Geological Interpretation of the Structure and Stratigraphy of the A/M Area, Savannah River Site, South Carolina

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DOE Contract No. DE-AC09-96SR18500

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Upper Three Runs Watershed
A/M Area Advanced Geological Study
Part 3 of 3

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and Stratigraphy of the A/M Area,
Savannah River Site, South Carolina (U)

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Part 1

Investigation on the Combined Use of Ground Penetrating Radar, Cone Penetrometer and High Resolution Seismic Data for Near Surface and Vadose Zone Characterization in the A/M Area of the Savannah River Site, South Carolina (U)

Part 2

Interpretation of Geological Correlation Borings 1, 2, 3 in the A/M Area of the Savannah River Site, South Carolina (U)

Part 3

Geological Interpretation of the Structure and Stratigraphy of the A/M Area, Savannah River Site, South Carolina (U)

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EXECUTIVE SUMMARY

The geological interpretation of the structure and stratigraphy of the A/M Area was undertaken in order to evaluate the effects of deeper Cretaceous aged geological strata and structure on shallower Tertiary horizons. The shallow horizons are often involved in environmental issues. Additionally, this study attempted to evaluate the nature, extent, affects and timing of regional faults that have affected the area.

This interpretation was completed by combining 87 existing cone penetrometer tests, 10 new cone penetrometer tests, 234 existing boring and geophysical log locations and 21 new geophysical log locations with 22 km of new high resolution seismic data, 27 km of existing data and a 275 m by 350 m 3-D seismic grid. Horizon information and fault intervals were interpreted from the seismic data and combined into a database with stratigraphic picks from the geophysical logs and cone penetrometers. Regional deep boring correlations were made using the geophysical logs to constrain the seismic horizon identification. Seismic horizon to stratigraphic interval correlations were made from sonic information derived from geophysical logging.

This study interpreted four major, crystalline basement involved faults. The apparent oldest regional fault trends NNE and is identified as the Crackerneck Fault. Three parallel (younger?) faults trend north. The westernmost fault is identified as the MWESTA Fault and the easternmost fault as the Steed Pond Fault. The central fault intersects the Crackerneck Fault and is identified as the Lost Lake Fault. These faults are not thought to be single breaks in all areas but linear zones of disruption. These faults are thought to be predominantly reverse faults with possible dip-slip, or minor strike slip motion.

At least three episodes (and possibly more) of faulting are observed in the data, 1) Mesozoic, probably Jurassic to Triassic in age, faulting in the crystalline basement rocks, 2) post-Cretaceous aged faulting that disrupted the entire Cretaceous sediment column and 3) Paleocene or later faulting that disrupted younger sediments. These younger structures trend to the NW and occur in an en-echelon pattern. This pattern may affect strata to near surface or surface horizons.

The stratigraphic information for the deeper horizons is limited due to the limited number of deep geophysical logs tied to the seismic information. However, a comparison of regional deep logs and seismic data confirm the near shore, fluvial to deltaic depositional character of the deeper A/M Area sediments.

INTRODUCTION

The A/M Combined Geological and Geophysical Program was organized to provide a comprehensive correlation capability between existing geological information, newly acquired geological core, advanced borehole geophysical data, surface high resolution reflection seismic information and ground penetrating radar data within the greater A and M Areas of the Savannah River Site. Specifically, the locations for all borings, seismic, cone penetrometer and ground penetrating radar data were chosen to maximize correlation to existing or newly acquired data and to compliment existing or ongoing environmental programs. This report presents an integration of new and advanced data with existing information combined into a comprehensive picture of the deep subsurface geology of the A/M Area. The area of investigation is defined on Figure 1. The location of the seismic lines and deep borings is shown on Figure 2.

The A/M Advanced Geological Study was a joint effort supported by several organizations and agencies. Funding for the program was provided through the WSRC Environmental Restoration Department and administered by WSRC Site Geotechnical Services. Drilling and field oversight was provided by the US Geological Survey through an inter-agency agreement administered through DOE-SRS Environmental Division. All field work was coordinated through WSRC Site Geotechnical Services. Additional subcontract services were provided as follows: drilling by EM&TC, Inc., core descriptions by SAIC, field support and coordination by Bechtel Savannah River, Inc., and Raytheon. Core geochemical sampling was provided by Microseeps, Inc. Core from the upper 150 feet of each boring was split with half sent to Rutgers University for detailed soils and transport analysis as part of the DOE-HQ FERC program. Borehole geophysical data were acquired by Schlumberger Wireline Services, Inc, and Western-Atlas Wireline, Inc. Additional well logging was provided by Graves Logging Services. Downhole acoustic suspension logging was acquired in GCB-1 and GCB-2 by Agbabian and Associates. Surface seismic information was obtained and processed by the Earth Sciences and Resources Institute of the University of South Carolina. Palynological data and additional core analysis were provided by the Department of Geological Science of Clemson University. Ground Penetrating Radar data for the GCB program were acquired and processed by Microseeps, Inc. All data analysis, interpretation and correlation is provided by WSRC, Site Geotechnical Services.

Data and interpretations from the A/M Advanced Geological Study are presented in three separate reports, two of which are references for this document:

- Investigation on the Combined Use of Ground Penetrating Radar, Cone Penetrometer and High Resolution Seismic Data for Near Surface and Vadose Zone Characterization in the A.M Area of the Savannah River Site (U), WSRC-RP-97-0184, and
- Interpretation of Geological Correlation Borings 1,2,3 in the A/M Area of the Savannah River Site, South Carolina (U), WSRC-RP-97-0185.

This report utilizes seismic and deep borehole geophysical data to characterize the pre-Tertiary strata. Tertiary maps are made as a comparison to Aadland's (1997) work and as a tie to his interpretations. Aadland's work was completed using a manual interpretation and mapping approach.

APPROACH TO INTERPRETATION

The general process for geological correlation within the A/M Area follows a basement to surface "bottoms up" depositional and lithostratigraphic approach. For deeper strata, the interpretation of geophysical log well ties are made to seismic reflection events and are used to establish base correlation horizons. For shallower strata, older geophysical logs and core are correlated with advanced geophysical logs and core from the GCB-1,2,3 borings to establish type lithostratigraphic locations. Activities defining the general approach are described in order:

- Install borings, obtain and analyze core, and geophysically log GCB-1, GCB-2 and GCB-3. Obtain spectral gamma logs in additional A/M deep cased wells P8R, P6R, P9R and from deep boring MMP-4SB.
- Acquire and process A/M seismic data.
- Correlate GCB's to existing basement boreholes using geophysical logs, core data, field description of core, Type Well picks and Aadland (1997) picks.
- Establish synthetic seismic data from GCB wells correlated to lithologic picks from core and geophysical log horizons.
- Correlate seismic horizons to GCB lithologic picks. Establish fault and structure trends through the area based on seismic offsets in the basement. Establish principal lithostratigraphic horizons on seismic and geophysical logs.

Figure 1. General study area. Colors represent the surface exposure of various geological formations. Tu is the Upland unit, Ttr is the Tobacco Road Formation. Tdb is the Dry Branch Formation. Tm is the McBean Formation. Qal1 and Qal1 represent Quaternary alluvial fill material, with the numbers representing relative ages of deposition. Grid coordinates are in UTM. Roads are noted as thin black lines. The heavy black line defines the area of data used for this study. Geology is from Prowell (1994).

- Correlate existing A/M well data picks to lithostratigraphic picks in the GCB borings.
- Incorporate CPT data into well grid. Correlate shallowest interpretable horizon to well picks.
- Incorporate geophysical data from new shallow environmental borings to fill data gaps
- Generate combined correlation maps based on interpretable seismic horizons and geophysical logs. Establish basement structural trends based on seismic offsets.
- Combine maps with structure into a three dimensional A/M data volume.
- Develop and present cross-sections through the data volume.
- Interpret data.

SOURCES OF INFORMATION

Nine high resolution reflection seismic lines were obtained to support deep mapping. The location of these lines are shown on Figure 2. In addition to these lines, three existing regional seismic lines were also utilized. These location of these lines are also shown on Figure 2.

Field data were acquired using an OYO DAS-1 signal enhancement seismograph operating in 96 channel mode. 40 Hz OYO geophones were used in geophone strings having 3 phones per string. The energy source consisted of an IVI MiniVIBE® remotely triggered vibrator sweeping from 50 to 200 Hz. In general, an asymmetric split spread acquisition geometry (24-gap-72 spread) was utilized, with shot and geophone spacings of 1.5 and 3.1 meters depending on the seismic line.

The following processing sequence was applied to the data: reformat SEG-2 field files to SEG-Y format, apply vibroseis whitening, F-K filter, predictive deconvolution, bandpass filter, trace edit, crooked line sort, statics, bulk velocity shift, velocity analysis, residual statics, apply normal moveout, stack, bandpass filter, trace amplitude balance, apply AGC.

Figure 2. Location of seismic lines and deep correlation wells and borings used in the study. Red lines are the seismic lines and the well or boring locations are labeled. Data are superimposed on surface geology (from Figure 1).

The dominant frequency from the high resolution survey is approximately 120 Hertz. The highest frequencies observed were approximately 200 Hertz. Based on the frequencies available, it was possible to discern horizons approximately 4 meters in thickness. Features that were thin, or sporadic, may have been imaged in some cases, but were not interpreted in this study.

Velocity logs from GCB-1 and 2, and from P8R and P9R, were used to construct synthetic seismic sections tied to stratigraphic horizons. The synthetic seismic section from GCB-1 tied to seismic line A-5 is shown in figure 3. Using the synthetic seismic ties, it was possible to identify specific reflection horizons on the seismic lines as specific defined stratigraphic horizons. The crystalline basement reflector, Top of Cape Fear Formation, Top of Middendorf Formation, and in some cases, the McQueen Branch Confining Unit were interpretable. These surfaces represent regional unconformities or eustasy related sequence boundaries and generally represent an acoustic impedance zone detectable by the seismic technique. In only a few cases were shallower horizons interpretable.

BACKGROUND GEOLOGY

Figure 4 is the generalized stratigraphic column for the Savannah River Site region. The depositional environments and sediment character for GCB-1, located in the center of the study area and thought to be representative, are shown on Figure 5. A detailed discussion of the stratigraphy and deposition is found in Fallow and Price (1995) and Aadland et al., (1995). Parts 1 and 2 of the Advanced A/M Geology Study (Wyatt et al., 1997 a and b) discuss the data derived from the ground penetrating radar, cone penetrometers and the geophysical characterization of borings GCB-1,2 and 3.

A conceptual model of the anticipated geology in the region of the A/M Area provides an intellectual framework to interpret the borehole geophysical and seismic data. The basic model should be consistent with known regional geology as described in established scientific literature. As data are evaluated against the model, an iterative thought process will allow features to be interpreted within the framework, or will suggest that modifications need to be made in the model. If there are highly unusual features that violate the character of the anticipated geology within the model, then a data "bust" may be indicated, or new information may be present to advance the known geology within the area.

Figure 3. Stratigraphic chart representing the sediments within the A/M Study Area. Data are from Aadland et al. (1995)

GCB-1

Figure 4. Combined interpretation of GCB-1. Stratigraphic picks are from the correlation of GCB-1,2 and 3 to regional horizons. Depositional environments are interpreted from the geophysical log signatures, field core descriptions and core laboratory data. Hydrostratigraphy is from Aadland et al., (1995). Stratigraphy and chronostratigraphy are from Aadland et al. (1995), Fallaw and Price, (1995) and DNAG, 1983. Palynology is from Christopher (personal communication).

The conceptual model of the anticipated deposition environment within the A/M Area is a near shore to delta plain environment. Therefore, sediments associated with a near shore deltaic, fluvial and near shore marine are anticipated. Variations in facies architecture associated with depositional processes in these environments are also anticipated. Facies architecture variations include "fining upwards" or "coarsening upwards" sedimentary sequences in a transgressive-regressive system. Sediments associated with near shore, littoral zone and beach environments may be highly variable both laterally and vertically. The model assumes that depositional sequences within the area are consistent with those published by Fallaw and Price (1995) and anticipates the regional unconformities present in these sequences to also be present in the area.

Structural features within the area are assumed to be consistent with the known post depositional regional stress fields. The presence of the Crackerneck Fault as defined in Stephenson and Stieve (1992) is also assumed. Any subsequent faulting within the area is assumed to be consistent with the Crackerneck Fault or associated with the post depositional stress fields. The conceptual model assumes no preferred age restrictions on structural features. The presence of faults, fractures and folds are anticipated.

The description of the sediments encountered in GCB-1 and described on Figure 5 verifies the basic conceptual model.

INTERPRETATION

Geophysical logs and core data from shallow borings and wells are the dominant source of data within the A/M Area. Few borings penetrate depths greater than 100m (330 feet) and most logs terminate within the Lang Syne/Sawdust Landing Formation and are too shallow for direct correlation with the seismic information. To allow for direct correlation with the higher quality information from the deep borings, the geophysical logs and core data from the shallow wells were tied to the stratigraphy determined from the deeper borings. The correlation of the shallow borings is discussed in Aadland (1997). The stratigraphic picks from the shallow borings, deep borings and CPT's are tabled in Appendix A.

Cone penetrometer soundings generally extend to depths of approximately 50m (150 feet) or approximately to the top of the Warley Hill Formation and occasionally reach the "green clay" bed within the formation. The Friction Ratio's from the cone penetrometer data were correlated with the geophysical logs from the shallow borings. Figure 6 is a correlation panel showing the

correlation of the deep borings with shallow borings and the cone penetrometer data.

Interpretation of Deep Correlation Borings

The deep correlation borings used to calibrate the seismic data are GCB-1, 2, 3 and P8R, P9R, MMP-4-SB and MBC08ASB. The locations for these boring are shown on Figure 2. The interpretations of borings GCB-1, 2, and 3 are discussed in Part 2 of this series (WSRC-RP-97-0185). The stratigraphic horizons from GCB-1, 2, 3 were used to correlate the horizons from P8R, P9R, MMP-4-SB and MBC08ASB. The geophysical data from all of these borings (except MCB08ASB) are calibrated to international standards and were used to correlate and verify all geophysical logs within the A/M Area. Data were correlated using TerraSciences® petrophysical software. Figure C-1 is a structural correlation panel showing the stratigraphic horizons for these deep correlation wells. This panel is flattened on an elevation of 97m (300 feet) relative to mean sea level. The stratigraphic horizons are those utilized to map specific intervals within the study area. In general, only the Late Cretaceous horizons are visible on the seismic data.

The figure C-1 correlation panel follows no particular strike or trend except that P8R, GCB-1 and P9R are in the central portion of the A/M Area with P8R being more westerly, GCB-2 is in the southeastern area, MMP-4SB and GCB-3 are in the eastern area and MCB08ASB is in the northern area. Therefore, the correlation panel proceeds from the west central portion of the study area southeastward, westward and then to the north. These logs are used only to evaluate the relationship of the stratigraphic units across the study area.

This panel demonstrates several interesting features. All horizons, except the McQueen Branch Confining Unit, from MCB08ASB in the north to P8R in the southwest, show the southerly basinal dip. There are offsets in crystalline basement, particularly associated with GCB-3, P9R and GCB-1, that are continuous through to the Lang Syne/Sawdust Landing unconformity. In GCB-3 and MCB08ASB the regional structure does not track as well as in the wells to the south and west and it is possible that there is another erosion event beveling the structure prior to the Lang Syne/Sawdust Landing event, and probably occurring at the Cretaceous/Tertiary boundary. In well P8R, the structure reverses from a general downward sense of motion to an upward sense of motion in the lower Black Creek Formation. It is possible that well P8R cuts a reverse fault in the Middendorf/Black Creek intervals. This is supported from historic anecdotal evidence that the lower intervals of well P8R are deviated along a fault plane.

The Middendorf, Black Creek (including McQueen Branch Confining Unit) and Steel Creek Formations (generally, the entire Cretaceous section) are fairly uniform in thickness across the area. The Middendorf thins (or the Cape Fear may be missing) in P9R suggesting that the upwards motion noted in basement was present and either erosion or non-deposition occurred during Middendorf time. The upper Black Creek also thins suggesting reactivation of the upward sense of motion during Black Creek time.

The Steel Creek thins in GCB-3 suggesting erosion or non-deposition at this location during or in post Steel Creek time. The overall thickness of the Steel Creek to Lang Syne/Sawdust Landing interval including the clays of the early Paleocene, may be described as a transitional strata. The Lang Syne/Sawdust Landing shows only minimal effects from the underlying structure (on the order of 3 to 4 meters). The basement related structures show approximately 30 to 40 meters of relief.

The Congaree and Warley Hill Formations are fairly uniform in thickness. The sag seen in the Warley Hill in GCB-3 is contrary to regional dip and is probably associated with the basement structure. The sag seen in GCB-1 may also be associated with a basement related structure. The interval from the Santee unconformity to the Warley Hill unconformity is generally uniform but thickens in GCB-1. The Santee surface is also a cut and fill surface and suggests that the motion documented in GCB-1 was not active in post-Santee time.

Figures C-2 through C-6 are a series of the regional correlation panel flattened on the stratigraphic horizons. These cross-sections allow for an evaluation of depositional style to be made for each stratigraphic unit. Figure C-2 is flattened on the Cape Fear Formation. Flattening on this horizon has the effect of removing much of the basement related structural influence from the panel. As seen in the figure, the basement horizon shows only regional dip from north (MCB08ASB) to the southwest in GCB-1 and P8R. The Middendorf is uniform except for the thinning over the P9R (or missing Cape Fear) and GCB-1 area. The depositional sequences in the middle Middendorf appear to be more clay rich in GCB-3 and MMP-4SB, both in the southeastern portion of the study area. Distinctive sand packages are present throughout the Middendorf. Most are thin bedded but the upper Middendorf (upper 30 meters) varies from a shoaling to a fining upwards unit. The lower Middendorf generally consists of two sand units that are coarsening upwards to sheet sands, that begin to "shale out" or become more clay-rich basinward. It appears as though the lower sand units are missing in P9R (or the Cape Fear may be missing). The depositional pattern of the Middendorf is

consistent with a near shore, marine sequence. There is no geophysical log evidence of subaerial exposure within the Middendorf.

Figure C-3 is flattened on the McQueen Branch unit within the Black Creek Formation. The McQueen Branch is a predominantly clayey unit and may represent a maximum flooding surface. The unit is generally thicker and massive to the north and east and splits into two distinctive clay units separated by an intervening sand unit. The lower clay unit becomes dominant to the north while the upper clay unit merges with the lower unit or shoals out. This may suggest a highstand, retreat and highstand scenario on the local to regional level. The McQueen Branch unit tends to thin over the basement high associated with the P9R area. This interval may be the sequence boundary between the Campanian and Maestrichtian.

The lower Black Creek Formation, between the basal McQueen Branch Confining Unit and the top of the Middendorf thickens basinward by approximately 5 meters. The lower Black Creek generally has more clay in the basal zone and is sandier in the upper zone. This is true for all deep borings except P8R where faulting may affect the section. The depositional character of the lower Black Creek is very similar to the underlying Middendorf. It is possible to track specific sand units only on local scales.

Figure C-4 flattens on the top Black Creek/contact with basal Steel Creek. The upper Black Creek thins to the southwest or basinward. The thinning may be a localized effect caused by the locally uplifted strata. Sandy sediments are more dominant over the structure suggesting a more near shore, localized environment. Interspersed clays are present to the north and east. It may be possible to track Black Creek sand units on localized scales.

Figure C-5 is flattened on the top of Steel Creek Formation. The Steel Creek thickens in GCB-2 and MMP-4-SB by 3 to 4 meters, both to the south and east within a basement involved trough. The formation thins over a basement structural high in GCB-3 but only slightly (about 1 m) over the GCB-1 and P9R high. The sediment fill in the trough is generally a sand, which is missing over the GCB-3 structure. Distinctive sand packages may be mappable within this formation and appear to be consistent through several regional wells. This horizon may be the local Paleocene/Cretaceous contact (the K/T boundary).

Figure C-6 is flattened on the Lang Syne/Sawdust Landing unconformity and is very similar to the original correlation figure C-1. With regional dip removed at this unconformity, the additional sediment fill within the Steel Creek in the GCB-2 and MMP-4-SB areas is obvious. The Cretaceous aged structural

influence is also present. The formation(s) become more clayey basinward (south and east) with little or no clay present in the north.

The characteristics of the sediments above the Lang Syne/Sawdust Landing are discussed in Aadland (1997).

Interpretation of Seismic Data

The seismic data were interpreted using the LandMark® software system according to the following approach. Each processed seismic line was plotted on the regional map with associated deep correlation borings. Available borehole sonic data from the deep borings, (from GCB-1, 2, 3, P8R, P9R and MMP-4-SB), were utilized to generate a synthetic seismic image, using the GMA® seismic software, for the area adjacent to the borehole. The synthetic seismogram ties well derived stratigraphic horizons to specific seismic horizons and allows for the interpretation and tracking of stratigraphy and structure across a seismic profile. Figure 3 is the synthetic seismogram from GCB-1.

The synthetic seismogram for each well was correlated with the adjacent seismic profiles. Horizons on the seismic profile that were correlative with the synthetic well tie were traced across the profile. In general the crystalline basement reflector (rock), the Cape Fear/Middendorf contact (top Cape Fear), the basal Black Creek/Middendorf contact (top Middendorf), and McQueen Branch Confining Unit horizons were interpretable stratigraphic events. The Lang Syne/Sawdust Landing intervals were not consistently discernible across the seismic data. In a few areas, the Warley Hill interval appeared to be interpretable, however this occurred too sporadically to map. In general, no shallower horizons were obviously interpretable on the seismic data. Figures B-1 through B-14 show the seismic data with stratigraphic horizons and faults interpreted.

Stratigraphic horizons were traced from well tie points following dominant seismic amplitude events. In areas where the horizons were difficult to track, no interpretations were made. In many cases, one stratigraphic horizon may be interpretable while others were not. The two way travel time values for each seismic shotpoint with an interpreted horizon were tracked, converted to depth based on the synthetic seismograms, and transferred to EarthVision 4.0® for mapping.

Faulted intervals were determined using the criteria of Sheriff (1982) and Campbell (1965) and include: 1) abrupt reflector terminations, 2) direct fault

Figure 5. Synthetic seismogram and tie to seismic data. Sonic and density data from GCB-1 were used to calculate the synthetic seismogram. Traces from seismic lines A-5 and CNF-1, adjacent to GCB-1, were used for correlation. The synthetic data have been phase shifted by 300°. Key stratigraphic horizons, identifiable on the seismic data, have been defined.

plane reflections, 3) presence of diffractions especially at a termination, 4) visible drag and rollover, 5) correlations of reflectors across a fault plane and possibly 6) loss of coherency beneath a fault plane or distorted dips seen through the fault plane (fault shadow). Using these criteria, faults were defined on the seismic profiles in LandMark® and transferred into EarthVision® for mapping.

It is probable that channels and other depositional features exist within the A/M Area and are imaged on the seismic data. However, the channels or other features are not highlighted on the seismic data and are not discussed in detail in this document because they will require a more intense interpretive effort using seismic signal attribute data (such as instantaneous frequency and phase). If obvious channels are observed in the data, then they are mentioned. The criteria used to define a channel are discussed in Reineck and Singh (1980) and include: 1) an obvious, incised erosional surface, 2) the presence of cross-bedding, 3) presence of point bar sequences, 4) an apparent thalweg, and 5) alternating sand/clay/gravel bars.

As noted on Figure 3, the synthetic and measured seismic response is generally associated with changes in density of approximately 0.2 g/cc². However, this does not account for all seismic events seen in the A/M data. Figure 7 shows a series of ternary plots comparing GCB-1 core and geophysical log parameters as possible attributes seen in the seismic data. On this figure, the density and sonic values (Dens and Dt, respectively) are compared against other parameters. These data have been normalized, therefore values near the center of the diagrams are not thought to be unique. Linear trends in the data are suggestive of progressive increases of density with depth (due to burial) and are not thought to be relative to seismic impedance events. There seems to be a positive correlation for many values of high porosity (Nphi) relative to density and sonic. There appears to be no consistent correlation with gamma ray values, resistivity, or percent thorium and uranium (as indicators of clay type). There may be a possible correlation with the Photoelectric log (PEF) suggesting that high density, high PEF (higher PEF values may mean more carbonate, anhydrite or heavy minerals are present) may have a seismic effect.

Figures 7 compare density and gamma ray values with porosity and the relative amounts of thorium and uranium. There appears to be no correlation in these data that may affect the seismic signal. Based on these ternary plots, and ignoring changes in sonic versus density values, porosity appears to affect the seismic data and may be reflected in the seismic sections.

Figure 6. Correlation of shallow cone penetrometer data to deep data. This correlation was used to compare the deep borehole stratigraphic pick data, from Figure A-1, to all of the shallow borings in the A/M Area (Appendix A). The shallow mapped horizons in Figures D-1 to D-x utilize these data.

Figure 7. Ternary diagrams from GCB-1 comparing possible seismic responses. "Dens" is density, "DT" is sonic delta-t, "NPHI" is neutron porosity, "GR" is gamma ray, "AHT90" is deep induction resistivity, "THOR" is thorium in ppm, "URAN" is uranium in ppm, and "PEF" is photoelectric factor.

Individual 2-D Seismic Line Interpretations

Seismic data are shown on figures B-2 through B-14 and the overall pattern of seismic coverage is shown on figure B-1. Figure B-1 also shows the relative seismic depths in time and the trend of the major faults in the area.

All seismic data are interpreted for faulting and stratigraphic horizon markers, as determined from the synthetic seismic data shown on figure 3. For all lines, the yellow horizon represents the top of "rock" or the surface of the unweathered Paleozoic crystalline basement. The dark red horizon marker is the contact of the Cape Fear Formation (Coniacian/Turonian, 90 mybp) with the overlying Middendorf Formation. The pink horizon is top of the Middendorf Formation (Campanian/Santonian, 82 mybp) or contact with the overlying Black Creek Formation, a regional unconformity. The orange horizon is the top of the confining unit or clay package that has been designated as the McQueen Branch Confining Unit (Aadland et al., 1995). This horizon lies within the Black Creek Formation and may represent the Campanian/Maestrichtian contact, another major unconformity. These four Cretaceous aged horizons appear consistently on all of the data and are used as the principal subsurface horizons for seismic mapping.

On all seismic lines, only five possible faults are shown. Faults, and projection lines, designated in red refer to the Crackerneck Fault (CNF). Faults in green refer to the MWESTA Fault and faults in pink refer to the Lost Lake Fault. Fault segments in orange refer to the Steed Pond Fault. Yellow fault segments are faults with no assigned orientation or name. These faults may have limited extent, may be associated with a named fault, or their extent may not be determined from our seismic coverage. The angle of the fault segments posted on each seismic line is somewhat arbitrary since our data were not designed to image structure below the crystalline surface.

Seismic lines SRS-1, SRS-7, and SRS-12 are regional lines acquired in 1987. Lines CNF-1 and CNF-2 were obtained to help map the CNF system for regional implications and are high resolution data. Lines A-1 through A-5 were obtained to aid in mapping the subsurface associated with the M-Area plume remediation efforts and are also high resolution data. Line MCB-1 was acquired to evaluate the shallow structure and stratigraphy associated with the Miscellaneous Chemical Basin waste unit and to evaluate the use of very high resolution acquisition with a vibroseis source. Each seismic line is interpreted.

SRS-1

Line SRS-1 is shown on figure B-2. This approximate north-south line is the definitive data for the existence of the CNF, shown as a red line. Regional dip from this data is southerly at approximately 1.5%. The vertical offset in the CNF is approximately 12 ms two way time (TWT), or 30 to 35 meters, on the basement horizon. The horizontal extent of the offset is across two shotpoints or approximately 35 meters. Compensating faults, or more recent faults, associated with the CNF, are shown in yellow. These faults may accommodate the stresses associated with the CNF. The northwestern fault (in yellow) is associated with the green dashed line which is the projection of the AMWESTA fault, therefore, these two faults are probably the same. The fault noted in pink to the southeast of the CNF is the Lost Lake Fault and the dashed pink lines are the projections of this fault through the area from other seismic data. The basement reflector, in yellow is consistently tracked by the dark red Cape Fear marker horizon except immediately northwest of the CNF where there is an apparent increase in thickness of the Cape Fear, or where there may be remnant Triassic trough sediments. The pink horizon is the Middendorf Formation contact with the Black Creek Formation. Over the faulted intervals, it is difficult to track a consistent horizon and disturbed or eroded sediments are seen. The orange McQueen Branch horizon demonstrates a fault propagation fold geometry. Folded and flexed sediments are apparent from the McQueen Branch to approximately 100 ms, although these events are not traceable across the data. The overall sediment wedge thickness appears to increase to the southeast as expected. Changes in amplitude laterally along horizons to the southeast, particularly in the lower Black Creek, may indicate the stratigraphic or facies changes associated with shallow channeling, other near shore or fluvial processes. This line intersects five of the A/M lines CNF-1, A-3, A-1A, A-2 and SRS-7. In all cases, the interpreted horizons match those from the other lines and the data are consistently tied.

SRS-12

Line SRS-12 is shown on figure B-3. This northeast to southwest line shows the regional coastal plain dip to the south-southwest. Minor undulations are apparent in the basement horizon and all four regional faults are present (refer to Figure B-1). The projection of the CNF coincides with the CNF fault segment defined on this line. The Cape Fear horizon tracks the basement horizon and has been faulted near the CNF. The Lost Lake Fault is now westward of the CNF implying that the Lost lake Fault is younger and has crossed the CNF (possibly implying strike-slip motion). It appears as though the Middendorf and McQueen Branch thin across the flexural high between shotpoints 100 and 200. The Middendorf and McQueen Branch horizons are not consistently evident across the data and only those intervals associated

with and confirmed by Line CNF-2, which crosses these data, were chosen. Flexural changes, associated with the major faults, are seen in the marked horizons. Many of these flexural events prograde upward through the section. There may be a splay fault from the Lost Lake fault near shotpoint 360 also implying a shear motion. There are no obvious depositional features seen in the data.

SRS-7

Line SRS-7 is shown on figure B-4. Obvious north to south regional dip is highlighted by the yellow basement horizon. Zones of dip reversal in the basement horizon are associated with the Lost Lake (pink) and Steed Pond Faults (orange). A complex series of unassigned faults, near the intersection of line SRS-4, defines a major basement structural feature. The Cape Fear and Middendorf horizons track the basement dip but both formations increase in thickness basinward. The interval between the Middendorf and top of the McQueen Branch appears to thin basinward, or has been eroded on the anticline associated with the Lost Lake fault. There are thickened sediments, possible shoaling and channeling, and erosional truncations present between shotpoints 1300 and 1100, and over the Lost Lake flexure. This suggests that a transition zone exists adjacent to well P6R (projected into the seismic line) and downgradient from the study area. The splay associated with the Lost Lake Fault, and seen on line SRS-12, may be present here as well.

CNF-1

High resolution line CNF-1 is shown on figure B-5 and intersects eight of the A/M seismic lines. The yellow basement horizon is traceable across the data and indicates the presence of the MWESTA (green), CNF (red) and Lost Lake (pink) Faults. Projections of the MWESTA and Lost Lake faults, from the regional seismic lines, are also shown. Small unassigned faults west of the MWESTA Fault are present. The frequency content of this line is higher than lines SRS-12, 1 and 7, therefore specific horizon definition is greater. The Cape Fear is traceable across the data while the Middendorf horizon becomes ambivalent westward. The McQueen Branch horizon is not discernible across the westward portion of the line. The marked horizons agree with the stratigraphic tops picked from the geophysical data in wells GCB-1 and P9R. Generally, reflection events shallower than 200 milliseconds are chaotic and difficult to interpret because these data were designed to image the crystalline basement. Coherent seismic events in the shallower section are suggested but are difficult to distinguish from the noise. Therefore these events are not tracked across the data. There are bar and channel sand depositional features seen in the lower Black Creek and possible Middendorf formations. It is thought on these data that the increased

coherence of reflection events between 100 and 250 ms and between lines SRS-1 and A-3 may suggest the presence of more clay in the section.

CNF-2

Line CNF-2 is shown on figure B-6 and forms the northern tie and boundary for the A/M Area study. Coherent basement, Cape Fear, Middendorf and McQueen Branch horizons are traceable across the length of the section. The overall quality of the reflection events is greater in these data, probably because the surface geology was more conducive to seismic investigation. The CNF, Steed Pond and Lost Lake Faults are present, as are four unassigned fault intervals. The CNF, Steed Pond and Lost Lake faults have confirming projections present as well. It is important to note that the Lost Lake Fault is now westward of the CNF implying that the Lost Lake Fault has crossed the CNF and therefore represents younger deformation (it is possible that the sense of motion was transferred across one pre-existing joint zone to a parallel joint zone, resulting in the cross-over fault pattern, J. Bartholomew, personal communication). Good seismic ties to geophysical data exist at borings GCB-3 and MMP-4-SB (P30TA). For the major faults, there are possible angled reflection events within the crystalline basement that may be associated with deeper seated root faults that sole into deeper detachment zones. The overall notable feature on the line is the arch or domiform structure, bounded by the unassigned faults SE of P30TA and the Lost Lake Fault to the NW. The CNF is subparallel to the Lost Lake Fault. This structure is persistent upwards through the section to at least the Lang Syne/Sawdust Landing horizon. The overall thicknesses of the Middendorf and lower Black Creek (below the McQueen Branch unit) increase to the SE while the overall thickness of the Cape Fear appears to remain constant. Therefore, the domiform structure is post depositional to the McQueen Branch unit. The depocenter for the Cretaceous aged sediments appears to be to the SE. Channeling is noted within the lower Black Creek adjacent to shotpoints 500 to 600. Erosional truncation, evidenced by angled and termination reflectors, is seen NW of the CNF for all defined stratal horizons, suggesting that this area has been historically higher, or more landward.

A-1A

Line A-1A is shown on figure B-7. Line A-1A transects boring GCB-1 and has definitive ties to stratigraphic intervals defined in the boring. Only the Lost Lake Fault is seen in these data because the seismic traverse is approximately parallel and immediately overlying the strike of the fault. The unassigned fault segments in the data are all probably images of the fault. The similarity of the unassigned segments between shotpoints 400 and 500 and between shotpoint 600 and line A-5 suggest that these are the same feature, a fact further supported by the broad projection lines for the Lost

Lake. Therefore all of the faults on this line are associated with the Lost Lake Fault system. The anticlinal nature of the Lost Lake Fault structure appears to prograde upwards through the Lang Syne/Sawdust Landing intervals at shotpoint 600 and a possible Crouch Branch Confining Unit horizon is seen. This line is approximately due north and south but the overall sense of dip on the basement horizon is reversed, dipping northward. The entire length of this line is apparently influenced by the structure associated with the CNF and Lost Lake Fault intersection. There are several channels apparent in the data within the Middendorf and lower Black Creek sections.

A-1B

Line A-1B is shown on figure B-8. This seismic line transects the Lost Lake Fault more acutely and defines a noticeable fault geometry. The overall offset of the fault at basement is approximately 25 to 30 meters and a classic fault-propagation fold geometry is observed. These data may be interpreted through the Cretaceous section. The anticlinal, possibly upthrown block, disturbs sediments to at least the Lang Syne/Sawdust Landing unconformity. The synclinal trough is observable through the Black Creek Formation. Channeling and possible bar sequences are also seen in the Black Creek. It is interesting to note that the Cape Fear thins southwest of the Lost Lake Fault. Several small channels are observable within the data. This line is a NE to SW trending transect and a gentle regional dip to the SE is noted.

A-2

Line A-2 is a north to south trending transect and is shown on figure B-9. This line follows approximate regional Cretaceous dip and generally has all defined horizons present. Regional dip on the crystalline horizon is approximately 40 ms over 3500 meters or 1%. Coherent reflection events are present through the Cretaceous section but are not continuously present across the Tertiary portion of the data, and are therefore, not interpreted. An unassigned fault is seen in the data near the intersection with line A-5. This may be a conjugate fault associated with the nearby Lost Lake Fault, or a compensating fault between the Steed Pond and Lost Lake Fault zones (refer to Figure B-1). Overall Cretaceous sediment thickness remains constant across the data and downdip depositional thickening is not seen. This may suggest that the dip of the basement is associated with post-Cretaceous events. Erosional truncation is evident over the unassigned fault for sediments in the lower Black Creek and channel and bar sequences are noticeable across the remaining Black Creek and Middendorf sections. It is possible that the Paleocene and younger sediments are thickening to the south.

A-3

Line A-3 is shown on figure B-10. This NE to SW line follows basement dip and has approximately 65 ms (TWT) of dip over 3500 meters, or 1.5%. Basement "rock", Cape Fear and Middendorf horizons are defined but it was not possible to uniquely define the McQueen Branch horizon based on well or seismic ties, therefore, it is not shown. On this line, the CNF and Lost Lake Fault coincide near the NE end of the line. The unassigned faults near this juncture are probably associated with the intense deformation adjacent to this intersection. An intensely fractured zone is present near the intersection of A-3 and the CNF-1 seismic line. This zone is up on the NE and may offset horizons to approximately the Lang Syne/Sawdust Landing unconformity. Coherent reflection events are domed above this interval to horizons shallower than the Congaree which may suggest faulting occurred at least until the Santee unconformity time (Bartonian, 43 mybp). This faulted zone may be associated with the MWESTA fault (shown in green) and the projection of the fault from other seismic data. There is a general thickening of the Cretaceous to the SW and numerous small depositional features (shingling and bar sands) and disturbed sediments are seen. There may be a time sequence boundary within the Black Creek interval that is interpretable across the section and that is probably associated with the McQueen Branch or Campanian/Maastrichtian contact.

A-4

Line A-4 is a NE to SW trending line parallel to line A-3. It is shown on figure B-11. Regional dip is similar to line A-3 and a thickening of the lower Black Creek Formation is seen. The MWESTA Fault is assigned near the projection of well P8R but minimal offset is seen probably due to the oblique intersection of the seismic line and the fault trend. Reflection events are generally parallel, however, depositional features are present.

A-5

Line A-5 is generally perpendicular to lines A-1 through A-4 and was obtained as a basinal strike tie line. It is shown on figure B-12. All faults except the Steed Pond, and all defined horizons are interpretable on these data. This line defines a southeastward basement dip and the Cape Fear, Middendorf and lower Black Creek appear to thicken in this direction. The CNF is crossed approximately perpendicularly and the basement offset of 30 to 35 meters, similar to line SRS-1, is noted. The fault propagation fold geometry across the CNF is obvious and sediments are disturbed across the anticline to at least the Lang Syne/Sawdust Landing unconformity. The MWESTA Fault is offset in the basement reflector but apparently does not disturb shallower sediments, however, the unassigned fault NW of the MWESTA and possibly part of the MWESTA Fault zone does disturb sediments shallower than the

McQueen Branch. The Lost Lake Fault shows minimal disturbance on this line as it is projected through the transect, however, the unassigned fault NW of the Lost Lake Fault may be the expression of this fault in this seismic line. The overall sense of motion is appropriate for this to be the case. Depositional features similar to the other lines are noted.

MCB-1

Line MCB-1 is shown on figure B-13. These data were obtained using a higher resolution acquisition geometry and were acquired to evaluate the shallow structure and stratigraphy associated with the Miscellaneous Chemical Basin waste unit. Generally, the results from this line were disappointing with the amount of noise present interfering with coherent events. It is possible to interpret horizons as tied with lines A-5 and A-1A intersect the MCB-1 transect. A possible fault is interpreted between shotpoints 300 and 400 which coincides with the projected Lost Lake Fault. The shallow coherent horizons at approximately 100 ms are thought to be the Warley Hill, "green clay" horizon but there is no borehole seismic data to confirm this possibility. General dip is to the southwest.

3-Dimensional Data

A three dimensional seismic survey was obtained immediately southeast of line MCB-1. Results are shown in figure B-14. The rectangular cube was obtained over a surface area of approximately 275 meters by 352 meters using 120 cross-lines and 154 inlines with a 2.2 meter spacing (a 2.2 meter bin size). An IVI MiniVibe vibratory source was used. In general, best results were obtained from 200 ms and deeper. Little to no data were interpretable above 200 ms.

Figure B-14 shows time slices, in relative amplitude, through the data cube. Each time slice has the time and stratigraphic interval noted. The projection and strike of the Lost Lake Fault, with relative sense of motion, which is projected through the area from the 2-D seismic lines, is included for reference. The 325 ms time slice corresponds to the approximate top of "rock" or crystalline basement. A pronounced negative amplitude (purple) feature is seen in the southeastern portion of the cube, surrounded by a higher amplitude event. This low amplitude feature is the same low amplitude feature seen surrounding the heart shaped high amplitude feature seen in the 320 ms time slice (approximately 20 meters shallower). Therefore, the low amplitude event is higher by 5 ms and has the same approximate sense of motion as the Lost Lake Fault predicts. At 340 ms, approximately 40 meters below the top of "rock", the trend of the Lost Lake Fault bisects a phase change (of about 180°) event presumed to be the same for the shallower

horizons. It is not evident that this relationship exists upwards through the cube, although there are notable changes across the projected strike of the Lost Lake Fault. The features that trend northwest to southeast in the 260 and 270 ms time slices may be faults at oblique angles to the main basement trend. This is supported in the time slices at 256 and 260 ms. The NW-SE trending high amplitude reflector in the eastern central portion of the cube in slice 260 ms is the same high, but weak, reflector in the central west portion of the cube, between inlines 40 and 60 of time slice 256 ms. This implies a general up to the west sense of motion, however, the trend of the features is oblique to the trend of the Lost Lake Fault. It is interesting to note that the trend of these features parallel the NW to SE trending sides of the high amplitude basement feature seen in the 320 and 325 ms time slices. This suggests that the basement trend of the Lost Lake Fault zone is NE to SW but individual faults within the zone may be parallel or synthetic/antithetic to the basement trend. This also suggests that individual basement fault blocks may be small in size along the fault zone (approximately 150 by 150 meters in the case of the high amplitude feature in the basement). It is not evident how far the fault extends into basement on the 500 ms time slice. These data are basically random and out of the range of the seismic investigation.

It should also be noted that there are linear, amplitude coherency events in the 3-D data. These features are often associated with structural features such as fault cuts, and are also associated with sedimentary features such as channel boundaries. Within the useable 3-D data, there are no obvious channel features or unique facies changes, although it is possible that there are facies changes associated with the slopes of the faulted blocks. The trend of the low amplitude events in time slice 256 ms, for example, may be interpreted as a channel meander, however, inline evaluation suggests that the reflection event is structurally controlled. The lack of channels and definitive structures is probably a function of the small size of the 3-D cube and the representative subsurface sampled.

DISCUSSION

Mapping

Seismic horizon picks, converted from time to depth using the synthetic information from GCB-1, GCB-3, P8R and P9R were combined with the stratigraphic picks from the geophysical logs and CPT's to create the database for mapping. Mappable horizons from the seismic data include the acoustic crystalline basement ("rock"), Cape Fear, Middendorf and McQueen Branch surfaces. In a few cases the Black Creek horizon was observable but these were too sporadic to adequately map. Data were forced, using a static

shift and velocity/depth corrections, to match actual depths from the deep correlation borings. The data from each horizon were then mapped. For the seismically derived horizons, the projected major fault planes (MWESTA, CNF, Lost Lake and Steed Pond) were included in the mapping database and used to constrain contours adjacent to the faults. Each mapped surface is discussed.

Stratigraphic intervals from shallower horizons were determined using geophysical log response and core correlation. The previous intervals from the work of Aadland (1997) were reviewed and modified according to the regional deep boring correlations. Stratigraphic picks from available cone penetrometer data were combined with new and existing information. These stratigraphic "picks" were incorporated into Earth Vision® 4.0 for mapping. Shallow mapped horizons include the top of Black Creek Fm., top of Steel Creek Fm., Lang Syne/Sawdust Landing unconformity, and Warley Hill unconformity. A surface elevation map is included for discussion.

Top of Crystalline Basement ("rock")

Figure D-1 is the surface of the crystalline basement. The dominant faults projected through the area and seen on figure B-1 are shown. It is obvious that the area in the center of the map is complexly disturbed. The area between the Steed Pond Fault (most eastern fault) and the Crackerneck Fault is structurally higher than areas east and west. Deeper basement is to the southwest and westward of the CNF and MWESTA faults. The overall maximum structural elevation change across the area is approximately 70 meters. Regional dip is to the southeast. Structure and dip on the northwest, northern, northeast and southeast, and possibly the southwest edges of the map are influenced by map edge gridding affects and are extrapolations of data.

Top of Cape Fear Formation

The surface of the Cape Fear Formation is shown on Figure D-2. Although the same map edge affects are present as in the basement map, the general trend of the data are similar. The deeper basin is to the west southwest in these data and the structural high through the center of the study area associated with the CNF and Lost Lake Fault is present. The Cape Fear is basically draped over the basement structure and has smoothed many of the minor structural perturbations found on the basement map by infilling. However, the formation is offset by faulting. The structural change across the area on the Cape Fear is also approximately 70 meters, suggesting that much of the structure is post Cape Fear in age. Basinward dip is to the west southwest. The depositional character is not obvious on this map, although sediments primarily associated with structurally lower areas east of the

central high are present. It is probable that this area has been lowered structurally, but it is also possible that there was a trough or flow passage through the area as well.

Top of Middendorf Formation

The structural top of the Middendorf Formation is shown on figure D-3. The central structure is present with an overall elevation change across the area of approximately 50 meters. Generally the formation dips to the south. The structural effects of the Crackerneck and Steed Pond Faults are immediately obvious. Map edge effects are great, particularly the steep structural change to the north between the Crackerneck and Steed Pond Faults. A ramp like structure may be present from the central high eastward to the Steed Pond Fault. Structure is more complex west of the Crackerneck/Lost Lake Faults.

Top of McQueen Branch Unit

The top of the McQueen Branch unit is shown on figure D-4. This map is different than the underlying Middendorf in that the regional dip appears to be dominantly to the southeast. Structural elevation change across the area is approximately 20 meters and is represented by a monocline or dip reversal flexure across the regional faults. Minimal effects are seen from the MWESTA and Steed Pond Faults. More convoluted structure is seen associated with the CNF and Lost Lake Faults, particularly in the area of the greatest seismic data density in the center of the map. The gridding edge effects are great in the northern portion of this map.

Top of Steel Creek Formation

The top of the Steel Creek Formation is shown on figure D-5 and is generated from borehole geophysical data. These values are the same as those used in the manually contoured maps of Aadland (1997). The shallower faulting on the surface of the Cretaceous from Aadland (1997) is shown on the maps for reference and may be affecting the depositional pattern. Few borings penetrated the Steel Creek horizon within the area and most are centrally located, therefore the edge effects on this map are large. There are few regional faulting effects seen in the map except for the convoluted structure adjacent to the CNF and Lost Lake Faults. Between the time of deposition of the McQueen Branch unit and Steel Creek Formation, there was a large near shore marine depositional influence across the area. Thick marine sands were deposited in the upper Black Creek Formation, and a regional unconformity or disconformity at the top of the Black Creek-contact with basal Steel Creek has smoothed the surface. A regional unconformity, the possible Cretaceous/Tertiary boundary global erosion event has further planed the Steel Creek surface.

Surface of the Lang Syne/ Sawdust Landing Unconformity

The top of the Lang Syne/Sawdust Landing Formation is shown on figure D-6. This map was also created using the same data as Aadland (1997). The northwest to southeast trending structures may be associated with shear reactivation along the CNF and Lost Lake Faults (shown on this and subsequent maps for trend information). There are thickness variation in the Lang Syne/Sawdust Landing sediments across the area that appear to be related to older structure on the surface of the Steel Creek Formation. The trend of the structural features is oblique to the strike of the regional faulting. Deformation extent may be restricted by the bounding AMWESTA and Steed Pond Faults. The initial timing of this oblique faulting/folding is observed in the structural map of the Steel Creek Formation, therefore it is assumed that the timing of the reactivation is post-Ypresian. The change in structural elevation across the features is approximately 12 meters as compared with approximately 14 to 16 meters at Steel Creek time. It is not known whether the structure is accommodated by folding or faulting but the abrupt elevation change in some areas may suggest faulting while the less abrupt changes may suggest folding. The en-echelon, periodic character of the structural events (high, low, high, low, high) occurring approximately every 1000 meters, is strong evidence for structural control. A current dominated near shore sand depositional character is not thought to be the cause of the en-echelon pattern because the features are along dip into the basin and not along margin strike.

Surface of the Warley Hill Unconformity

The surface of the Warley Hill unconformity is shown on figure D-7 and is similar to the Lang Syne/Sawdust Landing surface. The structural influences of the underlying formations are still present but have been muted in character by sediment in-filling of the Congaree Formation. The net structural elevation change across the area is approximately 8 to 10 meters. The rate of structural change is generally more subdued than on the surface of the Lang Syne/Sawdust Landing except for the area adjacent to the Lost Lake Fault trend.

Figure D-8 is the surface topography. This map is included to show the regional basement fault trend lines as they relate to the present surface. One important observation is the continuance of the local structural high in the center of the study area. The approximate north to south trend of the buried high seen in the Warley Hill and Lang Syne/Sawdust Landing maps (figures D-6 and D-7) is present on the modern surface. The en-echelon pattern seen in the Lang Syne/Sawdust Landing map may also be present. The net structural elevation change across the present surface is approximately 45 meters because erosion has cut through the underlying Tobacco Road/Dry

Branch Formations and through the Santee unconformity. Aadland (1997) discusses the structure and stratigraphy of the shallower sediments.

Faulting and Structure

The four major faults, interpreted from the seismic data, are accompanied by several smaller, unassigned faults. It is possible that many of the unassigned faults may be correlated together and form additional fault systems, possibly those of Aadland (1997). It is also probable that many of the smaller fault are basement splays from the regional faults and that the larger faults are the primary offsets in a complex fault system. However, it is not possible, without additional data, to confirm these alignments. Many of the unassigned faults have significant offsets, or have complex structures, and may be important to shallower horizons, however, additional data are required to examine this possibility in detail.

The oldest fault thought to affect the A/M Area is the CNF. This fault trends approximately N35E across the study area and may extend an indeterminate distance to the SSW and NNE. This fault shows reverse motion and is generally up on the SE and down on the NW. The amount of throw on crystalline basement varies from approximately 30 to 35 meters maximum to approximately 10 meters minimum within the study area. The angle of the fault is generally greater than 60° from horizontal. The CNF follows a propagation fold model (Cumbest and Wyatt, 1997) and disturbs sediments through the Warley Hill Formation. It is possible that horizons shallower than the Warley Hill are influenced but this is difficult to determine from the seismic data or borehole mapping. The correlation of CPT, GPR and high resolution seismic data from Part 1 of this study (Wyatt, et al., 1997, WSRC-RP-97-0184) suggests that there are near surface structural influences, however, it is not clear that the shallow effects are from the CNF. They may possibly be from later faulting.

On seismic lines SRS-1 and A-5 (figures B-2 and B-12 respectively), which cross the fault perpendicularly, a synclinal trough is noted in the footwall block. An additional sediment fill is seen in the trough suggesting that either syndeposition was occurring during pre-Cape Fear compressional faulting (Coniacian/Turonian?, 90 mybp) or that the CNF is a re-activated Mesozoic normal fault with a depositional remnant in the down warped interval associated with the extensional event (Triassic/Jurassic/early Cretaceous, > 90 mybp?).

A schematic of the fault propagation model similar to the CNF is shown on Figure 8 along with an actual seismic schematic of the CNF from line SRS-1.

The comparison between these two figures is obvious although the seismic schematic does not demonstrate any fore limb thickening of sediments except possibly in the Lang Syne or Warley Hill intervals. The lack of sediment thickening may be from the high angle of the CNF and unconsolidated nature of the sediments above the axis.

The Lost Lake Fault is thought to be younger than the CNF because it apparently intersects and disturbs the CNF near the northern end of seismic line A-3 (refer to figure B-1). Because of the conjugate nature of the Steed Pond and MWESTA faults to the Lost Lake Fault, they are thought to also be younger than the CNF, and approximately the same age as the Lost Lake. These faults trend approximately N10E, and within the study area, only the Lost Lake Fault intersects the CNF. To the southwest, and beyond the study area, the MWESTA Fault may also intersect the CNF.

The MWESTA, Lost Lake and Steed Pond Faults were grouped because they generally exhibited the same relative sense of motion, along linear trends, throughout the study area. However, the relative sense of motion may vary along these faults because of shear displacement. On many of the mapped horizons, the sense of offset varies along these faults and between faults. At the McQueen Branch Confining Unit (Figure D-4) for example, the Steed Pond and MWESTA Faults appear to have a left lateral offset while the Lost Lake may have more of a right lateral motion. The Lost Lake Fault is projected through the high resolution seismic line MCB-1 on Figure C-13. On this figure, it is possible that offset exists in the shallow horizons (up on the NE) and that the fault splays into a positive flower structure, indicative of a shear motion.

On Figures D-6 and D-7, the Lang Syne/Sawdust Landing and Warley Hill horizons respectively, the NW/SE trending highs appear to truncate at the MWESTA and Steed Pond Faults. These highs may be flexural folds associated with the differential shear motion between the MWESTA and Steed Pond Faults. The overall sense of motions for the fault zone bounded by the MWESTA and Steed Pond faults would be right lateral. The axial crests of the structural highs appear to be offset by approximately 3000 meters from crest axis to crest axis, which may be a predictive tool for location of additional highs.

Of the MWESTA, Steed Pond and Lost Lake Faults, only the Lost Lake appears to influence shallow sediments. In general, the structural influence from these faults, as derived from the seismic data, appears to diminish above the Middendorf Fm., however, the resolution of the data do not preclude the possibility of shallow deformation. For example, the structural

highs noted on the Warley Hill map (figure D-7) may be associated with these faults but are not resolvable within the frequency of the seismic data¹¹.

On seismic line A1-B (Figure B-8), the Lost Lake Fault may exhibit the greatest displacement. Sediments may be disrupted through the Lang Syne/Sawdust Landing unconformity. A geometry similar to a fault propagation fold is observed but not to the extent of the CNF. There is a possible back splay associated with the fault at this location. On Figure B-13, the Lost Lake Fault is projected through seismic line MCB-1. These seismic data were designed to image shallower strata and the basement offset for the fault is not as obvious as on other lines. The seismic data generally show an upthrown block to the NE similar to Figure B-8, however, the disturbed zone is more complex than imaged on Figure B-8. The fault appears to release its tip stress into a series of fault strands accommodating the relative offset. Fault stranding may be important in groundwater studies as multiple pathways appear to offset the shallow horizons. Figure 9 shows a strike-slip fault motion prograding through shallower sediments, and may schematically indicate the type of structures present.

Assuming that structural influences have affected the topography of various stratigraphic horizons through time, then it should be possible to estimate timing and total displacement of sediments. The effects of erosion are difficult to estimate. Figure 10 is a graph of approximate maximum elevation relief, average, minimum and maximum interval thickness for the stratigraphic horizons. Data were extracted from map figures D-1 through D-6 and Appendix A.

Several observations may be made from this graph. The amount of structural relief on the surface of the crystalline basement is the greatest observed. The structural relief on the Cape Fear and Middendorf Formations exceeds the average and maximum sediment thickness, suggesting post or syndepositional structure dominated during the Mesozoic through Santonian time. The minimum (and average) sediment thickness from the McQueen Branch Confining Unit to the Middendorf (lower Black Creek), and Steel Creek to McQueen Branch (Steel Creek and upper Black Creek), exceeds the overall amount of structural relief on these horizons. This suggests that depositional events predominated over structural events during the Campanian through Maestrichtian time. For the Lang Syne/Sawdust Landing to Steel Creek interval, the structural relief is greater than the minimum sediment thickness and less than the average thickness. This suggests that a combination of structural and depositional events have occurred during the Paleocene. From the Warley Hill to Lang Syne/Sawdust Landing (Lutetian to Ypresian), the sediment thickness exceeds the overall amount of structural

relief available suggesting a dominantly depositional environment. From the present day land surface to the Warley Hill (Bartonian and younger), the average sediment thickness is exceeded by the structural relief but the maximum sediment thickness exceeds the relief. Therefore, this suggests a combination of depositional and structural events.

Based on the data from this graph, it is possible to establish the following series of events: 1) Paleozoic to Coniacian/Turonian: structural events dominant (assumed), 2) Coniacian/Turonian to Santonian: structural events dominant, 3) Campanian to Maestrichtian: depositional events dominant, 4) Paleocene: depositional and structural events, 5) Lutetian to Ypresian depositional events dominant, 6) Bartonian and younger, depositional and structural events.

Stratigraphy

A variety of depositional environments and structural influences have affected the strata within the A/M Area. In general, all sediments within the area may be characterized as near shore marine to fluvial punctuated by submarine or subaerial erosional events. Within formations, the depositional character may change across the area as the environment of deposition changed along slope. Adjacent to faults, the sediment character may vary due to tectonic influences. The regional stratigraphy is discussed in Fallaw and Price (1995), Aadland et al., (1995) and Aadland (1997).

The deep borings and seismic data may be combined to define the lateral variability and character of sediments within a specific formation. The log signatures of the geophysical curves may be used to interpret the depositional sequence or environment relative to formation and depth, particularly for the sand sequences (Busch and Link, 1985, and Serra, 1985). This, in turn, may be associated with an area along a seismic line and further associated over a larger area. Each deep Cretaceous stratigraphic horizon will be discussed. Tertiary strata are discussed in Aadland (1997).

Cape Fear Formation

The Cape Fear Formation varies in thickness across the A/M Area from approximately 6 meters eastward to 12 meters westward. The geophysical log signature is similar in all penetrating borings, therefore the depositional environments are thought to be similar, although no definitive environment may be interpreted from the geophysical data. In general, and referencing the core descriptions in Part 2 (Wyatt et al. 1997, WSRC-RP-97-0185), the formation appears to be a fluvial or shoaling lag deposit with interspersed

sands, cobbles, pebbles, silts and heavy minerals. Aadland (1997) contends believes that the Cape Fear may be missing in well P9R.

The geophysical logs from GCB-1, GCB-3, P8R and MMP-4-SB suggest that the formation may consist of at least two and possibly three shoaling events. Three distinctive lower energy intervals, punctuated by sandy/silty higher energy events are noted in the GCB-1 log. In MMP-4-SB, three events are also noted but have a different character, suggesting a low energy or shoaling (possible heavy mineral) lag, then a higher energy environment, followed by another low energy environment. Since structural relief exceeds depositional thickness, it is possible that the stratigraphic and depositional character of the Cape Fear is dominated by episodic structural events causing periodic shoaling.

The seismic data provide little information on the depositional or stratigraphic character of the Cape Fear. The seismic data does support a thickening of the interval westward but in general, the thickness of the Cape Fear is less than the resolution of the data. Overall, the near source, shoaling environments interpreted for the Cape Fear are consistent with the initial rising sea levels during the Late Cretaceous and suggests that the A/M Area was near shore during this eustatic event.

Middendorf Formation

The Middendorf Formation varies in thickness across the area from approximately 25 meters along a central axis to 35 meters eastward and westward in the area. It is possible to track consistent members through the formation, therefore the thinned areas are apparently caused by erosion. Individual members or beds within the formation alternate between thinly bedded, high frequency, dominantly sands with interspersed clays to thinly bedded, high frequency, dominantly clays with interspersed sands. The varying pattern of sand units from "spikey" to "bell", "funnel" and "serrate" shapes all suggest a bar, bar-finger, delta front sheet sand, depositional environment. The best developed sand units are in GCB-3, PW-113, MMP-4-SB and MBC08ASB, suggesting that the north and west portions of the study area were shoreward during the Middendorf deposition. Neither the sand or clays are well developed in GCB-1, P8R or GCB-2 suggesting an environment with more of a marine influence.

The seismic data suggest that the Middendorf develops a more variable character to the south-southeast. Line SRS-7, an approximate dip line for Middendorf depositional time, shows a more variable character seaward, while having a relatively stable "railroad tracks" character landward or up dip. Seismic line CNF-2, an updip strike line for Middendorf deposition also

displays a "railroad track" appearance while line CNF-1, further down dip, has a more variable character.

Black Creek Formation (including the McQueen Branch Confining Unit)

The Black Creek Formation's depositional character and environment is similar to the Middendorf Formation except that an increase in silts and clays throughout the formation is suggestive of a lagoonal to back bay shallow water and lower delta plain environments. Distinctive sand and clay units are mappable across the area and are generally well developed to the north and east and less developed to the south and southwest.

The McQueen Branch Confining Unit (MqBCU) is a member of the Black Creek Formation, consisting of thick clays intercalated with thin sand/silt layers. The MqBCU approximately divides the Black Creek into upper and lower units. In GCB-1, 2 and 3, the MqBCU contains rich organic clays interspersed with heavy minerals and iron staining. A greater abundance of heavy minerals and staining is present in GCB-3 suggesting deposition further up slope. Across the structural high associated with GCB-1 and P9R, the MqBCU thins suggesting a structural influence affecting deposition. In general, the MqBCU appears to be distributed in a near shore, back barrier bay environment and may represent a sequence time line or surface erosional interval between depositional cycles of the over and underlying Black Creek.

The lower Black Creek zone is generally more clay dominated than the upper zone. Several (generally three) clay units may be tracked across the lower portion of the Black Creek but are missing or thin above the GCB-1 and P9R high. The sand units within the lower zone have log characteristics of bar-finger sands or delta sheet sands combined with bar sands. Since the sand signatures are difficult to track across the data, they are probably more associated with discontinuous bars rather than delta type sheet sands.

The upper Black Creek zone is sand dominated and was probably deposited in a higher energy environment. Individual sand units are difficult to map across the area and the overall log signatures suggest bar-finger sands and bar pinchouts. In some logs, MBC08ASB for example, there may be a tidal inlet fill log signature.

Across the A/M Area, the overall character and variation of the lower Black Creek and MqBCU remains fairly constant. Further down dip to the south and southeast (south and east of the Crackerneck Fault), the depositional character appears to change and a more varied depositional pattern is seen.

This may be the transition from upper delta, tidally influenced deposition to a lower delta marine influenced environment.

The seismic character of the upper Black Creek is less distinct than the lower Black Creek and the overall depositional pattern is more difficult to discern. In lines CNF-2 and SRS-7, the character is more consistent in the down dip areas to the south and southeast. This may indicate a more stable, marine influenced environment, while a higher energy, more discontinuous environment existed to the north and northwest.

Steel Creek Formation

The stratigraphic character of the Steel Creek Formation is not discernible from the seismic data. From the deep borings, the formation is fairly uniform in thickness across most of the study area but thins in GCB-3. The GCB-3 log suggests that the upper portions of the Steel Creek have been eroded. There are distinctive sand units within the formation that may be locally tracked, however, they are not traceable through all of the deep borings. The overall log character of the sand units suggests a near shore bar-finger environment. Figure 11 shows the suggested depositional environments by formation.

SUMMARY

This study identified four principal crystalline basement involved faults. The oldest regional fault trends NNE and is identified as the Crackerneck Fault. Three younger faults trend north. The westernmost fault is identified as the MWESTA Fault and the easternmost fault as the Steed Pond Fault. The central fault intersects the Crackerneck Fault and is identified as the Lost Lake Fault. These faults are not thought to be single breaks in all areas but linear zones of disruption. The intersection of the Lost Lake and Crackerneck Faults is a highly complex area. These faults are thought to be predominantly reverse faults with possible dip-slip, or minor strike slip motion. The overall pattern of the Crackerneck Fault and possibly the Lost lake Fault follows a fault propagation fold model. The Crackerneck may be a re-activated Mesozoic normal fault. The overall subsurface structural relief within the A/M Area is thought to be controlled by these faults for strata older than the Middendorf Fm., and by a combination of sedimentation and structure for more recent sediments.

At least three ages of faulting are observed in the data. The oldest faulting is probably pre-Cretaceous and affected deposition of the Cape Fear Formation. There may be sediments pre-Cape Fear in the synclinal troughs associated with these older faults. The majority of faults are post-Cretaceous in age and disrupt the entire Cretaceous sediment column. At least two

pulses of post-Cretaceous movement are noted. A more recent structural event is seen in the Paleocene and younger sediments. This event may be a re-activation of the deeper faulting in a strike slip mode. These younger structures trend to the NW and occur in an en-echelon pattern. This pattern may affect strata to near surface or surface horizons.

The stratigraphic information for the deeper horizons is limited due to the limited number of deep geophysical logs tied to the seismic information. However, a comparison of regional deep logs allows for a discussion of possible deep stratigraphy. In general, all sediments were deposited in a near shore, marine to fluvial environment and vary from a tidally dominated to a wave dominated depositional character. For all Cretaceous strata, there is a noticeable change in depositional character south and southeast of the Crackerneck Fault from a near shore to more distal environment. Overall, there is a general thickening of Cretaceous strata to the southeast and south.

The correlation of the deep borings with the seismic data allows for an interpretation of structure and depositional character within the A/M Area.

Figure 8. Top figure is fault propagation folding over a reverse fault. (Modified after Cumbest and Wyatt, 1997). The lower figure is the actual seismic horizon schematic from line SRS-1 over the CNF. The horizons are labeled as; "rock" is crystalline basement, "CF" is the Cape Fear Fm., "Midd." is the Middendorf Fm., "MqBCU" is the McQueen Branch Confining Unit, "LS/SL" is the Lang Syne/Sawdust Landing Fm., and "WH" is the Warley Hill Fm. The offset in basement rock is approximately 30-35 m. The distance from the anticline axis to the syncline axis is approximately 400 meters.

Figure 9. Line drawing of map view of the deformation formed above a 90° basement fault reactivated in pure strike-slip mode in a brittle-ductile experiment. (Modified from Pascal et al. 1991)

Figure 10. Graph of structural relief, average, maximum and minimum sediment thickness for the mapped stratigraphic horizons. "CF" is Cape Fear, "Midd" is Middendorf, "McQBCU" is McQueen Branch Confining Unit, "SC" is Steel Creek, "LS/SL" is Lang Syne/Sawdust Landing, "WH" is Warley Hill.

Figure 11. Environments of deposition anticipated to exist within the A/M Area. Figure is modified from Aadland (1997). Stratigraphic units, with the anticipated environments of deposition within the A/M Area are shown in red.

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WSRC-RP-97-0186

Revision 0

December, 1997

Appendix A

**Stratigraphic Horizon Picks from Wells, Cone Penetrometer Tests and
Borings used to construct shallow maps.**

WELL NAME	UTM EAST	UTM NORTH	SURFACE ELEV. (M)	Tobacco Road Dry Branch Contact	SANTEE Unconformity	Top of Warley Hill Fm.	Top of Congaree, Fourmile, Fishburne Fms.	Lang Syne/Sawdust Landing Unconformity	Top of Steel Creek Fm.	Top of Black Creek Fm.	Top of Middendorf Fm.	Top of Cape Fear Fm.	Top of Saprolite, Basement Unconformity	Crystalline Rock "Acoustic Basement"
ABP03	431154	3686223	107.3	21.3	29.9	40.2	47.5	61.0	-	-	-	-	-	-
ABP08C	431010	3686141	112.8	27.7	36.9	45.7	52.4	-	-	-	-	-	-	-
AC02A	430221	3688499	104.5	13.4	22.6	39.9	45.4	-	-	-	-	-	-	-
AC03A	429993	3688582	91.4	6.1	17.4	33.2	43.6	57.0	-	-	-	-	-	-
ACHF01	431294	3687060	101.6	12.8	22.3	-	-	-	-	-	-	-	-	-
ACHF02	431272	3687028	101.3	12.8	23.2	-	-	-	-	-	-	-	-	-
ACHF03	431165	3687096	101.9	11.6	23.8	-	-	-	-	-	-	-	-	-
ACHF04	431105	3687105	102.8	12.8	25.9	45.4	-	-	-	-	-	-	-	-
ACHF05	431045	3687095	104.1	15.2	25.3	-	-	-	-	-	-	-	-	-
ACHF06	430986	3687079	105.8	19.5	27.4	-	-	-	-	-	-	-	-	-
ACHF07	430928	3687062	108.1	19.8	28.0	-	-	-	-	-	-	-	-	-
ACHF08	430869	3687045	109.9	18.0	28.3	-	-	-	-	-	-	-	-	-
ACHF09	430811	3687028	110.6	20.7	32.0	-	-	-	-	-	-	-	-	-
ACHF10	430751	3687018	109.4	21.9	32.6	-	-	-	-	-	-	-	-	-
ACHF11	430690	3687017	109.3	20.4	32.0	-	-	-	-	-	-	-	-	-
ACHF12	430629	3687019	109.6	17.4	27.7	-	-	-	-	-	-	-	-	-
AMB01SB	431745	3688999	114.9	20.4	34.1	46.0	52.7	71.0	-	-	-	-	-	-
AMB04A	431734	3689033	115.2	19.8	34.4	45.7	51.2	70.7	-	-	-	-	-	-
AMB05	431741	3689021	115.2	19.8	34.1	46.0	-	-	-	-	-	-	-	-
AMB06	431750	3689007	114.3	18.3	33.2	45.1	-	-	-	-	-	-	-	-
AMB07B	431791	3689015	113.1	20.1	32.3	45.1	50.9	69.2	-	-	-	-	-	-
AMB08D	431762	3688957	112.8	16.5	31.4	45.1	-	-	-	-	-	-	-	-
AMB09D	431780	3688861	111.6	16.8	31.7	43.9	-	-	-	-	-	-	-	-
AMB10A	431862	3688823	110.9	17.1	32.0	44.8	50.3	67.1	-	-	-	-	-	-
AMB11D	432027	3688869	110.3	17.7	31.4	45.1	50.9	69.2	-	-	-	-	-	-
AMB12D	431935	3688979	112.2	20.1	34.1	45.7	-	-	-	-	-	-	-	-
AMB13AR	431903	3688761	110.6	18.3	32.0	44.8	49.1	64.9	-	-	-	-	-	-
AMB18	431746	3688988	114.3	18.6	33.5	45.7	52.1	70.7	-	-	-	-	-	-
AMB19	431954	3688969	110.3	18.6	30.8	45.7	49.7	66.4	-	-	-	-	-	-
ARP05	430949	3688516	105.2	18.9	29.3	39.6	46.0	57.3	-	-	-	-	-	-
ARP06	431049	3688518	102.4	15.8	27.4	36.8	43.0	56.7	-	-	-	-	-	-
ARP07	430811	3686352	107.6	23.2	33.2	43.3	48.2	61.9	-	-	-	-	-	-
ARPIA	430873	3686511	107.6	19.8	28.7	40.8	-	-	-	-	-	-	-	-
ARP2	431007	3686616	102.1	-	-	-	-	-	-	-	-	-	-	-
ARP3	431100	3686502	103.0	16.5	24.7	36.6	-	-	-	-	-	-	-	-
ASB01A	431764	3689584	105.8	-	-	-	-	-	-	-	-	-	-	-
ASB02CR	431824	3689630	107.6	14.3	26.2	41.8	48.2	66.4	92.7	-	-	-	-	-
ASB03CR	431876	3689696	103.3	12.2	23.8	37.5	43.9	59.4	-	-	-	-	-	-
ASB04	431830	3689793	101.5	-	-	-	-	-	-	-	-	-	-	-
ASB05A	431763	3689714	104.5	-	-	-	-	-	-	-	-	-	-	-
ASB06	431736	3689636	106.1	15.5	26.5	40.8	50.3	63.7	89.0	-	-	-	-	-
ASB07	431724	3689644	107.0	-	-	-	-	-	-	-	-	-	-	-
ASB08	431741	3689685	105.8	13.1	24.1	38.4	46.3	64.9	89.9	-	-	-	-	-
ASB09B	432332	3689632	93.6	8.5	15.8	29.9	35.1	57.3	-	-	-	-	-	-
ASB10	431830	3689676	105.8	13.4	25.0	39.0	45.4	64.9	-	-	-	-	-	-
CPT-10A	431212	3687287	104.8	15.5	22.6	43.3	-	-	-	-	-	-	-	-
CPT-11A	430913	3687387	107.8	18.3	27.4	-	-	-	-	-	-	-	-	-
CPT-12	430303	3687666	109.8	18.3	28.7	43.3	-	-	-	-	-	-	-	-
CPT-13A	430403	3687663	108.8	-	-	-	-	-	-	-	-	-	-	-
CPT-13B	430404	3687670	106.7	16.8	25.6	50.6	-	-	-	-	-	-	-	-
CPT-14A	430742	3687786	106.4	18.3	27.4	-	-	-	-	-	-	-	-	-
CPT-15A	431280	3688263	112.0	20.4	30.8	-	-	-	-	-	-	-	-	-
CPT-17A	431787	3688252	104.9	18.3	29.3	-	-	-	-	-	-	-	-	-
CPT-18A	431345	3688022	109.1	19.5	28.8	-	-	-	-	-	-	-	-	-
CPT-18B	431345	3688034	109.2	19.5	29.6	-	-	-	-	-	-	-	-	-
CPT-19A	431277	3687997	108.6	15.2	28.3	-	-	-	-	-	-	-	-	-
CPT-1A	430995	3688644	107.8	16.2	24.7	-	-	-	-	-	-	-	-	-
CPT-2	430830	3688417	108.6	-	-	-	-	-	-	-	-	-	-	-
CPT-20A	431153	3687991	108.2	14.0	23.2	-	-	-	-	-	-	-	-	-
CPT-20B	431148	3687992	108.6	-	-	-	-	-	-	-	-	-	-	-
CPT-21A	431518	3687839	103.8	16.5	28.0	-	-	-	-	-	-	-	-	-
CPT-22A	431250	3688064	108.2	12.8	21.9	-	-	-	-	-	-	-	-	-
CPT-23A	430607	3688112	106.5	16.8	25.3	-	-	-	-	-	-	-	-	-
CPT-23B	430590	3688080	106.7	17.1	25.6	46.0	-	-	-	-	-	-	-	-
CPT-3D	430499	3687803	107.0	17.7	27.7	-	-	-	-	-	-	-	-	-
CPT-4A	430267	3687961	109.0	15.8	24.4	47.9	-	-	-	-	-	-	-	-
CPT-5A	430890	3688323	109.8	20.4	29.6	50.9	-	-	-	-	-	-	-	-
CPT-6A	431185	3688232	112.9	21.3	30.2	48.8	-	-	-	-	-	-	-	-
CPT-7A	431079	3687920	106.6	14.9	26.2	49.4	-	-	-	-	-	-	-	-
CPT-9A	431368	3687583	105.1	17.7	28.3	-	-	-	-	-	-	-	-	-
Top-01	431181	3688696	112.9	-	-	-	-	-	-	-	-	-	-	-
GCB01	431141	3687046	102.4	14.6	26.2	43.9	50.0	68.0	88.1	120.1	177.4	212.4	221.6	231.0
GCB02	433006	3687061	67.4	-	-	1.8	7.3	26.8	57.9	94.8	157.0	191.1	198.1	203.0
GCB03	432841	3689598	78.0	-	-	11.0	19.2	38.1	51.2	71.3	141.7	182.0	188.4	192.3
MBC01SB	431281	3690332	113.4	15.8	27.1	41.1	47.2	64.6	80.2	-	-	-	-	-
MBC02SB	431455	3690194	115.8	16.8	29.0	46.9	51.8	67.1	83.2	-	-	-	-	-
MBC03SB	431326	3689885	111.9	-	-	-	-	-	-	-	-	-	-	-
MBC04SB	431569	3689244	116.1	21.9	31.7	43.3	50.6	68.3	90.8	-	-	-	-	-
MBC05SB	431601	3689027	113.1	21.0	33.2	45.7	51.2	69.8	90.5	-	-	-	-	-
MBC06SB	432178	3688302	99.7	9.1	21.3	36.0	42.1	60.4	81.7	-	-	-	-	-

WELL NAME	UTM EAST	UTM NORTH	SURFACE ELEV. (M)	Tobacco Road Dry Branch Contact	SANTEE Unconformity	Top of Warley Hill Fm.	Top of Congaree, Fourmile, Fishburne Fms.	Lang Syne/Sawdust Landing Unconformity	Top of Steel Creek Fm.	Top of Black Creek Fm.	Top of Middendorf Fm.	Top of Cape Fear Fm.	Top of Saprolite, Basement Unconformity	Crystalline Rock "Acoustic Basement"
MBC07SB	431651	3687737	100.3	11.3	22.9	34.1	40.5	57.3	61.7	-	-	-	-	-
MBC08ASB	431286	3690338	113.4	14.6	26.5	41.5	46.3	63.4	79.6	113.7	187.5	222.5	-	-
MBC09SB	431617	3690650	106.7	8.8	18.6	36.0	41.5	59.4	75.6	-	-	-	-	-
MBC10SB	431775	3689407	109.7	21.3	31.1	45.1	51.2	68.3	95.4	-	-	-	-	-
MBC11SB	432010	3688942	110.0	18.0	29.9	45.1	50.9	68.9	86.9	-	-	-	-	-
MBC12SB	431900	3688189	102.7	13.7	23.5	35.1	42.7	59.4	86.6	-	-	-	-	-
MCB01CH	431452	3686104	96.9	11.0	19.2	36.0	45.4	61.6	80.8	-	-	-	-	-
MCB01PB	431173	3684429	93.3	5.5	10.7	30.8	40.5	59.1	-	-	-	-	-	-
MCB02CH	431333	3686239	102.7	16.2	26.8	42.1	50.6	66.1	84.4	-	-	-	-	-
MCB02PB	430375	3685242	85.6	0.3	11.0	22.9	34.4	54.3	-	-	-	-	-	-
MCB03CH	431037	3686254	107.6	19.8	30.2	40.2	46.6	62.8	92.7	-	-	-	-	-
MCB03PB	431532	3684691	97.8	9.4	20.1	36.3	45.1	63.1	-	-	-	-	-	-
MCB04CH	430903	3685918	113.7	26.5	34.7	46.9	55.2	69.8	-	-	-	-	-	-
MCB04CPZ	431522	3686074	94.2	9.4	17.4	34.4	44.2	59.4	-	-	-	-	-	-
MCB04PB	431666	3684920	98.8	11.6	21.0	34.4	43.9	64.6	-	-	-	-	-	-
MCB05CH	431120	3685999	109.7	20.7	31.1	43.3	50.9	64.0	92.4	-	-	-	-	-
MCB05EHP	431290	3685843	107.3	18.6	27.4	40.2	48.8	64.0	92.0	-	-	-	-	-
MCB05HHP	431197	3685553	106.4	15.5	26.2	41.5	49.7	61.9	-	-	-	-	-	-
MCB05LHP	431128	3685335	101.5	12.2	23.2	36.3	44.8	62.5	-	-	-	-	-	-
MCB05PB	430881	3684782	86.4	1.2	11.9	25.3	36.0	53.3	-	-	-	-	-	-
MCB06	431395	3686259	100.6	16.5	26.2	40.2	48.5	64.6	-	-	-	-	-	-
MCB06CH	431356	3686337	97.2	11.3	20.7	38.7	46.6	57.9	85.3	-	-	-	-	-
MCB06PB	430699	3684914	87.0	-	7.0	24.4	33.2	51.8	-	-	-	-	-	-
MCB07C	431361	3686126	102.4	17.1	25.9	41.8	50.3	-	-	-	-	-	-	-
MCB07CH	430680	3686258	105.2	17.1	28.0	37.2	45.4	57.9	82.3	-	-	-	-	-
MCB07EHP	431110	3685770	110.9	20.4	30.5	43.3	52.7	64.6	-	-	-	-	-	-
MCB07PB	430790	3685357	107.2	19.5	30.5	43.0	51.2	67.1	-	-	-	-	-	-
MCB08CH	431168	3684778	93.0	7.9	16.8	32.0	39.3	57.3	-	-	-	-	-	-
MCB08EHP	430887	3685823	108.2	18.3	27.4	40.8	49.4	64.6	-	-	-	-	-	-
MCB08PB	431542	3685289	98.5	8.5	17.4	32.3	41.8	60.0	-	-	-	-	-	-
MCB09DHP	430804	3686208	109.1	20.7	32.0	41.8	49.7	61.0	-	-	-	-	-	-
MCB09PB	430586	3685425	105.0	15.8	26.5	40.2	48.5	63.1	-	-	-	-	-	-
MCB10D	431404	3686535	93.3	8.2	19.8	35.4	42.7	54.3	-	-	-	-	-	-
MCB10F	430786	3686426	106.7	21.0	32.3	42.4	50.6	61.9	88.1	-	-	-	-	-
MCB10PB	430667	3685628	110.1	20.4	29.6	44.2	52.7	70.1	-	-	-	-	-	-
MCB11B	431599	3686035	91.4	5.2	14.6	25.0	33.5	48.5	-	-	-	-	-	-
MCB11BPZ	431234	3686331	101.5	15.5	27.1	43.3	52.7	65.5	-	-	-	-	-	-
MCB11E	431239	3686560	97.8	9.4	21.9	38.7	46.3	60.7	91.1	-	-	-	-	-
MCB11PB	430966	3685545	106.4	18.0	27.1	41.1	49.4	61.9	-	-	-	-	-	-
MCB12B	431237	3686484	99.4	12.2	24.4	41.5	49.7	62.5	-	-	-	-	-	-
MCB12CHP	431368	3686386	98.5	12.5	23.5	38.7	46.9	62.5	89.3	-	-	-	-	-
MCB12PB	431608	3685802	95.9	4.6	14.9	26.8	35.1	51.2	-	-	-	-	-	-
MCB13C	431267	3685772	108.2	18.9	28.3	42.4	51.2	64.0	-	-	-	-	-	-
mcp-01	431174	3686695	112.9	-	-	-	-	-	-	-	-	-	-	-
mcp-02	431174	3688701	112.7	-	-	-	-	-	-	-	-	-	-	-
mcp-03*	431170	3688699	112.6	-	-	-	-	-	-	-	-	-	-	-
mcp-04	431167	3688695	112.6	-	-	-	-	-	-	-	-	-	-	-
mcp-05	431172	3688686	113.0	-	-	-	-	-	-	-	-	-	-	-
mcp-06	431182	3688695	112.9	-	-	-	-	-	-	-	-	-	-	-
mcp-07	431157	3688699	112.5	-	-	-	-	-	-	-	-	-	-	-
mcp-08	431161	3688694	112.6	-	-	-	-	-	-	-	-	-	-	-
mcp-09	431180	3688688	112.9	-	-	-	-	-	-	-	-	-	-	-
MCP-10A	431101	3686211	108.7	-	30.2	-	-	-	-	-	-	-	-	-
MCP-10B	431038	3686254	107.6	-	-	-	-	-	-	-	-	-	-	-
MCP-10C	430975	3686297	107.2	-	-	-	-	-	-	-	-	-	-	-
MCP-10D	430912	3686340	106.9	-	-	-	-	-	-	-	-	-	-	-
MCP-11A	431233	3686255	103.0	-	28.3	-	-	-	-	-	-	-	-	-
MCP-11B	431234	3686331	101.4	-	26.8	-	-	-	-	-	-	-	-	-
MCP-11C	431236	3686408	100.9	-	24.4	-	-	-	-	-	-	-	-	-
MCP-11F	431235	3686341	98.1	-	22.3	-	-	-	-	-	-	-	-	-
MCP-12A	431333	3686239	102.6	-	24.4	-	-	-	-	-	-	-	-	-
MCP-12B	431351	3686313	99.1	-	19.5	-	-	-	-	-	-	-	-	-
MCP-12C	431368	3686387	98.5	-	21.3	-	-	-	-	-	-	-	-	-
MCP-12D	431386	3686461	93.6	-	15.2	-	-	-	-	-	-	-	-	-
MCP-12E	431404	3686535	93.3	-	15.5	-	-	-	-	-	-	-	-	-
MCP-12F	431357	3686337	97.1	-	-	-	-	-	-	-	-	-	-	-
mcp-16	431181	3688714	112.5	-	-	-	-	-	-	-	-	-	-	-
mcp-17	431177	3688719	112.6	-	-	-	-	-	-	-	-	-	-	-
mcp-18	431163	3688720	112.6	-	-	-	-	-	-	-	-	-	-	-
mcp-19	431152	3688705	112.9	-	-	-	-	-	-	-	-	-	-	-
MCP-1A	431106	3686130	-	-	-	-	-	-	-	-	-	-	-	-
mcp-20	431152	3688690	113.0	-	-	-	-	-	-	-	-	-	-	-
MCP-2A	431144	3686173	-	-	-	-	-	-	-	-	-	-	-	-
MCP-3A	431405	3686209	-	-	-	-	-	-	-	-	-	-	-	-
MCP-4A	431383	3686134	101.4	-	21.9	-	-	-	-	-	-	-	-	-
MCP-4B	431452	3686104	96.9	-	18.9	-	-	-	-	-	-	-	-	-
MCP-4C	431523	3686074	94.1	-	16.2	-	-	-	-	-	-	-	-	-
MCP-4D	431609	3686037	91.5	-	16.2	-	-	-	-	-	-	-	-	-
MCP-4E	431662	3686014	91.4	-	14.3	-	-	-	-	-	-	-	-	-
MCP-5B	431360	3686062	95.5	-	21.3	-	-	-	-	-	-	-	-	-

WELL NAME	UTM EAST	UTM NORTH	SURFACE ELEV. (M)	Tobacco Road Dry Branch Contact	SANTEE Unconformity	Top of Warley Hill Fm.	Top of Congaree, Fourmile, Fishburne Fms.	Lang Syne/Sawdust Landing Unconformity	Top of Steel Creek Fm.	Top of Black Creek Fm.	Top of Middendorf Fm.	Top of Cape Fear Fm.	Top of Saprolite, Basement Unconformity	Crystalline Rock "Acoustic Basement"
MCP-5C	431336	3685989	100.4	-	-	-	-	-	-	-	-	-	-	-
MCP-6A	431291	3686148	104.1	-	23.8	-	-	-	-	-	-	-	-	-
MCP-6B	431242	3686069	105.6	-	28.7	-	-	-	-	-	-	-	-	-
MCP-6C	431180	3686013	109.4	-	32.3	-	-	-	-	-	-	-	-	-
MCP-6D	431145	3685972	109.7	-	31.1	-	-	-	-	-	-	-	-	-
MCP-6E	431097	3685913	110.7	-	30.8	-	-	-	-	-	-	-	-	-
MCP-6F	431049	3685854	112.6	-	31.1	-	-	-	-	-	-	-	-	-
MCP-7A	431124	3686075	110.0	-	-	-	-	-	-	-	-	-	-	-
MCP-7B	431121	3685999	109.7	-	30.8	-	-	-	-	-	-	-	-	-
MCP-7C	431117	3685923	111.1	-	31.7	-	-	-	-	-	-	-	-	-
MCP-7D	431114	3685847	111.7	-	30.8	-	-	-	-	-	-	-	-	-
MCP-7E	431110	3685771	111.0	-	30.5	-	-	-	-	-	-	-	-	-
MCP-8A	431030	3686093	114.4	-	34.1	-	-	-	-	-	-	-	-	-
MCP-8B	430994	3686025	111.9	-	35.4	-	-	-	-	-	-	-	-	-
MCP-8C	430958	3685958	113.6	-	34.4	-	-	-	-	-	-	-	-	-
MCP-8F	430851	3685756	106.1	-	30.2	-	-	-	-	-	-	-	-	-
MCP-8A	431021	3686134	113.0	-	35.1	-	-	-	-	-	-	-	-	-
MCP-8B	430949	3686159	111.4	-	-	-	-	-	-	-	-	-	-	-
MCP-9C	430877	3686184	109.5	-	-	-	-	-	-	-	-	-	-	-
MHT01C	431323	3686196	110.6	19.5	29.9	43.9	50.6	-	-	-	-	-	-	-
MHT02C	431319	3686209	110.9	18.9	30.5	43.6	51.2	-	-	-	-	-	-	-
MHT03C	431347	3686213	110.3	21.0	31.1	44.5	50.6	-	-	-	-	-	-	-
MHT04C	431334	3686232	111.9	22.9	32.6	44.8	50.9	-	-	-	-	-	-	-
MHT05C	431354	3686228	110.9	21.9	32.3	43.3	50.6	-	-	-	-	-	-	-
MHT06C	431337	3686246	112.5	24.1	33.5	45.4	52.1	-	-	-	-	-	-	-
MHT07C	431360	3686255	112.2	21.9	31.4	44.8	51.2	-	-	-	-	-	-	-
MHT08C	431342	3686276	112.5	23.2	33.8	44.8	51.5	-	-	-	-	-	-	-
MHT09C	431365	3686268	112.2	21.0	30.2	44.2	51.2	-	-	-	-	-	-	-
MHT10B	431354	3686289	112.5	22.3	33.2	45.1	51.5	-	-	-	-	-	-	-
MHT11C	431316	3686247	111.6	21.6	32.6	44.5	50.9	-	-	-	-	-	-	-
MHT12C	431371	3686284	112.2	21.6	31.4	44.8	51.2	-	-	-	-	-	-	-
MHT13D	431334	3686240	112.2	-	-	-	-	-	-	-	-	-	-	-
MHT14D	431338	3686237	112.5	-	-	-	-	-	-	-	-	-	-	-
MHT15C	431351	3686146	109.1	20.4	31.1	43.0	49.4	-	-	-	-	-	-	-
MHT16C	431350	3686112	109.7	20.1	30.5	44.5	50.6	-	-	-	-	-	-	-
MHT17C	431384	3686108	109.1	20.4	29.6	43.0	50.0	-	-	-	-	-	-	-
MHT18C	431334	3686122	109.7	20.4	31.7	43.9	50.9	-	-	-	-	-	-	-
MHT19C	431343	3686134	109.4	20.1	31.1	43.3	50.3	-	-	-	-	-	-	-
MHT20C	431330	3686157	109.7	19.2	29.6	44.5	50.6	-	-	-	-	-	-	-
MHV08	431359	3686187	109.1	17.7	27.1	-	-	-	-	-	-	-	-	-
MSB-44	431793	3686762	114.0	20.4	32.3	44.5	51.2	67.7	89.9	-	-	-	-	-
MSB01	431411	3687929	107.0	15.8	26.8	41.5	46.9	66.4	-	-	-	-	-	-
MSB02B	431446	3688019	107.3	14.9	25.3	39.6	44.8	64.9	84.1	-	-	-	-	-
MSB03B	431367	3688034	109.4	18.0	30.8	42.1	48.2	68.9	-	-	-	-	-	-
MSB04C	431345	3687932	107.6	16.5	27.1	39.9	46.3	66.4	-	-	-	-	-	-
MSB05B	431015	3687695	104.5	12.5	25.6	43.9	50.3	67.1	-	-	-	-	-	-
MSB06B	431000	3687374	104.2	17.4	28.3	43.9	49.1	68.0	-	-	-	-	-	-
MSB07A	431200	3687308	104.2	17.4	27.1	42.1	48.2	-	-	-	-	-	-	-
MSB08B	431298	3687463	104.2	14.0	24.7	36.6	42.1	62.2	-	-	-	-	-	-
MSB09B	431278	3687987	108.8	15.8	26.8	43.0	48.2	63.4	-	-	-	-	-	-
MSB10A	431169	3687988	108.2	14.0	27.4	40.8	46.6	67.7	-	-	-	-	-	-
MSB11A	431288	3688146	110.6	17.4	29.0	43.6	50.9	68.3	-	-	-	-	-	-
MSB12A	430997	3687901	105.8	17.1	29.3	41.8	48.2	66.6	101.2	-	-	-	-	-
MSB13CC	431192	3687733	105.2	15.8	25.0	43.6	49.4	65.8	-	-	-	-	-	-
MSB14A	431456	3687887	105.8	16.5	27.7	39.0	45.4	-	-	-	-	-	-	-
MSB15A	431288	3688275	111.3	20.1	31.4	44.5	50.6	-	-	-	-	-	-	-
MSB16A	431195	3688476	111.6	17.4	27.4	44.5	50.3	-	-	-	-	-	-	-
MSB17A	430833	3687565	108.8	18.9	31.1	46.9	52.7	71.9	-	-	-	-	-	-
MSB18A	431079	3687156	103.6	14.3	28.5	44.5	50.6	-	-	-	-	-	-	-
MSB19A	432166	3688160	90.8	3.0	12.2	26.2	33.5	50.9	-	-	-	-	-	-
MSB20A	430506	3687918	107.6	16.8	28.0	43.9	50.9	-	-	-	-	-	-	-
MSB21A	430716	3688230	107.6	17.7	27.7	40.8	49.4	66.4	95.7	-	-	-	-	-
MSB22	431353	3688022	109.1	-	-	-	-	-	-	-	-	-	-	-
MSB23TA	431151	3688671	112.8	22.6	32.6	49.4	55.8	74.4	99.1	-	-	-	-	-
MSB24	431246	3688860	115.5	-	-	-	-	-	-	-	-	-	-	-
MSB25A	431399	3688553	111.3	-	-	-	-	-	-	-	-	-	-	-
MSB26AA	430902	3688605	109.7	18.6	29.0	44.5	50.3	70.7	95.7	-	-	-	-	-
MSB27TA	431098	3688879	114.0	24.4	34.1	50.9	59.1	74.7	95.4	-	-	-	-	-
MSB28A	430860	3688705	107.6	-	-	-	-	-	-	-	-	-	-	-
MSB29TA	431104	3688780	110.6	20.7	32.0	44.8	50.0	69.2	80.5	-	-	-	-	-
MSB30A	430593	3688804	107.3	14.6	24.7	44.2	50.0	68.3	-	-	-	-	-	-
MSB31A	431782	3688256	105.5	12.2	24.7	37.5	43.9	62.5	85.3	-	-	-	-	-
MSB32	432847	3688157	77.4	-	-	10.7	16.5	35.4	53.6	-	-	-	-	-
MSB33TA	432895	3687573	77.1	-	1.8	12.8	20.1	37.8	60.4	-	-	-	-	-
MSB34A	431355	3689068	116.4	21.0	30.5	44.5	50.0	69.8	-	-	-	-	-	-
MSB34TA	431365	3689055	116.4	23.2	32.6	44.5	50.9	71.3	92.0	-	-	-	-	-
MSB35A	431969	3688437	106.4	15.8	26.8	41.1	48.5	64.3	86.0	-	-	-	-	-
MSB36TA	431899	3687787	103.3	11.6	22.6	34.4	40.8	59.1	79.6	-	-	-	-	-
MSB37TA	431519	3689317	115.8	19.5	32.3	43.3	50.0	67.1	90.2	-	-	-	-	-
MSB38B	431626	3688287	108.8	15.2	27.1	41.8	47.2	65.5	88.4	-	-	-	-	-

WELL NAME	UTM EAST	UTM NORTH	SURFACE ELEV. (M)	Tobacco Road Dry Branch Contact	SANTEE Unconformity	Top of Warley Hill Fm.	Top of Congaree, Fourmile, Fishburne Fms.	Lang Syne/Sawdust Landing Unconformity	Top of Steel Creek Fm.	Top of Black Creek Fm.	Top of Middendorf Fm.	Top of Cape Fear Fm.	Top of Saprolite, Basement Unconformity	Crystalline Rock "Acoustic Basement"
MSB39TA	431559	3687661	103.6	15.8	26.2	35.4	41.5	61.6	77.7	-	-	-	-	-
MSB40B	432104	3688873	97.5	5.5	18.5	29.3	37.2	53.6	83.2	-	-	-	-	-
MSB41A	432564	3688903	98.1	9.1	20.7	33.8	41.5	59.4	79.2	-	-	-	-	-
MSB42D	431678	3689167	114.0	21.0	31.7	44.5	50.3	68.3	92.7	-	-	-	-	-
MSB43TA	430631	3689414	108.5	21.6	32.6	46.3	51.8	69.8	86.6	-	-	-	-	-
MSB44A	431793	3688762	114.0	20.4	30.5	44.5	51.2	67.7	-	-	-	-	-	-
MSB45A	431532	3688636	115.2	18.8	30.5	44.2	48.8	-	-	-	-	-	-	-
MSB46B	431694	3688615	112.8	15.8	27.4	42.1	49.4	67.1	-	-	-	-	-	-
MSB47BB	431408	3689877	111.9	17.4	30.2	42.1	47.5	65.5	82.9	-	-	-	-	-
MSB48C	431697	3690432	109.7	15.8	25.3	42.7	47.5	67.4	75.8	-	-	-	-	-
MSB49A	431137	3688950	101.2	14.6	26.2	44.2	52.4	67.7	-	-	-	-	-	-
MSB50	433011	3687061	67.4	-	-	1.5	9.4	28.3	-	-	-	-	-	-
MSB51B	433346	3687516	79.6	-	-	11.3	17.4	40.5	-	-	-	-	-	-
MSB52D	432405	3689118	97.2	4.6	15.8	32.3	41.1	57.0	-	-	-	-	-	-
MSB53B	432083	3690159	104.2	9.4	20.4	35.4	40.5	61.9	-	-	-	-	-	-
MSB54TA	431333	3690367	113.1	14.3	25.6	39.9	45.7	64.3	81.7	-	-	-	-	-
MSB55C	431119	3690168	111.9	14.3	25.3	39.9	43.9	60.4	78.6	-	-	-	-	-
MSB56D	429167	3688797	84.4	5.8	13.7	-	-	-	-	-	-	-	-	-
MSB57	431463	3687969	107.9	-	-	-	-	-	-	-	-	-	-	-
MSB58	431395	3688059	108.5	-	-	-	-	-	-	-	-	-	-	-
MSB59	431305	3687986	108.8	-	-	-	-	-	-	-	-	-	-	-
MSB60	431370	3687903	107.3	-	-	-	-	-	-	-	-	-	-	-
MSB61C	432352	3690221	96.0	1.2	11.6	28.3	33.5	52.4	-	-	-	-	-	-
MSB62B	431262	3687835	105.8	18.3	29.0	40.2	46.3	-	-	-	-	-	-	-
MSB63B	431373	3687659	105.2	16.5	27.4	39.0	44.8	68.1	-	-	-	-	-	-
MSB64B	430941	3687588	105.5	15.2	28.7	46.6	52.7	71.0	-	-	-	-	-	-
MSB65D	431624	3688118	105.8	-	-	-	-	-	-	-	-	-	-	-
MSB66TA	431334	3689397	116.1	18.6	33.5	45.4	52.7	69.2	101.2	-	-	-	-	-
MSB67B	431375	3689794	110.6	11.3	25.9	39.0	44.2	61.0	75.9	-	-	-	-	-
MSB68B	431471	3689826	108.2	9.8	25.0	37.8	43.3	63.1	-	-	-	-	-	-
MSB69TA	431314	3690099	115.5	18.3	29.3	44.2	49.4	66.8	84.1	-	-	-	-	-
MSB70C	430564	3687296	109.7	21.0	33.2	46.9	54.3	-	-	-	-	-	-	-
MSB71B	429966	3687622	104.5	16.5	28.0	46.3	53.3	68.3	-	-	-	-	-	-
MSB72B	432353	3686565	99.7	8.8	21.6	34.1	41.1	57.9	-	-	-	-	-	-
MSB73B	431182	3688799	103.0	18.9	29.3	44.5	50.3	64.9	-	-	-	-	-	-
MSB74D	432374	3687635	95.1	7.9	18.3	27.4	35.7	52.7	-	-	-	-	-	-
MSB75B	432026	3687288	99.1	11.0	21.6	32.6	39.0	54.9	-	-	-	-	-	-
MSB76C	430417	3687671	106.7	15.5	27.4	41.8	48.2	70.1	-	-	-	-	-	-
MSB77TA	431884	3690244	108.2	19.2	29.6	44.2	50.0	68.0	74.1	-	-	-	-	-
MSB78D	430346	3687839	110.0	18.3	29.0	47.2	49.7	-	-	-	-	-	-	-
MSB79B	431573	3687094	105.5	14.3	25.3	36.0	44.2	59.1	-	-	-	-	-	-
MSB81B	432726	3689616	80.8	-	3.7	15.5	23.2	38.1	-	-	-	-	-	-
MSB82C	431243	3689953	113.4	15.5	26.2	41.5	46.6	64.6	80.2	-	-	-	-	-
MSB83C	431193	3690250	112.8	18.9	28.0	40.8	45.7	61.9	-	-	-	-	-	-
MSB84C	430990	3690314	109.7	13.1	22.6	38.4	40.8	56.7	78.3	-	-	-	-	-
MSB85C	431484	3690248	115.2	18.3	29.9	45.1	49.7	65.5	80.5	-	-	-	-	-
MSB86C	431799	3690580	108.2	12.8	23.8	41.1	46.6	64.0	-	-	-	-	-	-
MSB87	432278	3688354	101.8	9.1	22.6	35.4	42.4	61.6	-	-	-	-	-	-
MSB88B	432839	3687154	71.9	-	-	4.0	12.2	29.0	60.0	-	-	-	-	-
MSB89B	431959	3689920	102.7	14.6	25.3	37.8	43.9	59.4	-	-	-	-	-	-
MSS01SB	432813	3687402	79.9	-	5.2	14.9	22.3	39.9	64.6	-	-	-	-	-
MSS02SB	432142	3686640	91.1	1.5	12.2	27.1	35.7	49.4	-	-	-	-	-	-
MSS03SB	432267	3687712	97.2	9.1	19.8	28.0	36.0	54.9	69.8	-	-	-	-	-
MSS04SB	432108	3687916	103.0	11.6	22.3	34.1	43.6	59.4	-	-	-	-	-	-
MSS05SB	432502	3687976	93.0	4.3	14.6	27.4	35.7	51.2	77.7	-	-	-	-	-
MSS06SB	432907	3687457	77.1	-	3.0	13.7	21.6	39.3	60.7	-	-	-	-	-
MSS07SB	432368	3687252	90.8	-	12.2	22.6	29.6	49.4	75.3	-	-	-	-	-
MSS08SB	433344	3688100	86.6	-	12.2	18.6	29.9	48.2	72.5	-	-	-	-	-
MSS09SB	432275	3686739	96.6	6.7	18.3	31.1	37.5	54.6	-	-	-	-	-	-
MSS10SB	431376	3686522	93.3	9.1	19.8	35.4	43.9	55.5	-	-	-	-	-	-
MVC-1	431180	3688685	113.1	-	-	-	-	-	-	-	-	-	-	-
mve-4 pro	431171	3688699	111.6	-	-	-	-	-	-	-	-	-	-	-
mve-5 pro	431183	3688712	110.4	-	-	-	-	-	-	-	-	-	-	-
MVE-1	431179	3688700	113.0	-	-	-	-	-	-	-	-	-	-	-
MVE-2	431167	3688691	113.0	-	-	-	-	-	-	-	-	-	-	-
MVE-3	431157	3688717	102.5	-	-	-	-	-	-	-	-	-	-	-
MW01SB	430862	3688499	105.5	14.3	25.0	41.8	48.2	64.0	-	-	-	-	-	-
MW02SB	430813	3687806	106.1	17.1	29.0	43.9	51.2	72.2	-	-	-	-	-	-
MW03SB	430541	3687762	106.1	17.1	28.3	43.6	49.4	71.0	-	-	-	-	-	-
MW04SB	430177	3688048	107.0	17.1	27.1	45.1	50.9	71.3	-	-	-	-	-	-
MW05SB	429790	3688154	102.1	14.0	23.8	38.7	44.2	64.6	-	-	-	-	-	-
MW06SB	430693	3688640	103.0	14.6	25.0	42.4	48.8	63.4	-	-	-	-	-	-
MW07SB	430383	3687896	109.1	17.1	29.0	44.2	50.0	74.7	-	-	-	-	-	-
MW08SB	430251	3687609	109.1	16.8	29.0	46.0	50.9	74.1	-	-	-	-	-	-
MW09SB	430062	3687377	105.2	23.8	34.7	52.1	58.2	77.7	-	-	-	-	-	-
MW10SB	430377	3687031	112.2	20.7	32.0	48.2	53.9	67.1	-	-	-	-	-	-
MW11SB	430759	3686996	109.1	21.9	32.9	46.0	52.7	65.5	103.0	-	-	-	-	-
MW12SB	431010	3688313	106.1	21.0	32.0	47.9	55.2	68.6	108.8	-	-	-	-	-
MW13SB	429874	3687057	110.0	25.9	37.2	53.6	58.8	72.8	-	-	-	-	-	-
MW14SB	429879	3687059	104.2	18.3	29.3	49.4	54.3	68.6	89.9	-	-	-	-	-

WELL NAME	UTM EAST	UTM NORTH	SURFACE ELEV. (M)	Tobacco Road Dry Branch Contact	SANTEE Unconformity	Top of Warley Hill Fm.	Top of Congaree, Fourmile, Fishburne Fms.	Lang Syne/Sawdust Landing Unconformity	Top of Steel Creek Fm.	Top of Black Creek Fm.	Top of Middendorf Fm.	Top of Cape Fear Fm.	Top of Saprolite, Basement Unconformity	Crystalline Rock "Acoustic Basement"
P30/MMP4B	434053	3688762	107.9	13.4	21.9	38.4	44.8	67.1	82.9	119.8	191.1	228.3	234.7	239.3
P6R	431351	3682009	77.2	-	14.6	27.7	35.1	53.0	80.8	118.3	186.5	228.0	234.7	256.8
P8R	430814	3687564	109.1	20.7	32.3	48.8	54.3	71.6	87.5	121.6	193.2	237.1	248.4	253.3
P9R	431978	3686767	98.1	6.1	17.7	31.7	37.5	58.2	82.3	114.9	180.7	204.8	210.9	222.2
PW112	434198	3689039	100.6	2.4	14.3	25.3	31.1	51.2	79.2	118.1	178.3	-	-	-
PW113	433893	3689033	100.6	2.4	13.1	34.4	40.2	58.5	70.4	111.3	181.4	209.1	-	-
RWM04	431186	3688479	110.9	17.7	27.7	44.8	50.9	69.8	-	-	-	-	-	-
RWM05	431393	3688547	110.9	15.2	25.6	43.6	50.9	70.7	-	-	-	-	-	-
RWM06	431780	3688263	105.5	12.8	24.4	39.0	44.2	62.8	-	-	-	-	-	-
RWM07	431835	3688121	105.5	12.2	23.5	39.0	44.5	62.5	-	-	-	-	-	-
RWM08	431111	3687757	105.2	16.5	26.2	43.6	50.3	68.3	-	-	-	-	-	-
RWM09	431478	3688833	115.2	-	-	-	-	-	-	-	-	-	-	-
RWM10	431321	3687929	107.6	-	-	-	-	-	-	-	-	-	-	-
RWM11	431336	3689023	115.8	-	-	-	-	-	-	-	-	-	-	-
RWM12	431494	3689894	109.4	14.3	26.5	39.9	44.8	63.7	-	-	-	-	-	-
RWM13B	431937	3689611	101.5	13.7	21.3	35.4	41.5	62.8	-	-	-	-	-	-
RWM14	431721	3689664	106.4	15.2	25.6	39.0	45.7	65.2	-	-	-	-	-	-
RWM15B	431725	3689276	111.6	17.1	29.3	45.7	51.8	69.5	82.9	-	-	-	-	-
RWM16	432102	3686857	97.2	6.7	17.4	29.0	36.9	54.9	-	-	-	-	-	-
SRW03SB	429471	3687157	100.6	15.5	25.6	43.6	49.4	65.5	84.4	-	-	-	-	-
SRW04SB	429445	3687071	97.2	11.0	21.6	40.2	45.4	61.9	81.4	-	-	-	-	-
SRW08SB	429141	3686895	87.5	4.3	14.9	26.5	33.8	51.5	77.7	-	-	-	-	-
SRW1	429317	3687140	55.4	8.8	17.7	37.2	39.6	60.4	-	-	-	-	-	-
SRW10SB	429271	3686964	91.7	8.2	18.9	32.9	39.9	57.9	74.1	-	-	-	-	-
SRW11	429201	3687024	89.6	6.1	14.9	29.9	34.1	56.1	-	-	-	-	-	-
SRW17SB	429546	3687374	100.9	13.4	25.0	43.6	50.9	65.2	93.3	-	-	-	-	-
SSR001	432168	3686765	97.1	5.2	18.6	31.1	38.1	54.9	-	-	-	-	-	-
SSR012	432339	3687594	94.0	6.7	14.3	25.6	35.1	50.0	-	-	-	-	-	-

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Appendix B

Seismic Reflection Data with interpreted horizons.

Figure B-1. Distribution of seismic data used for the A/M study. The locations of the seismic data, are shown as circles. The color along individual seismic lines are shallower than red colors. The thin lines are the projections of the Steed Pond Fault is orange, the Lost Lake Fault is pink and the MW

tions of the deep borings, used for correlation and to calibrate.
mic lines is proportional to depth in two-way time, darker blue
of the regional basement faults. The Crackerneck Fault is red,
STA Fault is green.

Figure B-2. Seismic line SRS-1. These vibroseis data were obtained using basement "rock", defined from the change in acoustic velocity. The dark red line is the McQueen Branch Confining Unit. The vertical lines are the Lost Lake Fault, the pink line is the Lost Lake Fault, the green line is the MWESTA Fault, the pink line is the Lost Lake Fault, the green line is the MWESTA Fault, the pink line is the Lost Lake Fault, the green line is the MWESTA Fault. Dashed lines or any color are project other area seismic data. Refer to Figure B-1 for the orientation of the data line.

g 55 foot group intervals. The yellow horizon is crystalline
ed is the Cape Fear Fm., the pink is the Middendorf Fm. and
interpreted faults. If present, the red line is the Crackerneck
Fault and the orange line is the Steed Pond Fault. Yellow
tions of the associated faults through this seismic line from
through the study area.

Figure B-3. Seismic line SRS-12. These vibroseis data were obtained u basement "rock", defined from the change in acoustic velocity. The dar the orange is the McQueen Branch Confining Unit. The vertical lines at Fault, the pink line is the Lost Lake Fault, the green line is the MWES vertical lines are unassigned faults. Dashed lines or any color are proj other area seismic data. Refer to Figure B-1 for the orientation of the dat

using 55 foot group intervals. The yellow horizon is crystalline
 k red is the Cape Fear Fm., the pink is the Middendorf Fm. and
 re interpreted faults. If present, the red line is the Crackerneck
 TA Fault and the orange line is the Steed Pond Fault. Yellow
 ections of the associated faults through this seismic line from
 a through the study area.

Figure B-4. Seismic line SRS-7. These vibroseis data were obtained from the basement "rock", defined from the change in acoustic velocity. The orange is the McQueen Branch Confining Unit. The vertical line is the Lost Lake Fault, the pink line is the Lost Lake Fault, the green line is the N vertical lines are unassigned faults. Dashed lines or any color are other area seismic data. Refer to Figure B-1 for the orientation of the

ed using 55 foot group intervals. The yellow horizon is crystalline
 e dark red is the Cape Fear Fm., the pink is the Middendorf Fm. and
 nes are interpreted faults. If present, the red line is the Crackerneck
 WESTA Fault and the orange line is the Steed Pond Fault. Yellow
 projections of the associated faults through this seismic line from
 the data through the study area.

Figure B-5. Seismic line CNF-1. These vibroseis data were obtained from the basement "rock", defined from the change in acoustic velocity. The data is color-coded: the orange is the McQueen Branch Confining Unit. The vertical lines represent faults: the orange line is the McQueen Branch Fault, the pink line is the Lost Lake Fault, the green line is the MWE Fault, and the other vertical lines are unassigned faults. Dashed lines or any color are probably from other area seismic data. Refer to Figure B-1 for the orientation of the data.

ing 10 foot group intervals. The yellow horizon is crystalline
 red is the Cape Fear Fm., the pink is the Middendorf Fm. and
 e interpreted faults. If present, the red line is the Crackerneck
 TA Fault and the orange line is the Steed Pond Fault. Yellow
 ctions of the associated faults through this seismic line from
 a through the study area.

Figure B-6. Seismic line CNF-2. These vibroseis data were obtained from the basement "rock", defined from the change in acoustic velocity. The orange is the McQueen Branch Confining Unit. The vertical line is the Lost Lake Fault, the pink line is the Cape Fear Fault, the green line is the Black Creek Fault. Dashed lines or any color other area seismic data. Refer to Figure B-1 for the orientation of

ned using 10 foot group intervals. The yellow horizon is crystalline
 he dark red is the Cape Fear Fm., the pink is the Middendorf Fm. and
 ines are interpreted faults. If present, the red line is the Crackerneck
 MWESTA Fault and the orange line is the Steed Pond Fault. Yellow
 e projections of the associated faults through this seismic line from
 the data through the study area.

Figure B-7. Seismic line A-1A. These vibroseis data were obtained from the basement "rock", defined from the change in acoustic velocity. The orange is the McQueen Branch Confining Unit. The vertical line is the Lost Lake Fault, the pink line is the Lost Lake Fault, the green line is the MW vertical lines are unassigned faults. Dashed lines or any color are from other area seismic data. Refer to Figure B-1 for the orientation of the

using 10 foot group intervals. The yellow horizon is crystalline
 ark red is the Cape Fear Fm., the pink is the Middendorf Fm. and
 are interpreted faults. If present, the red line is the Crackerneck
 STA Fault and the orange line is the Steed Pond Fault. Yellow
 jections of the associated faults through this seismic line from
 ata through the study area.

Figure B-8. Seismic line A-1B. These vibroseis data were obtained u
basement "rock", defined from the change in acoustic velocity. The da
the orange is the McQueen Branch Confining Unit. The vertical lines
Fault, the pink line is the Lost Lake Fault, the green line is the MWE
vertical lines are unassigned faults. Dashed lines or any color are pro
other area seismic data. Refer to Figure B-1 for the orientation of the da

ing 10 foot group intervals. The yellow horizon is crystalline
red is the Cape Fear Fm., the pink is the Middendorf Fm. and
e interpreted faults. If present, the red line is the Crackerneck
A Fault and the orange line is the Steed Pond Fault. Yellow
ctions of the associated faults through this seismic line from
through the study area.

Figure B-9. Seismic line A-2. These vibroseis data were obtained from the basement "rock", defined from the change in acoustic velocity. The orange line is the McQueen Branch Confining Unit. The vertical pink line is the Lost Lake Fault, the green line is the Lost Lake Fault. Dashed lines or any color other area seismic data. Refer to Figure B-1 for the orientation.

ained using 55 foot group intervals. The yellow horizon is crystalline
 /. The dark red is the Cape Fear Fm., the pink is the Middendorf Fm. and
 al lines are interpreted faults. If present, the red line is the Crackerneck
 he MWESTA Fault and the orange line is the Steed Pond Fault. Yellow
 r are projections of the associated faults through this seismic line from
 of the data through the study area.

Figure B-10. Seismic line A-3. These vibroseis data were obtained from the basement "rock", defined from the change in acoustic velocity. The orange is the McQueen Branch Confining Unit. The vertical line is the Lost Lake Fault, the pink line is the Lost Lake Fault, the green line is the Lost Lake Fault. Dashed lines or any color are other area seismic data. Refer to Figure B-1 for the orientation of

d using 10 foot group intervals. The yellow horizon is crystalline
 es are interpreted faults. If present, the red line is the Crackneck
 WESTA Fault and the orange line is the Steed Pond Fault. Yellow
 projections of the associated faults through this seismic line from
 e data through the study area.

Figure B-11. Seismic line A-4. These vibroseis data were obtained from the basement "rock", defined from the change in acoustic velocity. The dashed line is the Lost Lake Fault, the orange is the McQueen Branch Confining Unit. The vertical lines are faults. The pink line is the Lost Lake Fault, the green line is the MWF. The vertical lines are unassigned faults. Dashed lines or any color are from other area seismic data. Refer to Figure B-1 for the orientation of the data.

using 10 foot group intervals. The yellow horizon is crystalline
 ark red is the Cape Fear Fm., the pink is the Middendorf Fm. and
 are interpreted faults. If present, the red line is the Crackerneck
 STA Fault and the orange line is the Steed Pond Fault. Yellow
 projections of the associated faults through this seismic line from
 data through the study area.

Figure B-12. Seismic line A-5. These vibroseis data were correlated to the basement "rock", defined from the change in acoustic velocity. The orange is the McQueen Branch Confining Unit. The vertical line is the Lost Lake Fault, the pink line is the Lost Lake Fault, the green line is the Lost Lake Fault. Vertical lines are unassigned faults. Dashed lines or any color lines are unassigned faults. Refer to Figure B-1 for the orientation.

ained using 10 foot group intervals. The yellow horizon is crystalline
. The dark red is the Cape Fear Fm., the pink is the Middendorf Fm. and
al lines are interpreted faults. If present, the red line is the Crackerneck
the MWESTA Fault and the orange line is the Steed Pond Fault. Yellow
are projections of the associated faults through this seismic line from
of the data through the study area.

Figure B-13. Seismic line MCB-1. These vibroseis data were obtained from the basement "rock", defined from the change in acoustic velocity. The orange is the McQueen Branch Confining Unit. The vertical line is the Lost Lake Fault, the pink line is the Lost Lake Fault, the green line is the McQueen Branch Confining Unit. Dashed lines or any color are other area seismic data. Refer to Figure B-1 for the orientation of the

d using 5 foot group intervals. The yellow horizon is crystalline
 dark red is the Cape Fear Fm., the pink is the Middendorf Fm. and
 s are interpreted faults. If present, the red line is the Crackerneck
 ESTA Fault and the orange line is the Steed Pond Fault. Yellow
 projections of the associated faults through this seismic line from
 data through the study area.

Figure B-14. Time slices from the three dimensional seismic data. Each panel is labeled and is a specific time-depth slice in amplitude. Bright colors indicate low amplitudes. The horizontal lines on each panel represent each tenth cross-line and the vertical lines indicate each tenth in-lines. The north trending red hachured line is the approximate trend of the Lost Lake Fault.

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Appendix C
Correlation of Deep Borings

Figure C-1. Deep borehole correlation panel flattened on 300' relative to mean sea level. Key stratigraphic units and features are labeled. Gamma ray, calculated gamma ray or total spectral gamma ray data are shown, and blue curves are non-spectral gamma data. Original data are in feet with name and total presentation depth. The number across the tops of the curves refers to the total presentation depth. "Acoustic" refers to the top of the crystalline basement picked from the maximum change in gamma ray. "Midd" is the Middendorf Fm., "MqBCU" is the McQueen Branch Confining Unit, "BC" is the top of the Congaree Fm., "MqBCUtop" is the top of the Congaree Fm., "MqBCUbase" is the base of the Congaree Fm., "Cong" is the top of the Congaree Fm., "Sap" is the top of the Congaree Fm., "CF" is the top of the Congaree Fm., "TR/DB" is the contact between the Tobacco Road and Dry Branch Fms.

atigraphic horizons from the seismic data or from the Appendix A pick table pending on availability. Green curves are total spectral data, red curves are so curve depths are in feet. Each tick mark is 50 feet. Each boring is labeled the difference from the top of the presentation box to the surface elevation. sonic velocities. "Sap" is the saprolite contact, "CF" is the Cape Fear Fm., of the Black Creek Fm., "SC" is the top of the Steel Creek Fm., "LS/SL" is the "H" is the top of the Warlick Hill Fm.. "Santee" is the surface of the Santee

Figure C-2. Deep borehole correlation panel flattened on

the Cape Fear Fm. Each tick mark is 10 feet.

Figure C-3. Deep borehole correlation panel flattened on the McQ

Figure C-4. Deep borehole correlation panel flattened o

the Black Creek Fm. Each tick mark is 50 feet.

Figure C-5. Deep borehole correlation panel flatt

ned on the Steel Creek Fm. Each tick mark is 50 feet.

Figure C-6. Deep borehole correlation panel flattened on the Lang Sy

/Sawdust Landing unconformity. Each tick mark is 50 feet.

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Appendix D Maps

Figure D-1. Subsurface map on top of the crystalline basement "rock" as determined from the seismic data and the deep borings. Elevation are in meters relative to mean sea level. The grid is in UTM coordinates. SRS roads are shown for location. The pattern of seismic data is shown by thick black lines (numbered with shotpoints where data has been interpreted). The Crackerneck Fault is shown as a north trending solid thin black line, the MWESTA, Lost Lake and Steed Pond Faults are shown as NNE trending dashed lines. Faults interpreted from the deepest stratigraphic investigation of Aadland (1997) are shown as dotted lines.

-180 -175 -170 -165 -160 -155 -150 -145 -140 -135 -130 -125 -120 -115 -110 -105 -100 -95 -90 -85 -80

Figure D-2. Subsurface map on top of the Cape Fear Formation as determined from the seismic data and the deep borings.

0° 00'

TN

Figure D-3. Subsurface map on top of the Middendorf Formation as determined from the seismic data and the deep borings.

Figure D-4. Subsurface map on top of the McQueen Branch Confining Unit as determined from the seismic data and unit penetrating borings.

Figure D-5. Subsurface map on top of the Steel Creek Formation as determined from the seismic data and unit penetrating borings.

Figure D-6. Subsurface map on top of the Lang Syne/Sawdust Landing unconformity as determined from the seismic data and unit penetrating borings.

Figure D-7. Subsurface map on top of the Warley Hill Formation as determined from the seismic data and the regional borings.

Figure D-8. Surface map as determined from USGS DEM data.