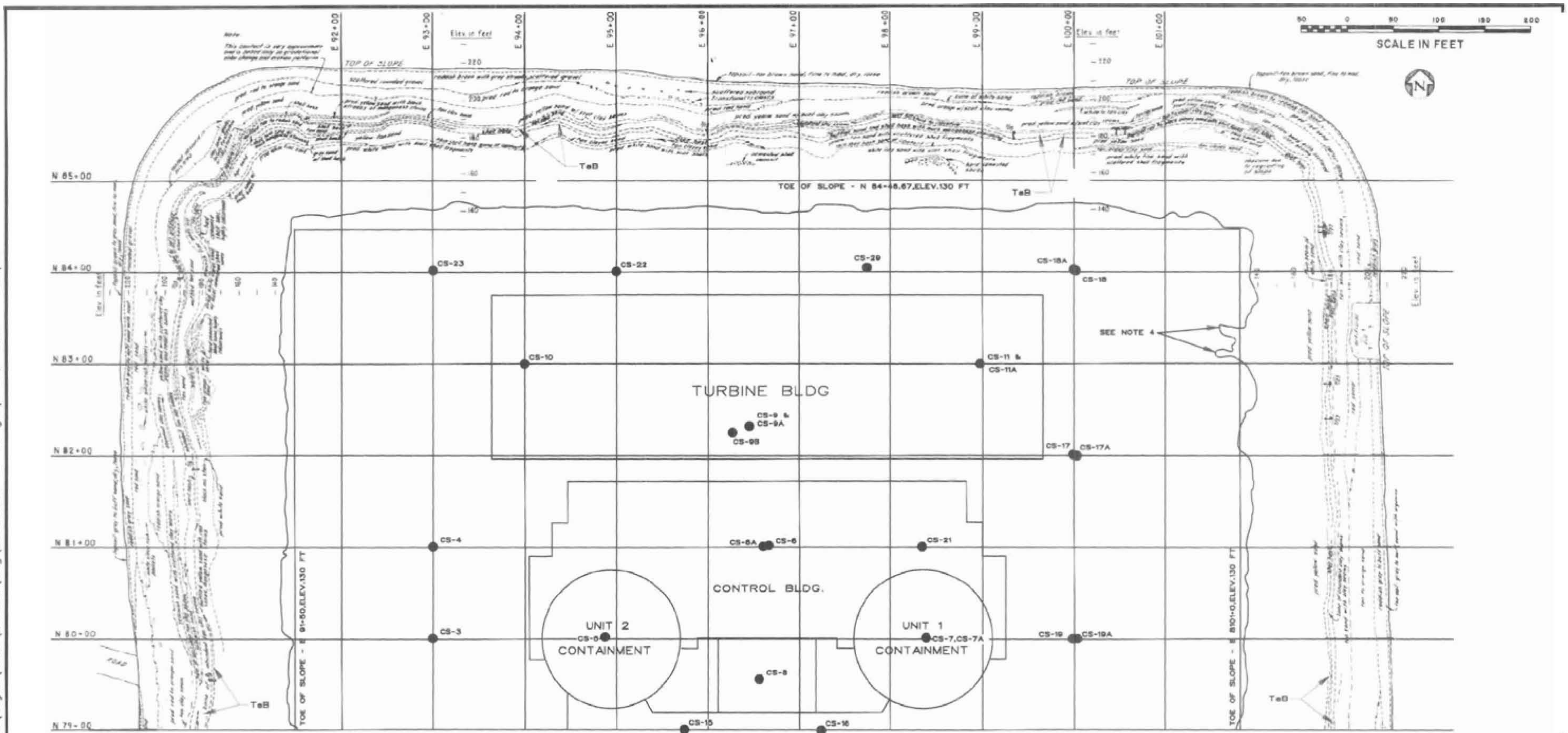
FIGURE 2-9

Southern Company Generation
Engineering and Construction Services
FOR

Southern Nuclear

ALVIN W. VOGTLE NUCLEAR PLANT
BOTTOM OF THE BLUE BLUFF MARL

SCALE	PROJ I.D.	DRAWING NUMBER	SH	CONT'D
NONE		ES1537S2-9	1	FINAL



MATCH LINE (FOR CONTINUATION SEE SHEET 2)

EXPLANATION

- CLAY SEAM
- LOCAL SEEPAGE-VARIES FROM OBSERVED DAMPNESS TO MODERATE TRICKLE
- SEEPAGE ZONE-SEEPAGE OCCURING OVER A LARGER AREA THAN
- SHELL FRAGMENTS
- CS-13 CORE HOLE FOR SAMPLING AND TESTING MARL

EOCENE

- TaB BARNWELL GROUP
- TeM LIBSON FORMATION

SEE DRAWING AX6DD352 AND TEXT FOR DETAILS OF STRATIGRAPHY

NOTES:

1. SIDE SLOPES ARE 2 HORIZONTAL TO 1 VERTICAL.
2. ALL ZONES MAPPED CONSIST OF SAND EXCEPT WHERE OTHERWISE NOTED. SEE DRAWING AX6DD352 AND TEXT FOR DETAILED DESCRIPTIONS OF STRATIGRAPHY. FOR EXAMPLE "YELLOW" REFERS TO YELLOW SAND.
3. BOTTOM OF EXCAVATION-130.00 ft., EXCEPT AUXILLARY BUILDING WHICH IS ELEV.108.75 ft
4. THE APPARENT IRREGULARITY OF THE UPPER CONTACT OF THE LIBSON FORMATION REFLECTS THE IRREGULAR CONFIGURATION OF THE EXCAVATION AT THE TIME OF MAPPING AND IS NOT RELATED TO STRUCTURE IN THE MARL. SEE DRAWINGS AX6DD372 AND AX6DD373 FOR DETAILED SURVEY INFORMATION ON THIS CONTACT.

REFERENCE: VEGP, FSAR

FIGURE 2-10, Sh.1

Southern Company Generation Engineering and Construction Services

FOR

Southern Nuclear

ALVIN W. VOGTLE NUCLEAR PLANT
GEOLOGIC MAP
POWER BLOCK AREA

SCALE	PROJ I.D.	DRAWING NUMBER	SH	CONT'D
NONE		ES1537S2-10	1	2

ANSI B: 17x11 Acad2006
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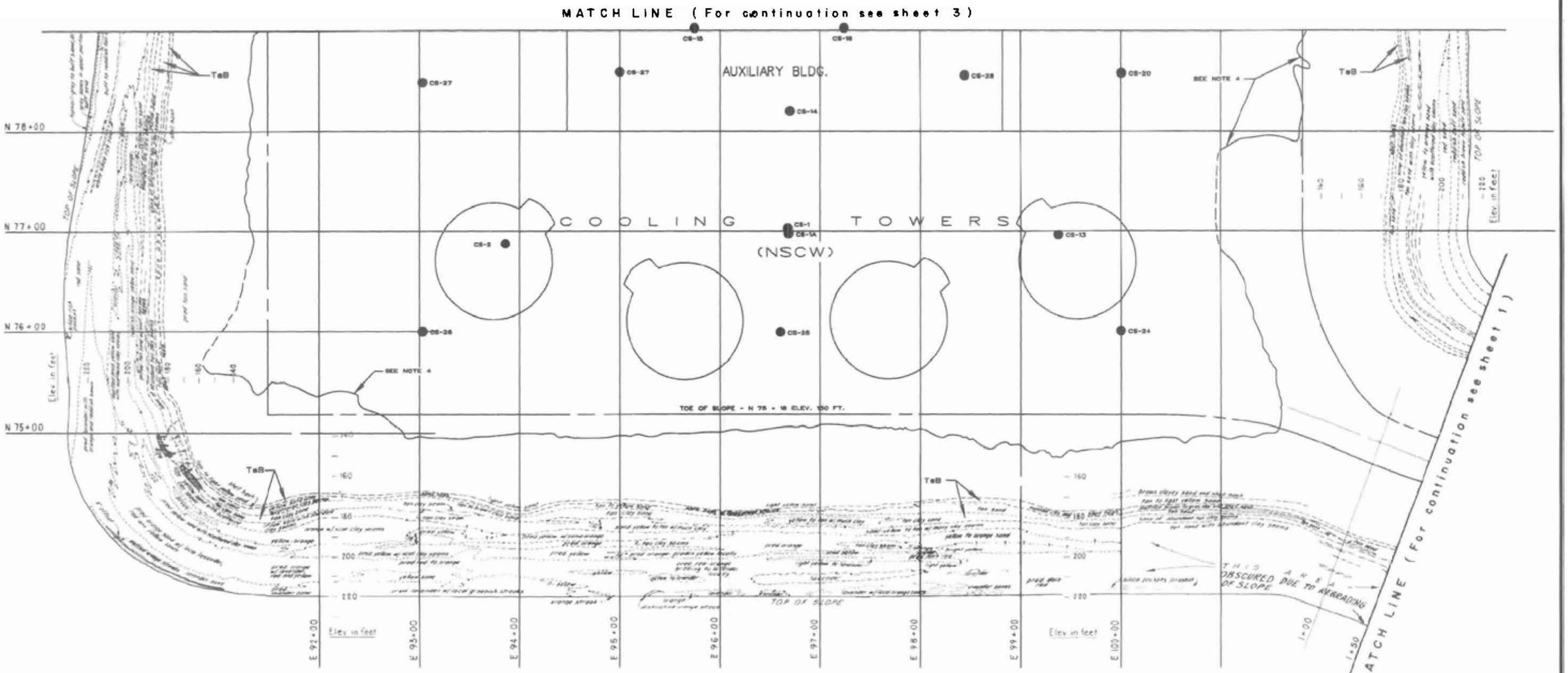

EXPLANATION

- CLAY SEAM
- LOCAL SEEPAGE-VARIES FROM OBSERVED DAMPNESS TO MODERATE TRICKLE
- SEEPAGE ZONE-SEEPAGE OCCURING OVER A LARGER AREA THAN
- SHELL FRAGMENTS
- CS-13 CORE HOLE FOR SAMPLING AND TESTING MARL

EOCENE
- TeB BARNWELL GROUP
- TeM LIBSON FORMATION

SEE DRAWING AX6DD352 AND TEXT FOR DETAILS OF STRATIGRAPHY

NOTES:

1. SIDE SLOPES ARE 2 HORIZONTAL TO 1 VERTICAL.
2. ALL ZONES MAPPED CONSIST OF SAND EXCEPT WHERE OTHERWISE NOTED. SEE DRAWING AX6DD352 AND TEXT FOR DETAILED DESCRIPTIONS OF STRATIGRAPHY. FOR EXAMPLE "YELLOW" REFERS TO YELLOW SAND.
3. BOTTOM OF EXCAVATION=130.00 ft., EXCEPT AUXILLARY BUILDING WHICH IS ELEV.108.75 ft.
4. THE APPARENT IRREGULARITY OF THE UPPER CONTACT OF THE LIBSON FORMATION REFLECTS THE IRREGULAR CONFIGURATION OF THE EXCAVATION AT THE TIME OF MAPPING AND IS NOT RELATED TO STRUCTURE IN THE MARL. SEE DRAWINGS AX6DD372 AND AX6DD373 FOR DETAILED SURVEY INFORMATION ON THIS CONTACT.

REFERENCE: VEGP, FSAR

50 0 50 100 150 200

SCALE IN FEET

N

FIGURE 2-10, Sh.2

Southern Company Generation
Engineering and Construction Services
FOR

Southern Nuclear

ALVIN W. VOGTLE NUCLEAR PLANT
GEOLOGIC MAP
POWER BLOCK AREA

SCALE	PROJ I.D.	DRAWING NUMBER	SH	CONT'D
NONE		ES1537S2-10	2	3

ANSI B: 17x11 Acad2006
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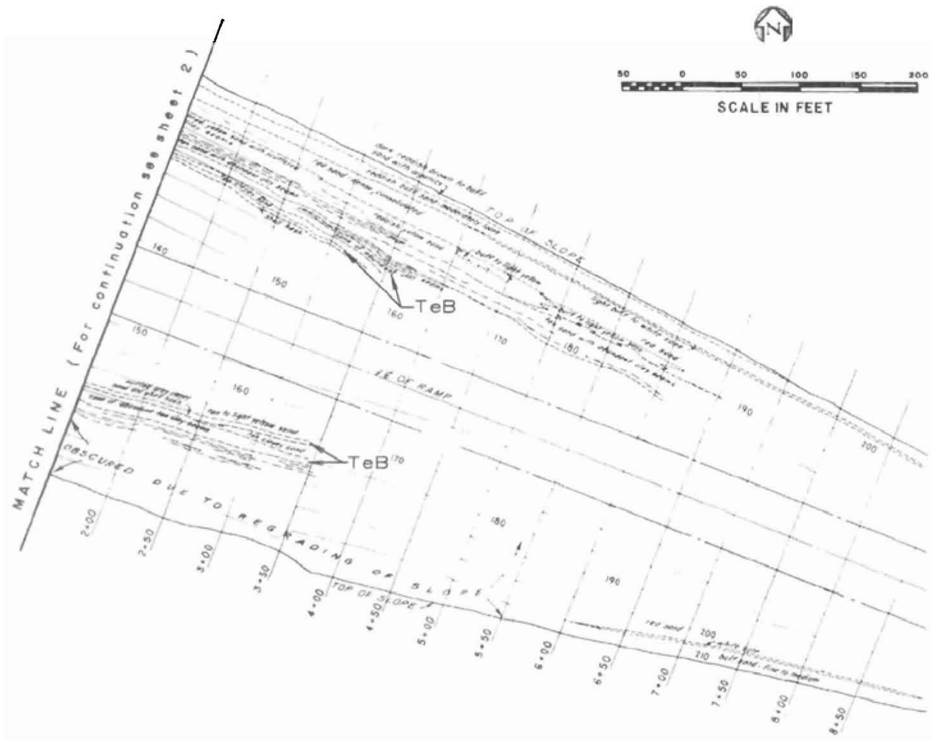

EXPLANATION

CLAY SEAM

LOCAL SEEPAGE-VARIES FROM OBSERVED DAMPNESS TO MODERATE TRICKLE

SEEPAGE ZONE-SEEPAGE OCCURING OVER A LARGER AREA THAN

SHELL FRAGMENTS

CS-13 CORE HOLE FOR SAMPLING AND TESTING MARL

EOCENE

TeB BARNWELL GROUP

TeM LIBSON FORMATION

SEE DRAWING AX6DD352 AND TEXT FOR DETAILS OF STRATIGRAPHY

NOTES:

1. SIDE SLOPES ARE 2 HORIZONTAL TO 1 VERTICAL
2. ALL ZONES MAPPED CONSIST OF SAND EXCEPT WHERE OTHERWISE NOTED. SEE DRAWING AX6DD352 AND TEXT FOR DETAILED DESCRIPTIONS OF STRATIGRAPHY. FOR EXAMPLE "YELLOW" REFERS TO YELLOW SAND
3. BOTTOM OF EXCAVATION=130.00 ft., EXCEPT AUXILLARY BUILDING WHICH IS ELEV.108.75 ft.
4. THE APPARENT IRREGULARITY OF THE UPPER CONTACT OF THE LIBSON FORMATION REFLECTS THE IRREGULAR CONFIGURATION OF THE EXCAVATION AT THE TIME OF MAPPING AND IS NOT RELATED TO STRUCTURE IN THE MARL. SEE DRAWINGS AX6DD372 AND AX6DD373 FOR DETAILED SURVEY INFORMATION ON THIS CONTACT.

REFERENCE: VEGP, FSAR

FIGURE 2-10, Sh.3

Southern Company Generation
Engineering and Construction Services
FOR

Southern Nuclear

ALVIN W. VOGTLE NUCLEAR PLANT
GEOLOGIC MAP
POWER BLOCK AREA

SCALE	PROJ I.D.	DRAWING NUMBER	SH	CONT'D
NONE		ES1537S2-10	3	FINAL

ANSI B: 17x11 Acad2006
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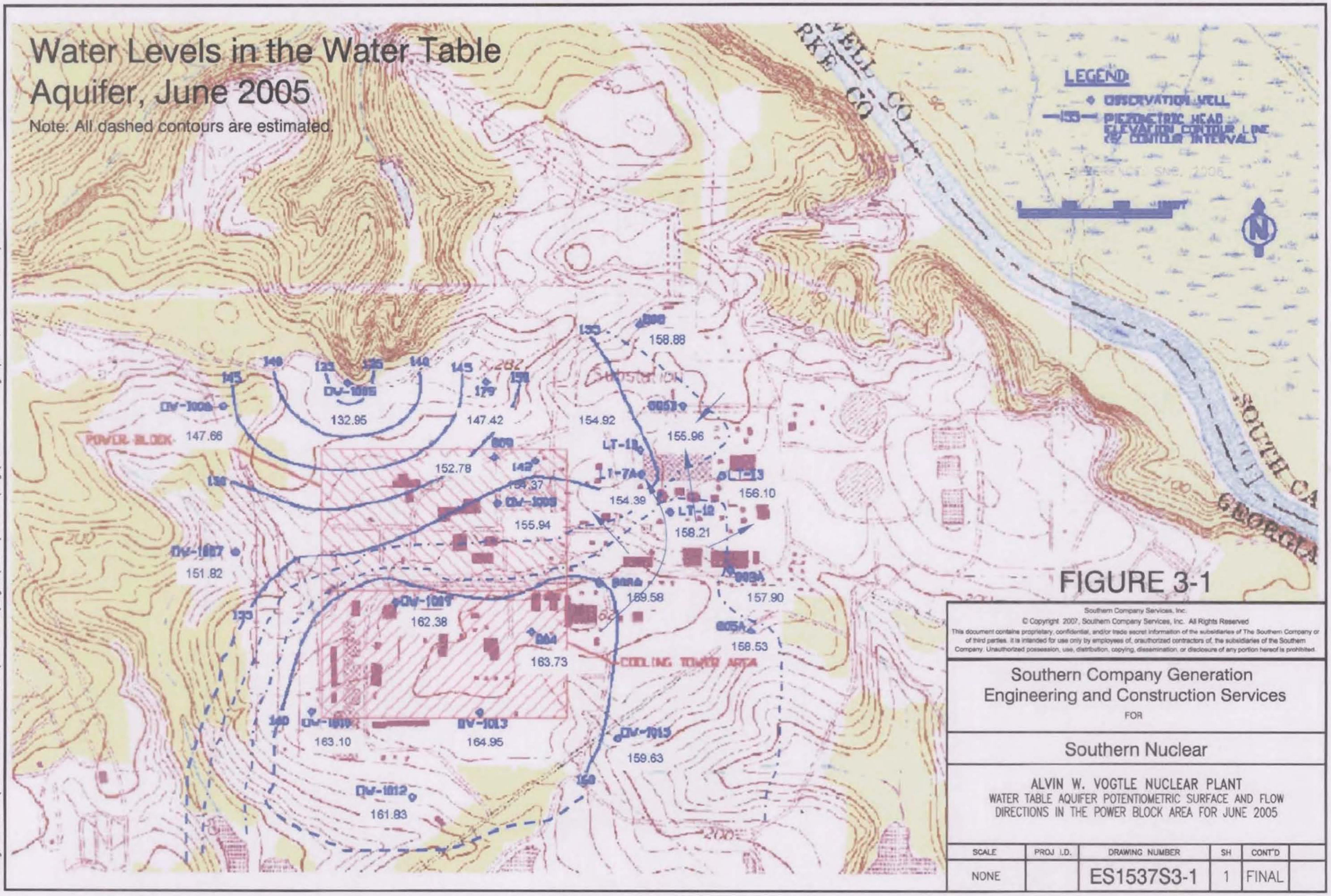

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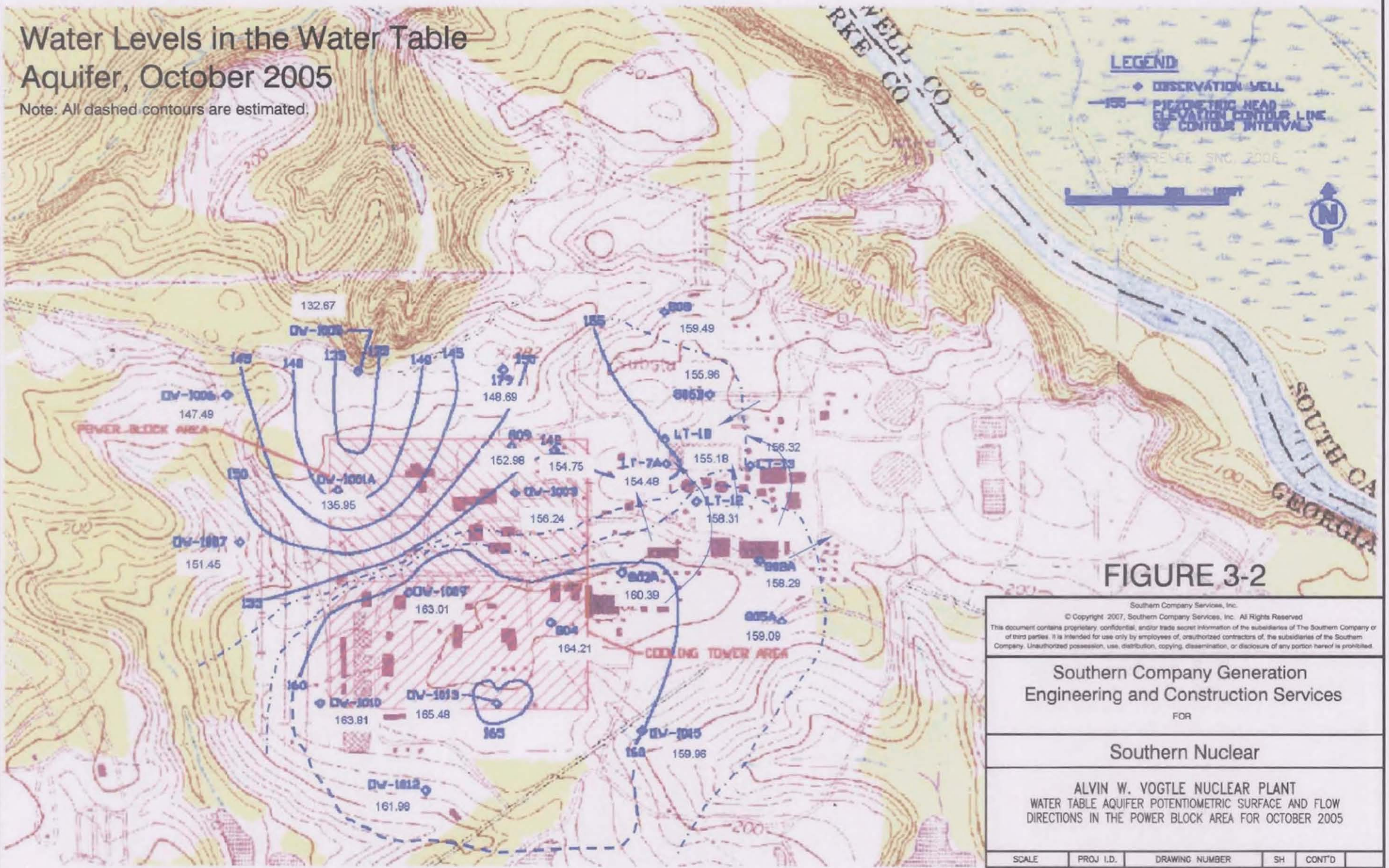

FIGURE 3-2

Southern Company Generation Engineering and Construction Services

FOR

Southern Nuclear

ALVIN W. VOGTLE NUCLEAR PLANT
WATER TABLE AQUIFER POTENTIOMETRIC SURFACE AND FLOW DIRECTIONS IN THE POWER BLOCK AREA FOR OCTOBER 2005

SCALE	PROJ I.D.	DRAWING NUMBER	SH	CONT'D
NONE		ES1537S3-2	1	FINAL

ANSI B: 17x11 Acad2006
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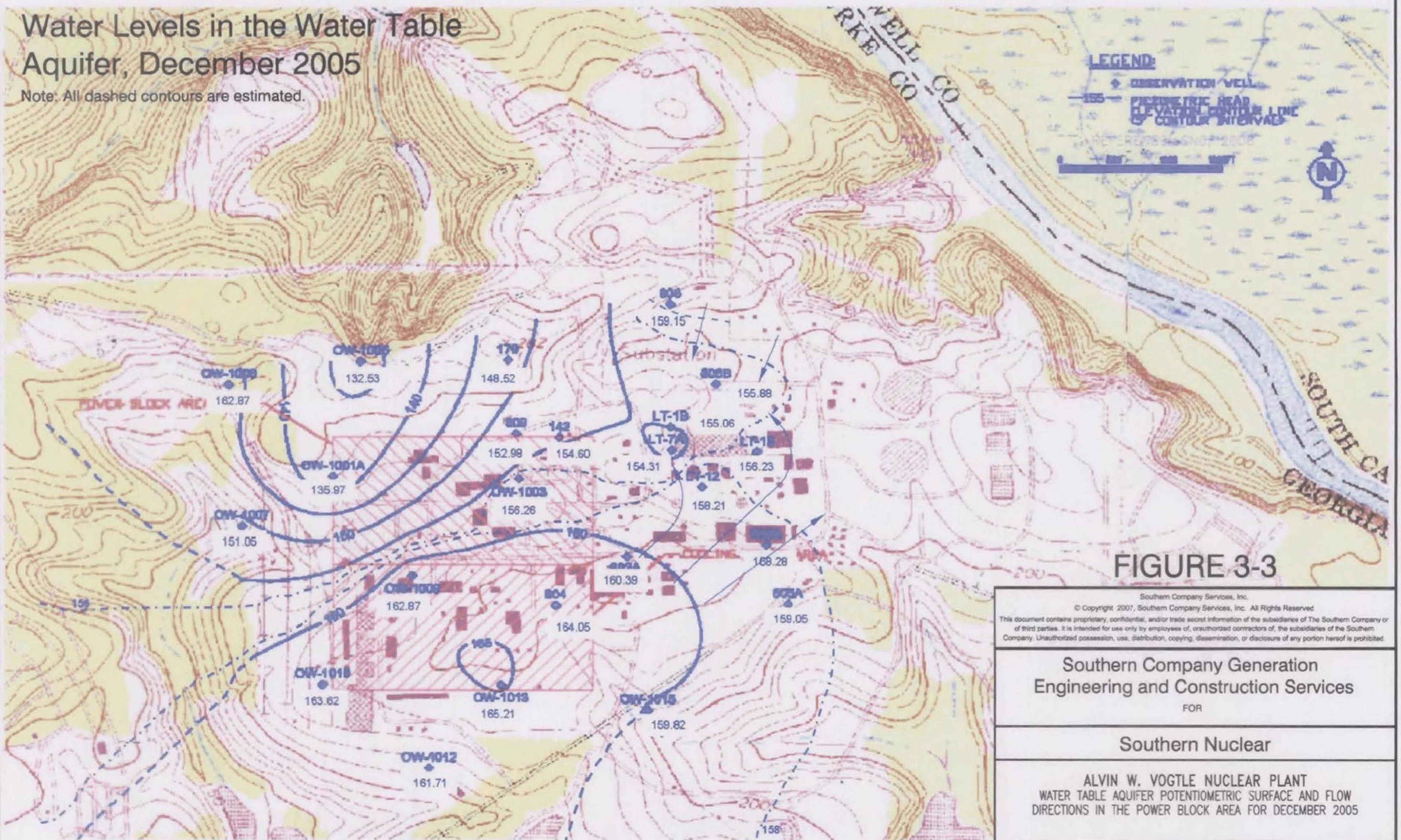

FIGURE 3-3

Southern Company Generation
Engineering and Construction Services

FOR

Southern Nuclear

ALVIN W. VOGTLE NUCLEAR PLANT
WATER TABLE AQUIFER POTENTIOMETRIC SURFACE AND FLOW DIRECTIONS IN THE POWER BLOCK AREA FOR DECEMBER 2005

SCALE	PROJ I.D.	DRAWING NUMBER	SH	CONT'D
NONE		ES1537S3-3	1	FINAL

ANSI B: 17x11 Acad2006
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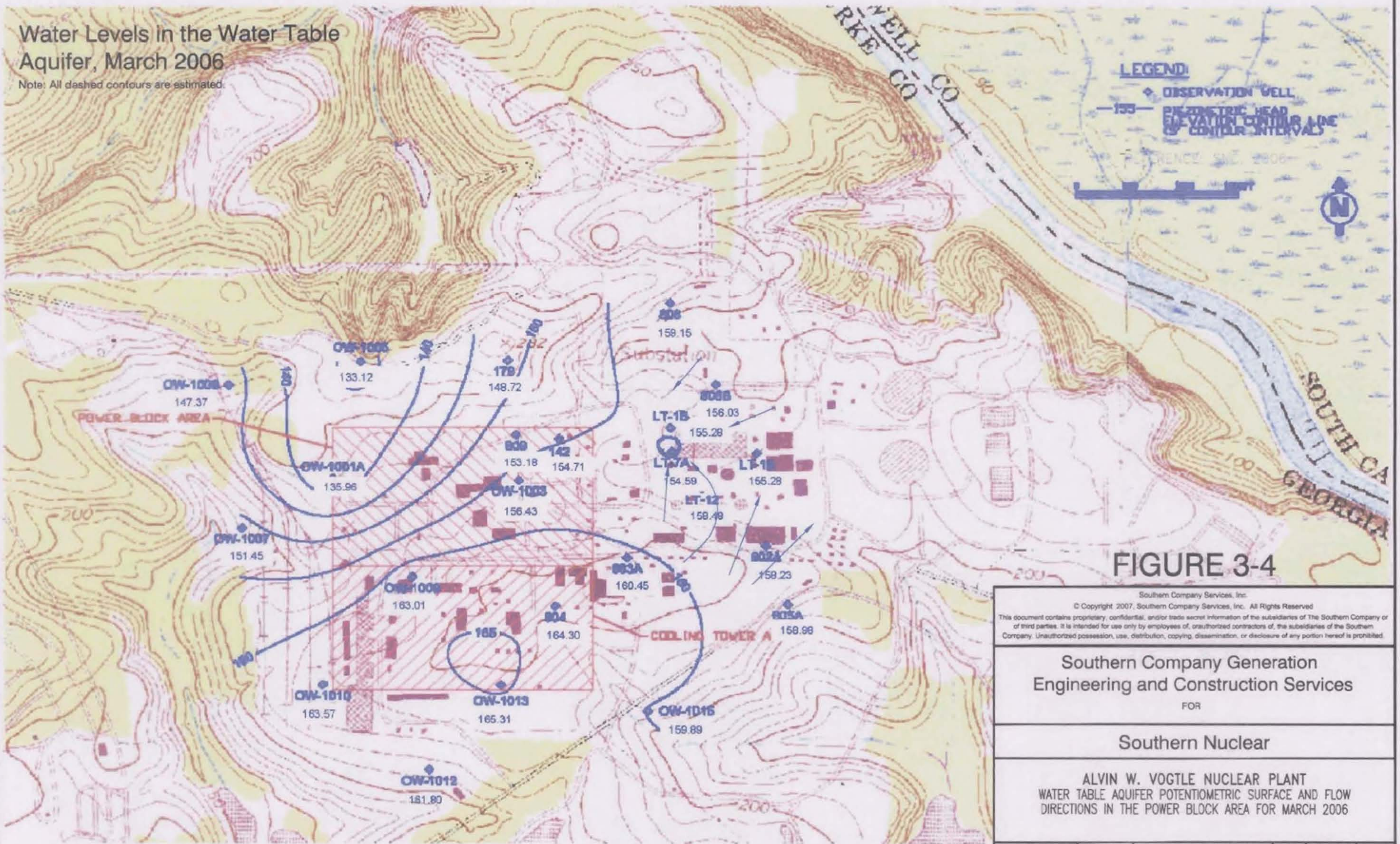

FIGURE 3-4

Southern Company Services, Inc.
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Southern Company Generation
Engineering and Construction Services
FOR

Southern Nuclear

ALVIN W. VOGTLE NUCLEAR PLANT
WATER TABLE AQUIFER POTENTIOMETRIC SURFACE AND FLOW DIRECTIONS IN THE POWER BLOCK AREA FOR MARCH 2006

SCALE	PROJ I.D.	DRAWING NUMBER	SH	CONT'D
NONE		ES1537S3-4	1	FINAL

ANSI B: 17x11 Acad2006
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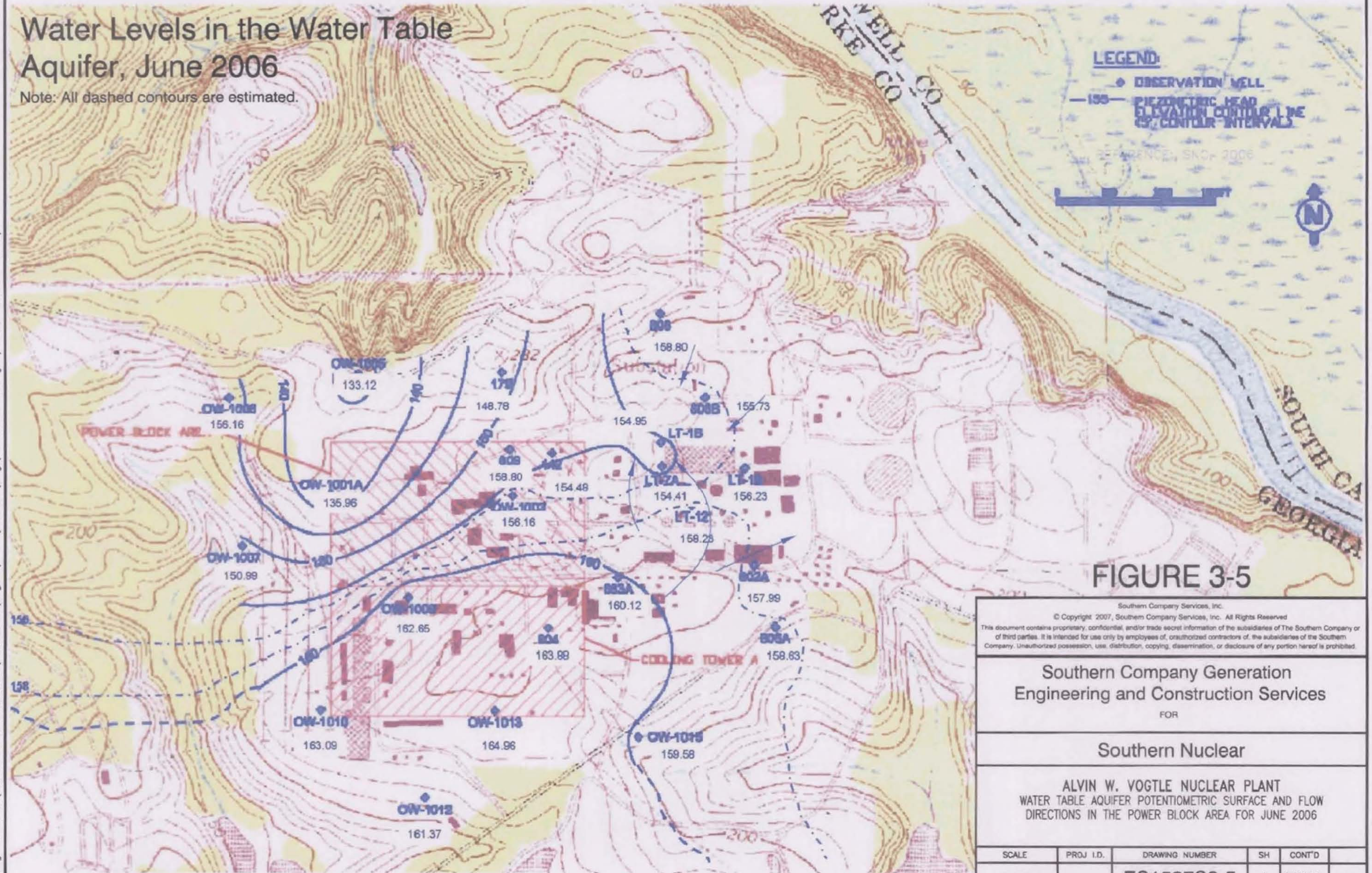

Southern Company Generation
Engineering and Construction Services

FOR

Southern Nuclear

ALVIN W. VOGTLE NUCLEAR PLANT
WATER TABLE AQUIFER POTENTIOMETRIC SURFACE AND FLOW DIRECTIONS IN THE POWER BLOCK AREA FOR JUNE 2006

SCALE	PROJ I.D.	DRAWING NUMBER	SH	CONT'D
NONE		ES1537S3-5	1	FINAL

ANSI B: 17x11 Acad2006
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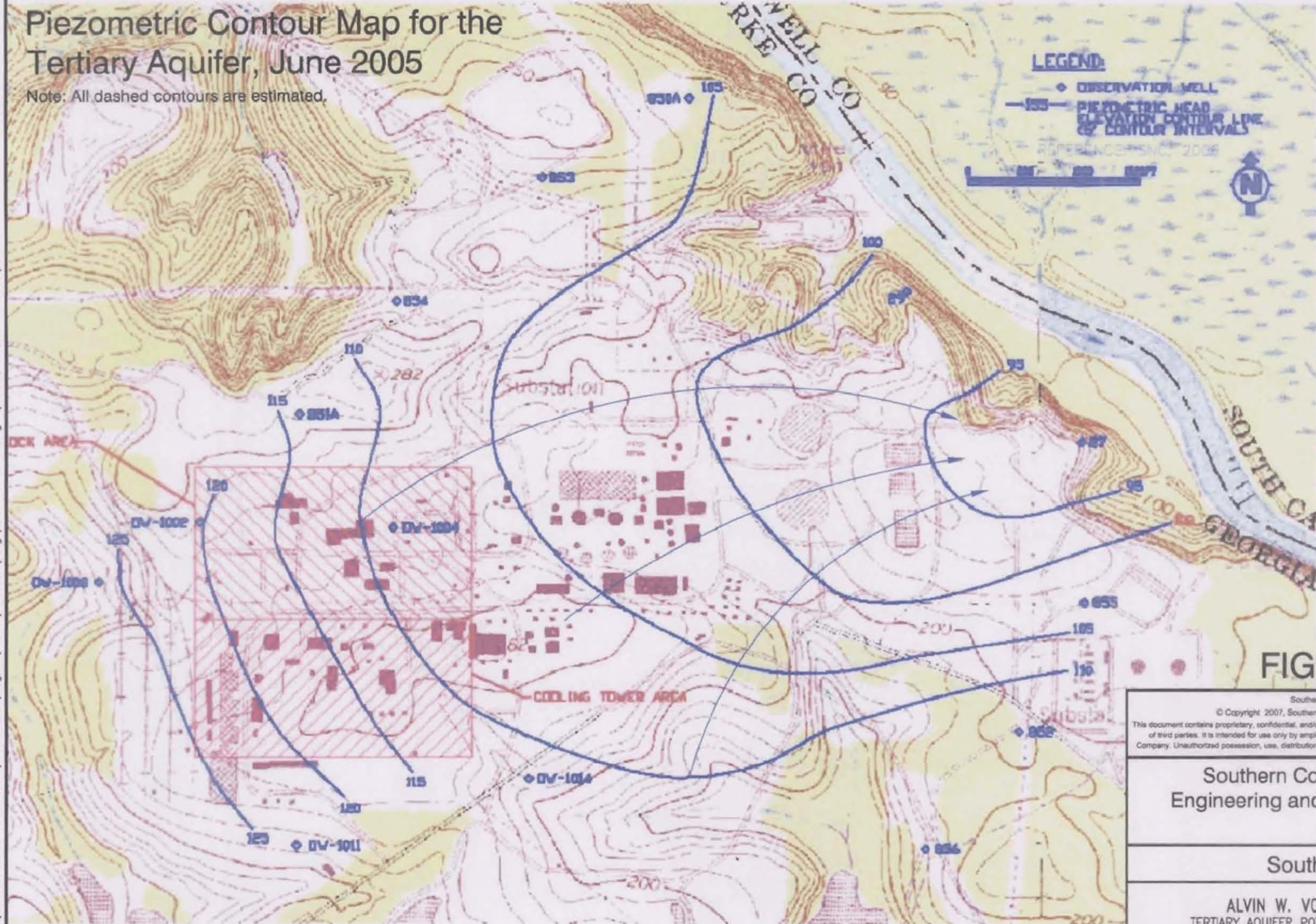

FIGURE 3-6

Southern Company Generation Engineering and Construction Services

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ALVIN W. VOGTLE NUCLEAR PLANT
TERTIARY AQUIFER POTENTIOMETRIC SURFACE AND FLOW DIRECTIONS IN THE POWER BLOCK AREA FOR JUNE 2005

SCALE	PROJ I.D.	DRAWING NUMBER	SH	CONT'D
NONE		ES1537S3-6	1	FINAL

ANSI B: 17x11 Acad2006
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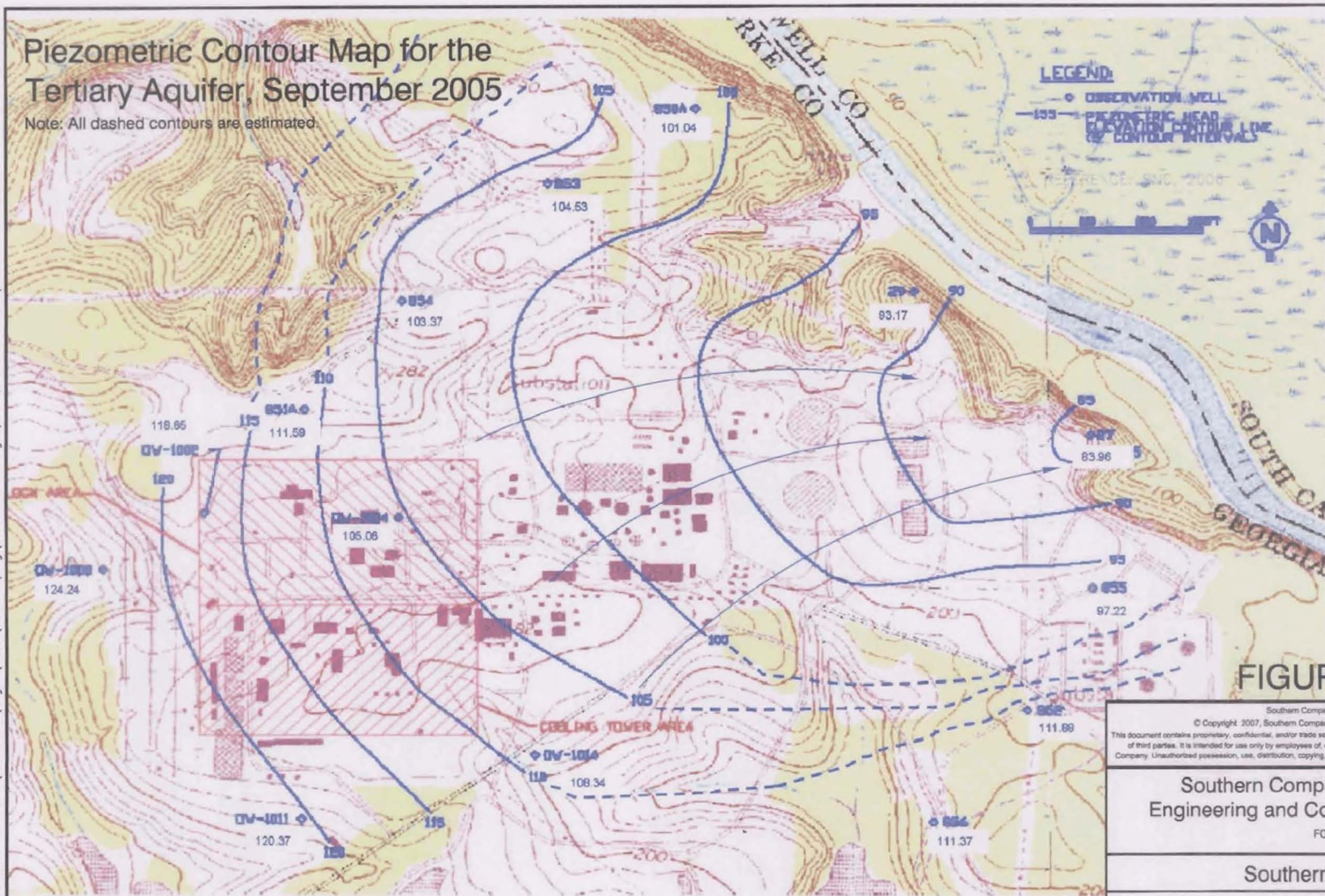

FIGURE 3-7

Southern Company Generation
Engineering and Construction Services

FOR

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ALVIN W. VOGTLE NUCLEAR PLANT
TERTIARY AQUIFER POTENTIOMETRIC SURFACE AND FLOW DIRECTIONS IN THE POWER BLOCK AREA FOR SEPTEMBER 2005

SCALE	PROJ I.D.	DRAWING NUMBER	SH	CONT'D
NONE		ES1537S3-7	1	FINAL

ANSI B: 17x11 Acad2006
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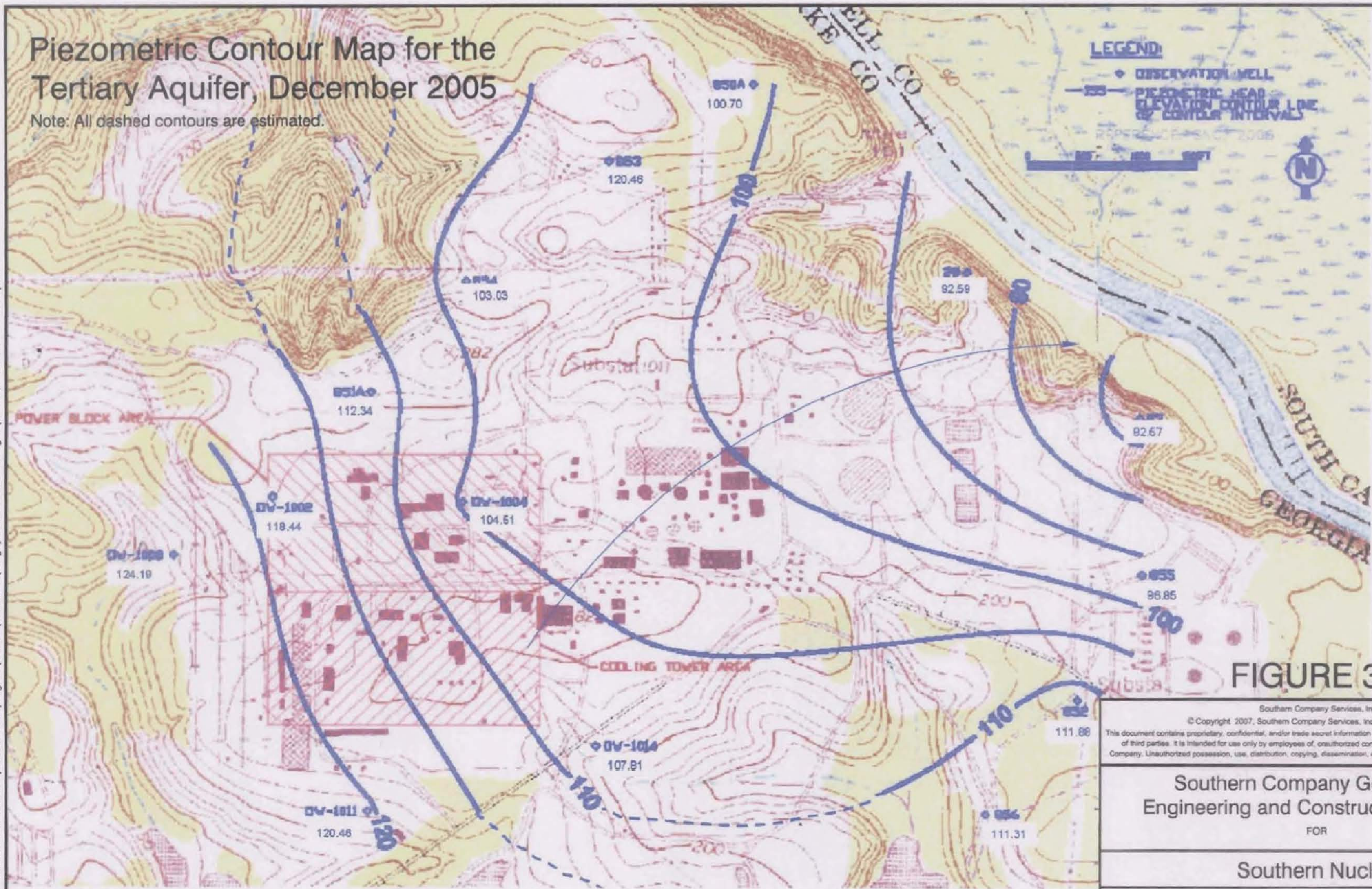

FIGURE 3-8

Southern Company Generation
Engineering and Construction Services
FOR
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ALVIN W. VOGTLE NUCLEAR PLANT
TERTIARY AQUIFER POTENTIOMETRIC SURFACE AND FLOW DIRECTIONS IN THE POWER BLOCK AREA FOR DECEMBER 2005

SCALE	PROJ I.D.	DRAWING NUMBER	SH	CONT'D
NONE		ES1537S3-8	1	FINAL

ANSI B: 17x11 Acad2006
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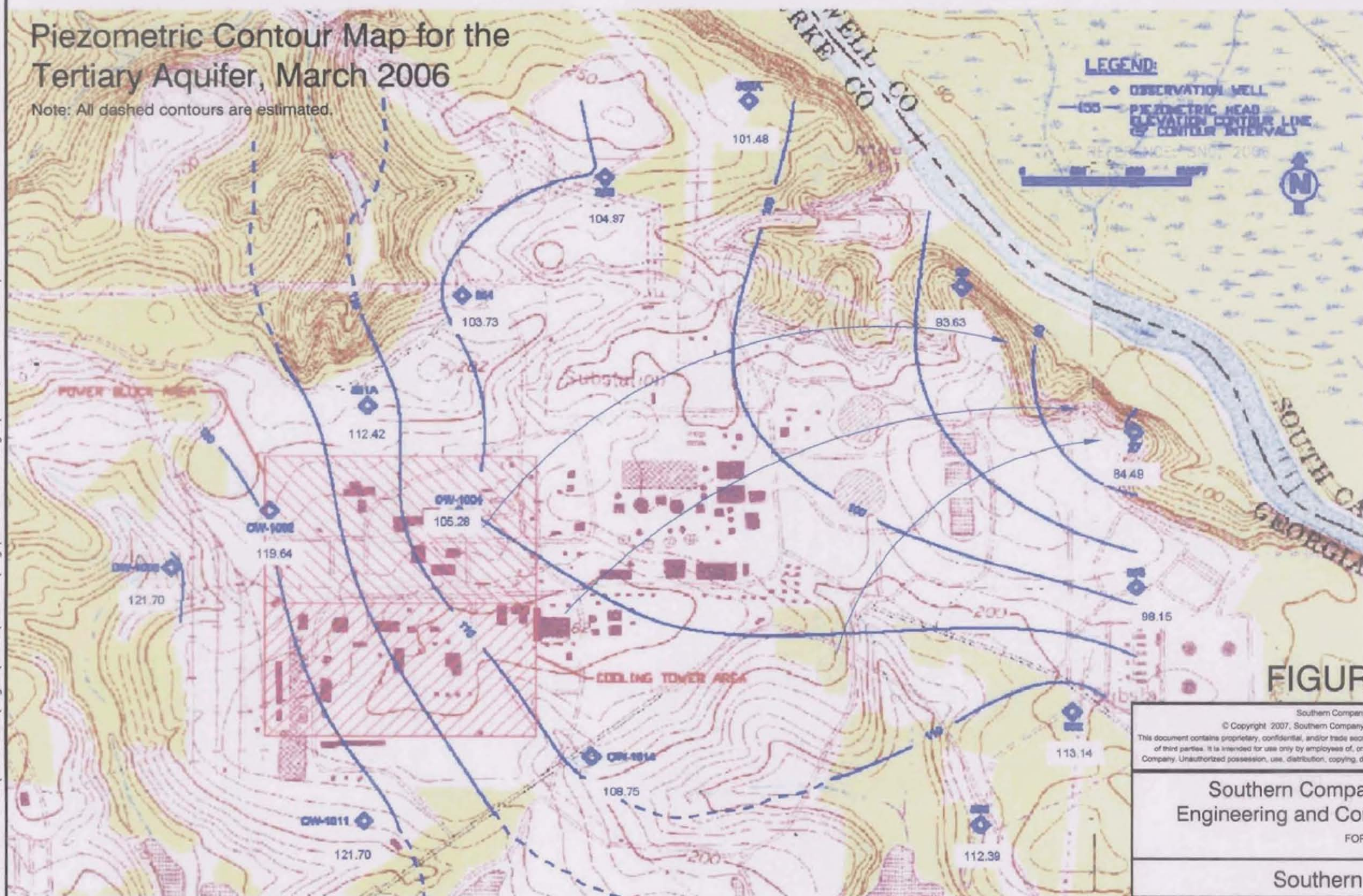

FIGURE 3-9

Southern Company Generation
Engineering and Construction Services
FOR
Southern Nuclear

ALVIN W. VOGTLE NUCLEAR PLANT
TERTIARY AQUIFER POTENTIOMETRIC SURFACE AND FLOW DIRECTIONS IN THE POWER BLOCK AREA FOR MARCH 2006

SCALE	PROJ I.D.	DRAWING NUMBER	SH	CONT'D
NONE		ES1537S3-9	1	FINAL

ANSI B: 17x11 Acad2006
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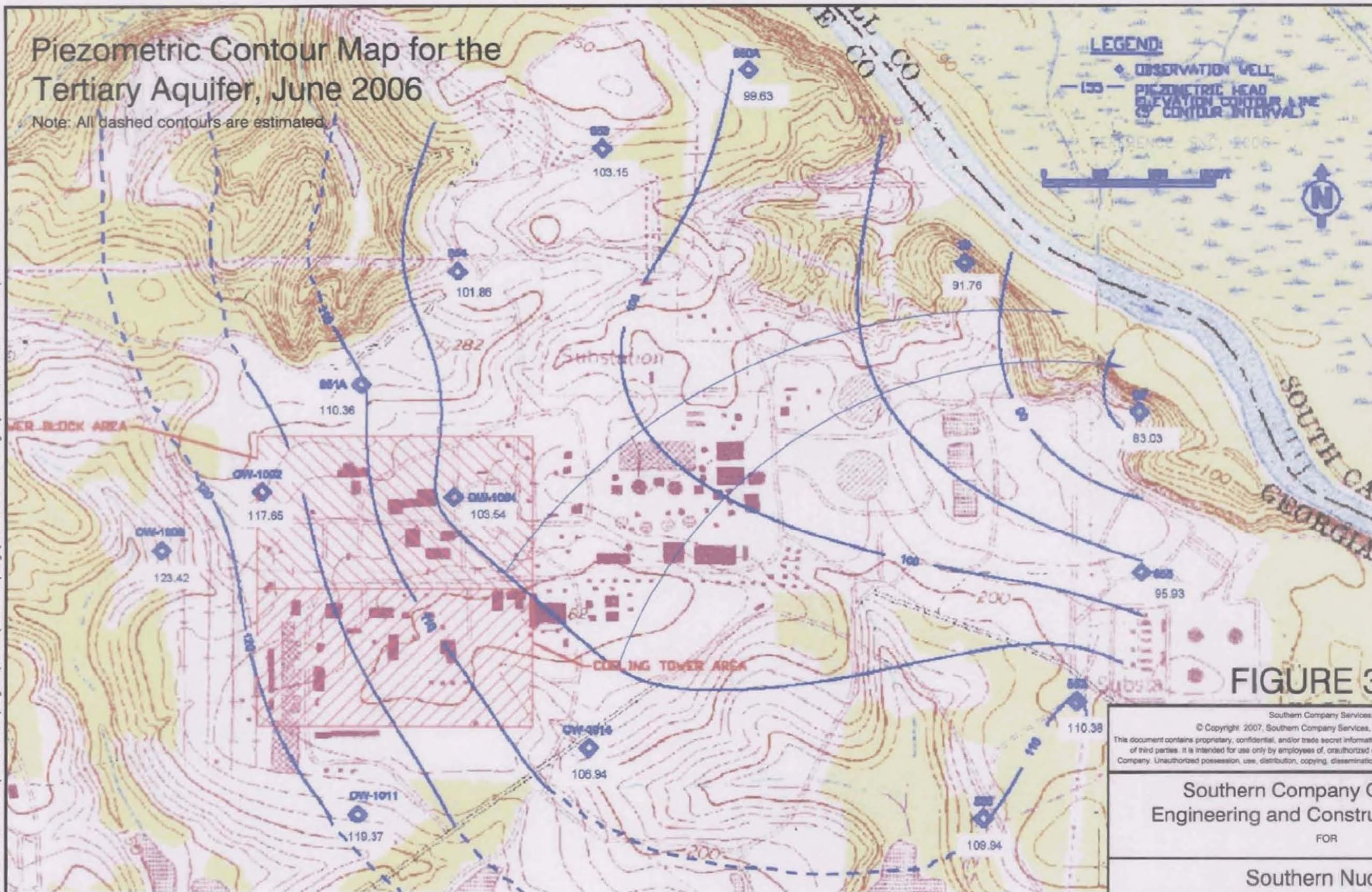

FIGURE 3-10

Southern Company Generation
Engineering and Construction Services
FOR

Southern Nuclear

ALVIN W. VOGTLE NUCLEAR PLANT
TERTIARY AQUIFER POTENTIOMETRIC SURFACE AND FLOW DIRECTIONS IN THE POWER BLOCK AREA FOR JUNE 2006

SCALE	PROJ I.D.	DRAWING NUMBER	SH	CONT'D
NONE		ES1537S3-10	1	FINAL

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ANSI B: 17x11 Acad2006
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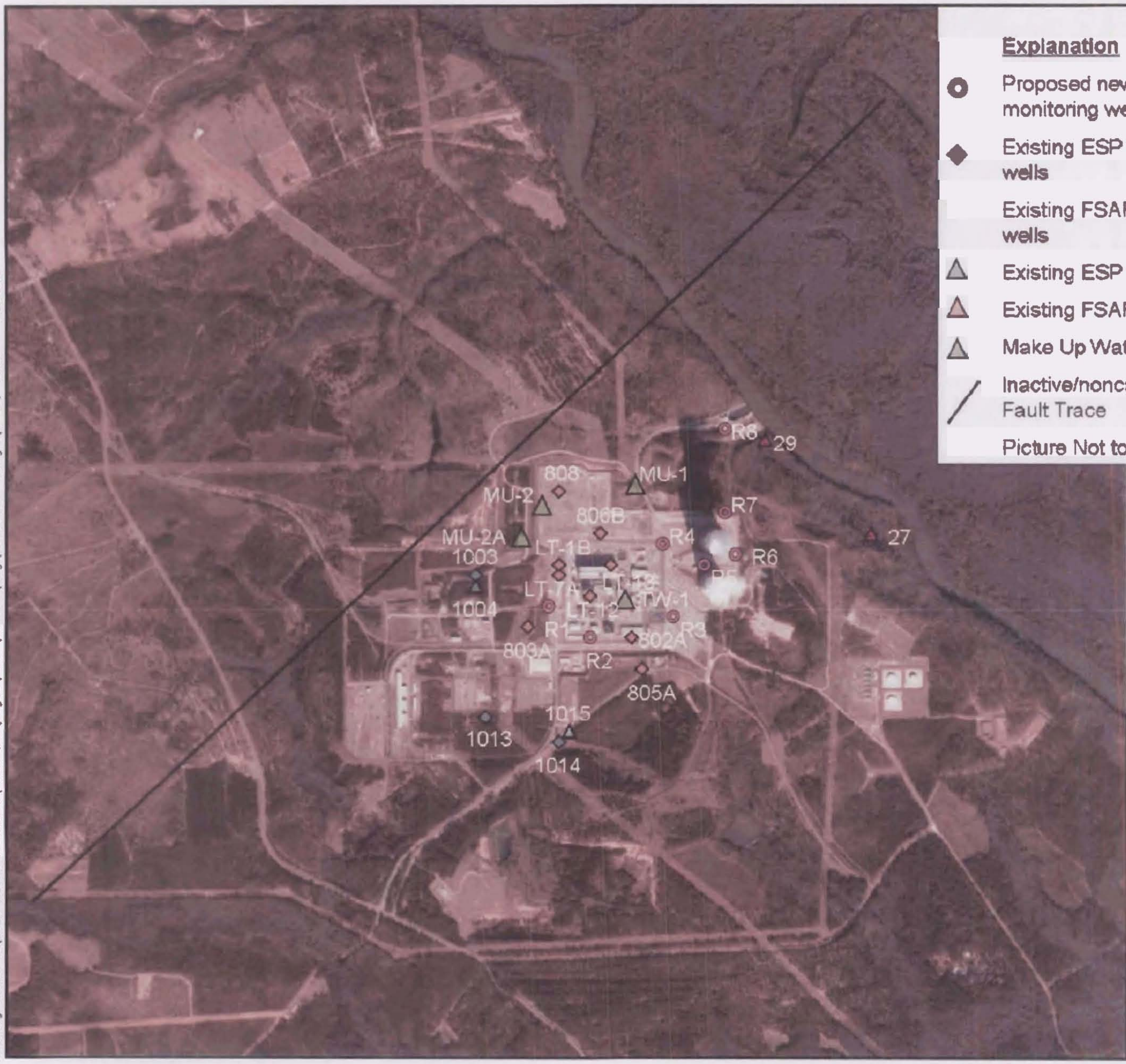

Explanation

- Proposed new radionuclide monitoring wells
- Existing ESP Water Table aquifer wells
- Existing FSAR Water Table aquifer wells
- Existing ESP Tertiary aquifer wells
- Existing FSAR Tertiary aquifer wells
- Make Up Water Wells
- Inactive/noncapable Pen Branch Fault Trace

Picture Not to Scale

FIGURE 4-1

Southern Company Generation
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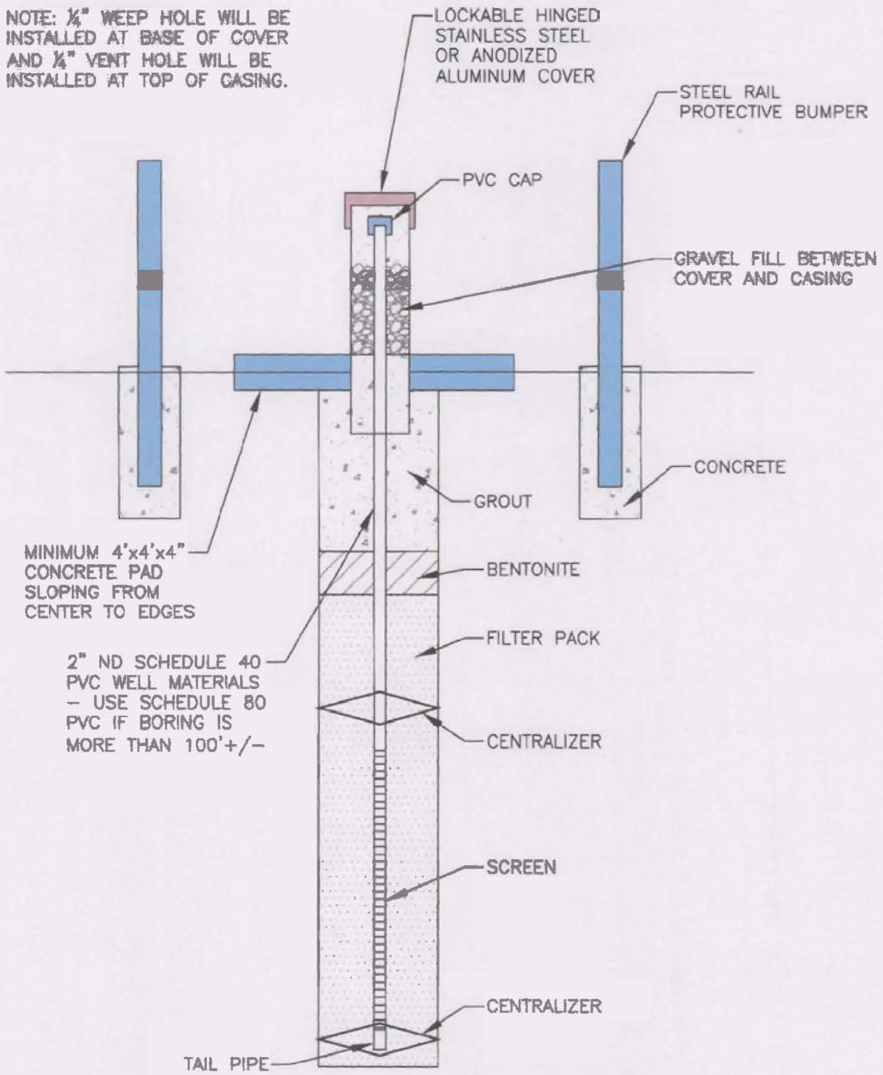
ALVIN W. VOGTLE NUCLEAR PLANT
GROUNDWATER MONITORING WELL NETWORK SHOWING
EXISTING AND PLANNED WELLS

SCALE	PROJ I.D.	DRAWING NUMBER	SH	CONT'D	
NONE		ES1537S4-1	1	FINAL	



NOT TO SCALE

FIGURE 4-2

Southern Company Generation
Engineering and Construction Services
FOR
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ALVIN W. VOGTLE NUCLEAR PLANT
CONCEPTUAL WELL CONSTRUCTION DETAILS

SCALE	PROJ I.D.	DRAWING NUMBER	SH	CONT'D
NONE		ES1537S4-2	1	FINAL

ANSI B: 17x11 Acad2006
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