MCB-CL #365

Box 1 SOW	0 - 37'
Box 1 BOW	36' - 51.5'
Box 2	51.5' - 62.5'
Box 3	62.5' - 72.5'
Box 4	72.5' - 81'.0
Box 5	81.0' - 88.5'
Box 6	88.5' - 97.5'
Box 7	97.5' - 105.5'
Box 8	105.5' - 113'
Box 9	113' - 120'
Box 10	120' - 128.5'
Box 11	128.5' - 135.75'
Box 12	135.75' - 143.25'
Box 13	143.25' - 150.00'
Box 14	150.' - 171.5'
Box 15	171.5' - 180.75'
Box 16	180.5' - ~~[illegible]~~ - 191'
Box 17	191' - 204'
Box 18	204' - 215.5'
Box 19	215.5' 226'

Job No: 365 Project: MCB-CL Date: 3/16/94

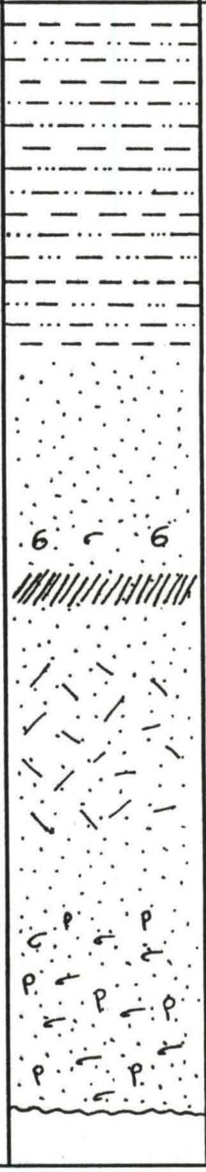
Driller: Alliance Environmental Drilling Method: ~~Hollow Stem Auger~~

Well I.D. SOW-1 Location: Verona Loop Training Area

Core Type: Split spoon Lat. 34 41.76'N Long. 77 27.93'W

Altitude (MSL): 23.5' Log By: Powers/Nelson/Sutton

Depth Interval (ft.)	Description	Graphic Log	Core Box #
5 - 7	Mottled gray-yellow silty CLAY.		
10 - 12	Mottled gray bright reddish-brown silty CLAY.		
15 - 17	Very light gray, very well sorted, medium quartz SAND.		
20 - 22	Grading downward into medium gray carbonate-bearing quartz SAND. Scattered gastropod and brachiopod casts. Sharp contact with bright-red iron-stained medium-coarse quartz SAND with iron nodules.		
25 - 27	Tan, carbonate-bearing, phosphate-bearing, medium quartz SAND. Scattered shell fragments and echinoid spines.		
30 - 32	Medium gray, carbonate and phosphate-bearing, medium quartz SAND. Scattered echinoid plates.		
35 - 37	Medium gray, carbonate and phosphate-bearing, medium quartz SAND. Scattered echinoid plates.		
	Total Depth @ 37'		



Job No: 365 Project: MCB-CL Date: 3/16/94

Driller: Alliance Environmental Drilling Method: ~~Hollow-Stem Auger~~ CONTINUOUS CORE

Well I.D. BOW-1 Location: Verona Loop Training Area

Core Type: 94 mm Lat. 34 41.76'N Long. 77 27.93'W

Altitude (MSL): 23.5' Log By: Powers/Nelson

Depth Interval (ft.)	Description	Graphic Log	Core Box #
36 - 39	Thin bed (<1 ft.) of medium gray carbonate and phosphate-bearing quartz SAND with abundant echinoid plates and other macrofossil fragments. The rest of this core is the same except that the fossils are more scattered.		Box 1
39 - 40	Medium gray, very fine carbonate/quartz SAND.		
40 - 41	Four-inch thick tan bed with a dense accumulation of echinoid plates, with tan, carbonate-bearing, medium quartz SAND.		
41 - 46.5	Medium gray, carbonate-bearing with a trace of phosphate grains, medium quartz SAND.		
46.5 - 51	Tan, silty carbonate/quartz medium SAND with abundant phosphatic and calcareous skeletal fragments (bones, shark teeth, bryozoans, pectins, and echinoids). Knots of indurated and semi-indurated material.		
51 - 55.5	Indurated to semi-indurated, carbonate cemented quartz and calcareous SANDSTONE with abundant shell fragments.		Box 2
55.5 - 56	Medium gray, carbonate/quartz fine SAND with small phosphatic and calcareous skeletal material.		
56 - 57.5	Medium gray, calcareous/quartz fine SAND with scattered calcareous fossil fragments.		

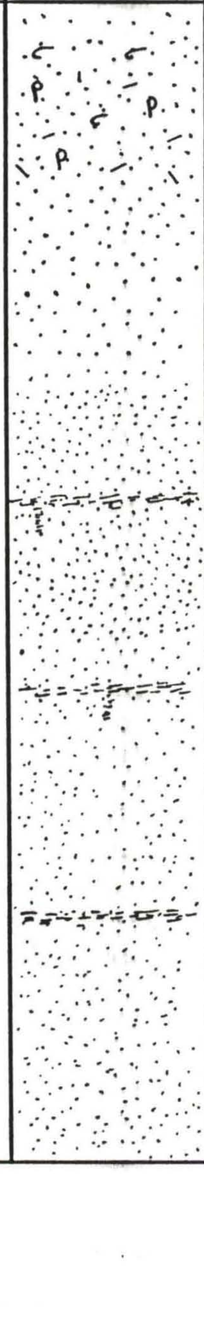
Job No: 365 Project: MCB-CL Date: 3/16/94

Driller: Alliance Environmental Drilling Method: Hollow-Stem Auger

Well I.D. BOW-1 Location: ~~Verona Loop Training Area~~

Core Type: 94 mm Lat. 34 41.76'N Long. 77 27.93'W

Altitude (MSL): 23.5' Log By: Powers/Nelson

Depth Interval (ft.)	Description	Graphic Log	Core Box #
57.5 - 61	Dark gray, quartz/calcareous, minor phosphate and/or heavy minerals, very fine SAND.		Box 2
61 - 61.1	Dark gray, quartz/calcareous, very fine SAND with abundant calcareous and phosphatic skeletal fragments.		
61.1 - 71	Dark greenish gray, quartz/calcareous very fine SAND with trace of phosphate or heavy minerals sand. Grading downward into dark gray, quartz/calcareous SILT with trace phosphate or heavy minerals. No visible bedding (massive).		Box 3
71 - 135	Dark greenish gray, quartz/calcareous clayey SILT with trace phosphate or heavy minerals. No visible bedding (massive). Occasional thin, light-colored lamination and dark gray burrows from 90'-93'.		72.5' Box 4 81.0' Box 5 88.5' Box 6 97.5' Box 7 105.5' Box 8 113' Box 9 120' Box 10 128.5' Box 11

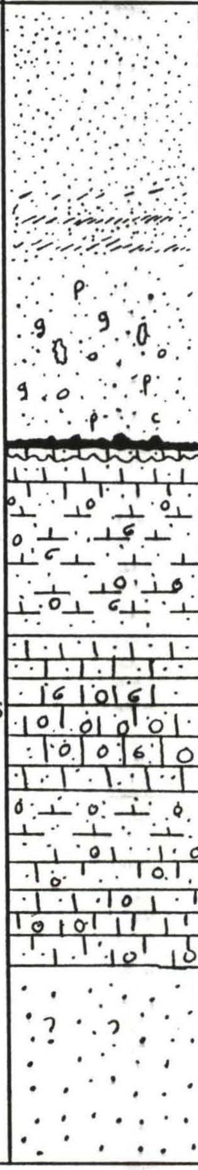
Job No: 365 Project: MCB-CL Date: 3/16/94

Driller: Alliance Environmental Drilling Method: ~~Hollow-Stem Auger~~

Well I.D. BOW-1 Location: Verona Loop Training Area

Core Type: 94 mm Lat. 34 41.76'N Long. 77 27.93'W

Altitude (MSL): 23.5' Log By: Powers/Nelson

Depth Interval (ft.)	Description	Graphic Log	Core Box #
135 - 143.25	Blebs of lighter colored silt in dark gray, quartz/calcareous SILT. May be becoming finer downward.		Box 12
143.25 - 145	Grading downward into olive gray, quartz/calcareous SILT with wisps, laminations, and blebs of very light gray which may be carbonate(?).		Box 13
145 - 148	Olive gray, quartz/calcareous SILT with scattered sand to pebble-sized phosphate grains, increasing in abundance downward.		
148	Black, thin microsphorite crust.		
148 - 149	Cream-colored with minor glauconite, very porous, bryozoan BIOSPARUDITE, indurated but slightly friable. Fossils coarsen downward.		
149 - 150	Deep green, glauconitic/iron phosphate(?) crust, grading downward into light gray bryozoan, gastropod-bearing, pelecypod-bearing BIOMICRUDITE with numerous vugs and porous zones.		
150 - 156.5	Light bluish-gray, dense, mold and cast, pelecypod-bearing BIOMICRUDITE.		Box 14
156.5 - 157	Light gray, hard, vuggy, mold and cast, bryozoan, pelecypod, BIOMICRUDITE with phosphate and glauconite grains.		
157 - 161	Driller estimates SAND. No recovery.		

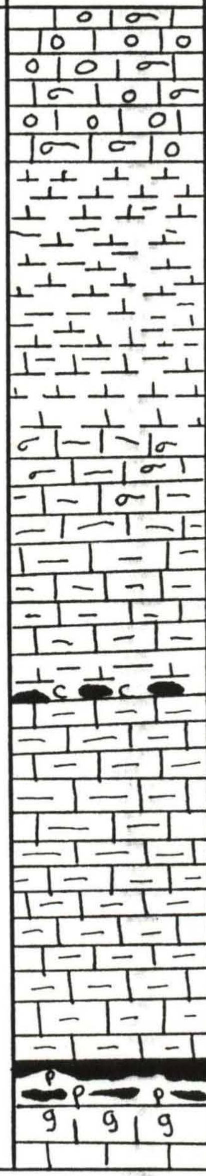
Job No: 365 Project: MCB-CL Date: 3/16/94

Driller: Alliance Environmental Drilling Method: ~~Hollow-Stem Auger~~

Well I.D. BOW-1 Location: Verona Loop Training Area

Core Type: 94 mm Lat. 34 41.76'N Long. 77 27.93'W

Altitude (MSL): 23.5' Log By: Powers/Nelson

Depth Interval (ft.)	Description	Graphic Log	Core Box #
161 - 166	Interbedded light gray vuggy BIOMICRUDITE. Pelecypods, gastropods, large whole irregular echinoid fossil, with alternating approximately one-foot thick gray lime mud intervals. Poor recovery. Porosity looks high.		Box 14
166 - 171.5	Grading downward into light gray sandy MICRITE. Semi-indurated with minor glauconite. Fossils not visible. Low porosity.		
171.5 - 176	171.5 Semi-indurated zone with interspersed bright green authigenic glauconite.		Box 15
175.5 - 180.75	Light gray-tan, slightly sandy bryozoan-bearing BIOMICRUDITE. Lime cement is semi-indurated but looks very tight. Porosity looks low.		
180.75 - 191	Light tan, slightly sandy, bryozoan BIOMICRITE. Fossils are sparse and hard to see. Lime cement is semi-indurated but looks very tight. Porosity looks low. Chert horizon is one to two inches at 186 feet.		Box 16
191 - 204	Light tan, slightly sandy, bryozoan-bearing BIOMIC-RUDITE. Fossils are sparse. Lime cement is semi-indurated but looks very tight. Porosity looks low.		Box 17
204 - 205	Same as above but grading downward into tan BIOMICRUDITE with glauconite-filled burrows. Porosity still low.		Box 18
206 - 206.5	Hard gray/bright green/dark brown BIOLITHRUDITE with mixed phosphate/glauconite crust/clasts and encrusting bryozoans. Looks like diastemic surface. Porosity increasing dramatically from above.		

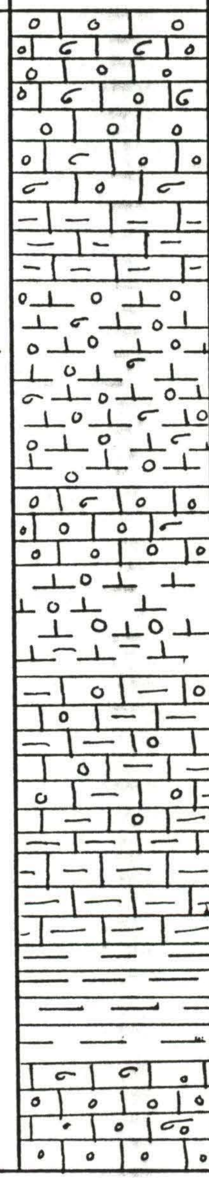
Job No: 365 Project: MCB-CL Date: 3/17/94

Driller: Alliance Environmental Drilling Method: ~~Hollow-Stem Auger~~

Well I.D. BOW-1 Location: Verona Loop Training Area

Core Type: 94 mm Lat. 34 41.76'N Long. 77 27.93'W

Altitude (MSL): 23.5' Log By: Powers/Nelson

Depth Interval (ft.)	Description	Graphic Log	Core Box #
206.5 - 211	Light gray, molluscan BIOLITHOMICRUDITE. Very hard, moldic with numerous clasts and fragments of glauconite and phosphate pebbles. Porosity looks high.		Box 18
211 - 215.5	Friable molluscan hash BIOSPARUDITE with abundant phosphate/glauconite grains grading downward into muddier matrix.		
215.5 - 218	Light greenish-gray, muddy molluscan hash BIOLITHO-MICRUDITE with abundant glauconite and phosphate grains.		Box 19
218 - 225	Light greenish gray, vuggy, very hard molluscan BIOMICRUDITE. Porosity looks very high.		
225 - 233	Light gray, semi-indurated and friable bryozoan, molluscan BIOLITHOMICRUDITE. Porosity looks moderate.		Box 20
233 - 251	Light gray-greenish gray, well lithified molluscan BIOMICRUDITE grading downward into BIO-SPARUDITE. Porosity looks moderate.		
251 - 260	Light gray-light greenish gray, soft, muddy, very friable BIOLITHOMICRUDITE. Porosity looks moderate to low.		Box 21
260 - 271	Greenish gray, moderately well lithified molluscan bryozoan BIOSPARUDITE. Glauconite and phosphate common. Porosity looks very high.		Box 22

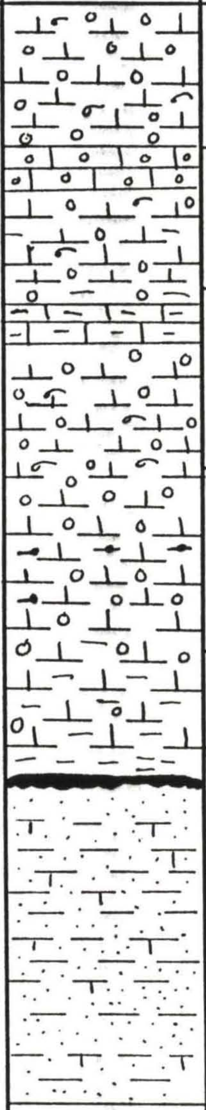
Job No: 365 Project: MCB-CL Date: 3/18/94

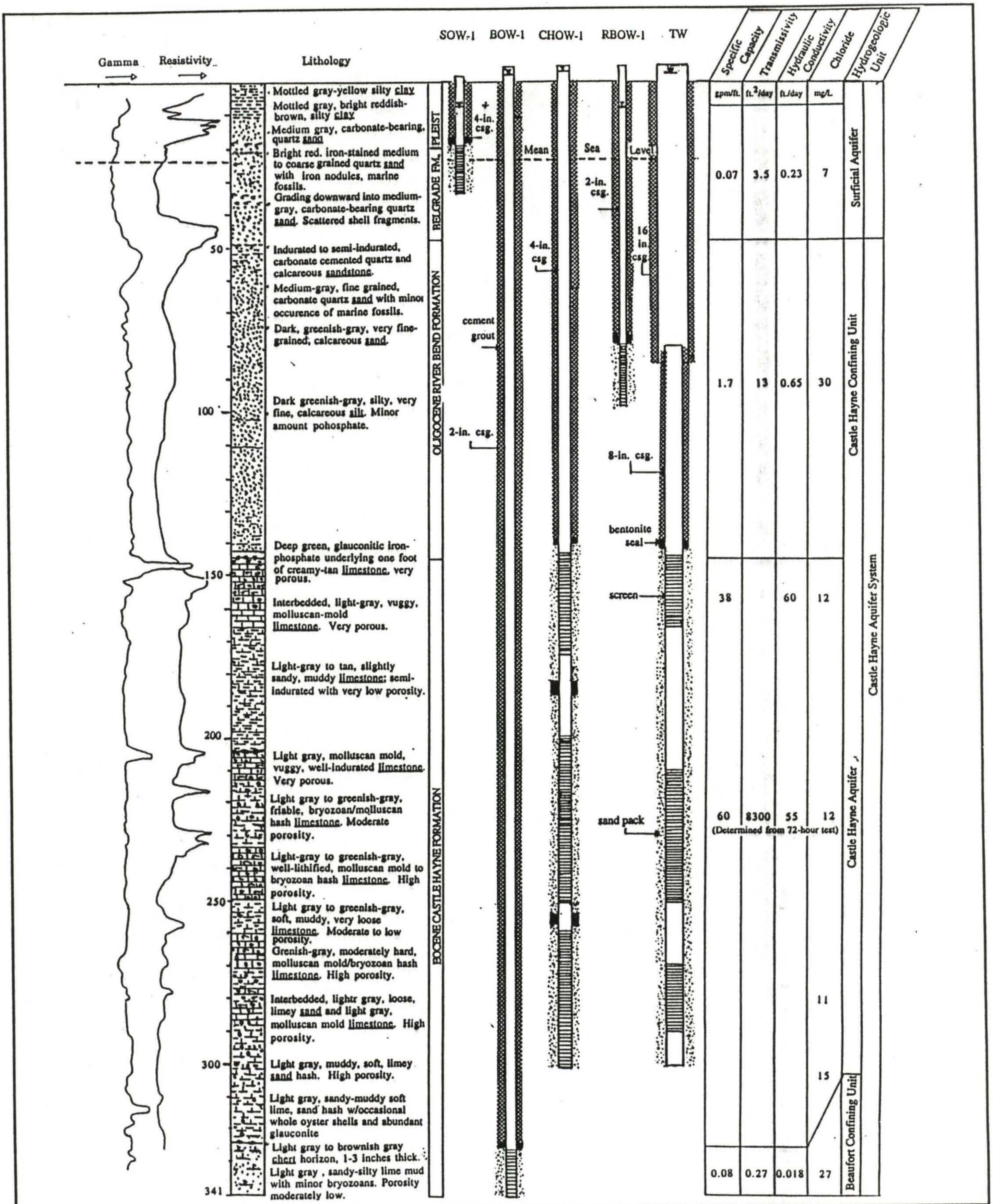
Driller: Alliance Environmental Drilling Method: Hollow-Stem Auger

Well I.D. BOW-1 Location: Verona Loop Training Area

Core Type: 94 mm Lat. 34 41.76'N Long. 77 27.93'W

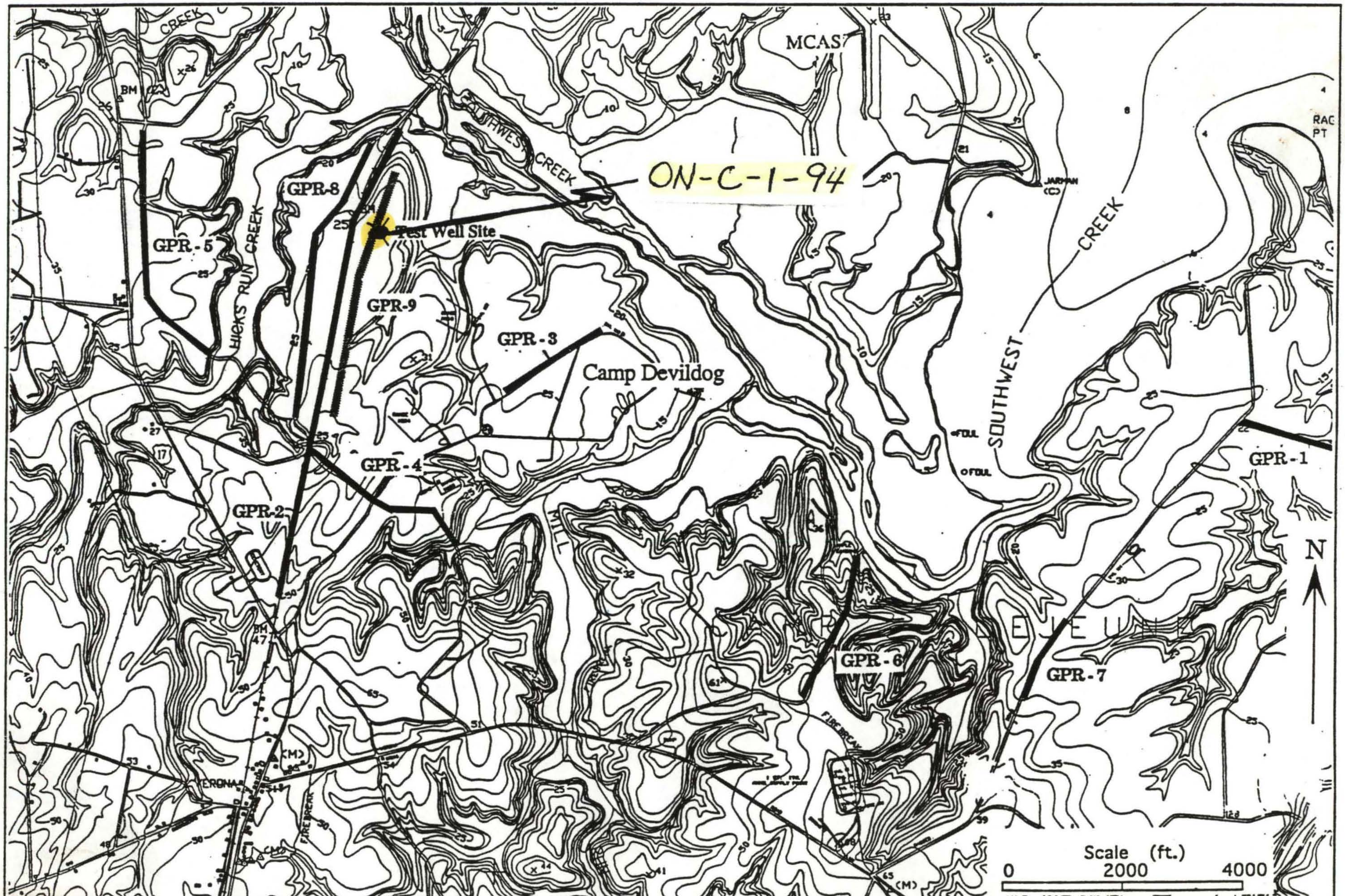
Altitude (MSL): 23.5' Log By: Powers/Nelson

Depth Interval (ft.)	Description	Graphic Log	Core Box #
271 - 292	Interbedded, light gray loose CALCARENITE/light gray muddy BIOMICRUDITE and moderately lithified molluscan mold BIOSPARUDITE. Porosity looks very high.		Box 22
292 - 301	Light gray, muddy soft BIOLITHOMICRUDITE with abundant glauconite. Porosity looks moderately good.		Box 23
301 - 318	Same as above with alternating zones of greater mud content and lower porosity.		Box 24
318 - 326	Light gray, sandy/muddy BIOLITHOMICRUDITE with occasional glauconite pebbles and large whole oyster shells that look like original shell material. Produces a large gamma kick.		Box 25
326	Dark brownish gray, two-inches thick chert horizon.		
326 - 331	Medium gray, friable, silty, pebbly, sandy lime MUD. No large fossils visible but common small trepestome (branching) bryozoans. Porosity looks moderately low. May be Pee Dee(?).		Box 26
	Bottom of core hole at 331 feet.		



Geophex

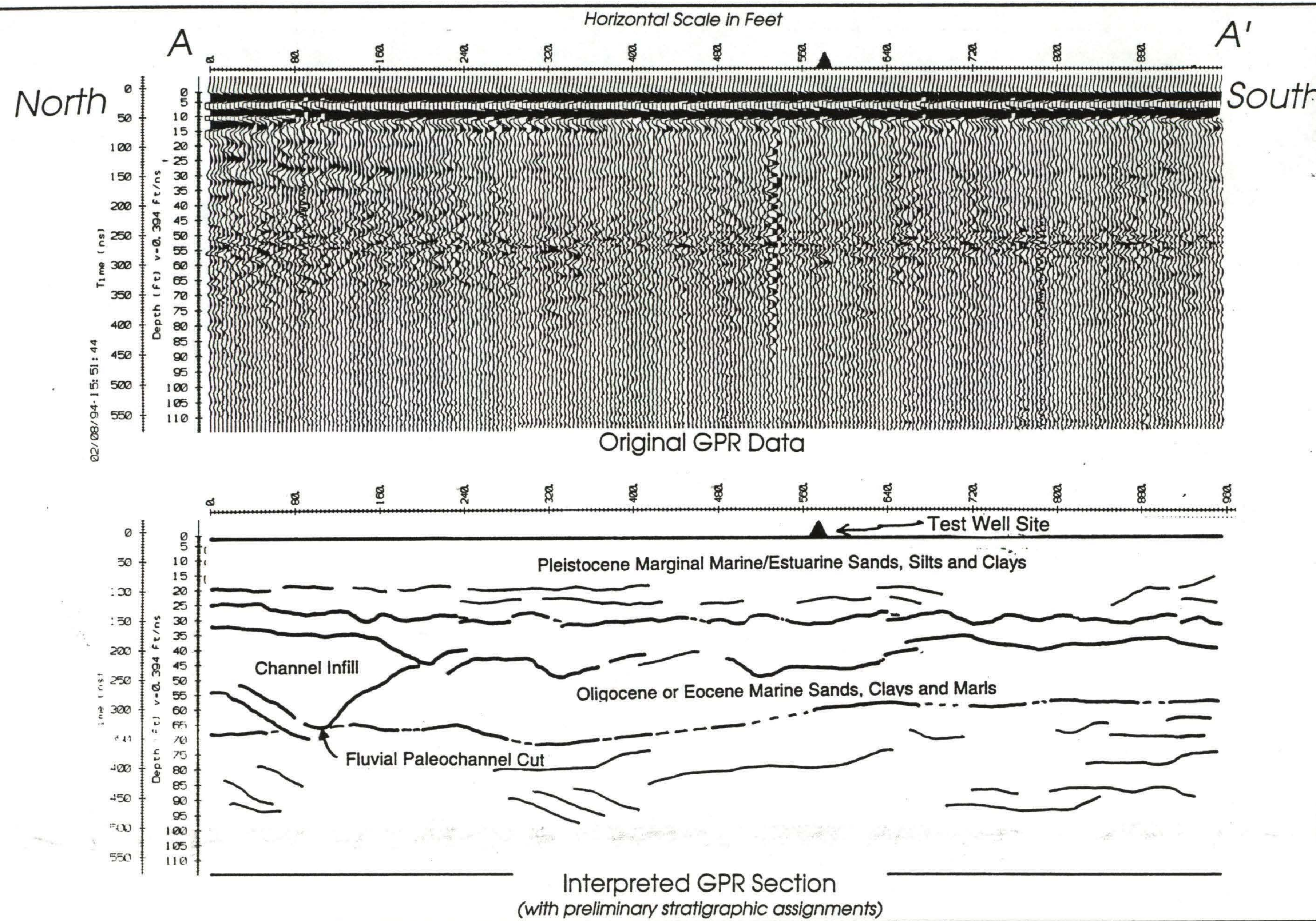
Figure 30. Stratigraphic section showing the depth and thickness of strata encountered in boring BOW-1, along with a scaled drawing of each test and observation well and key hydrologic parameters.



Geophex

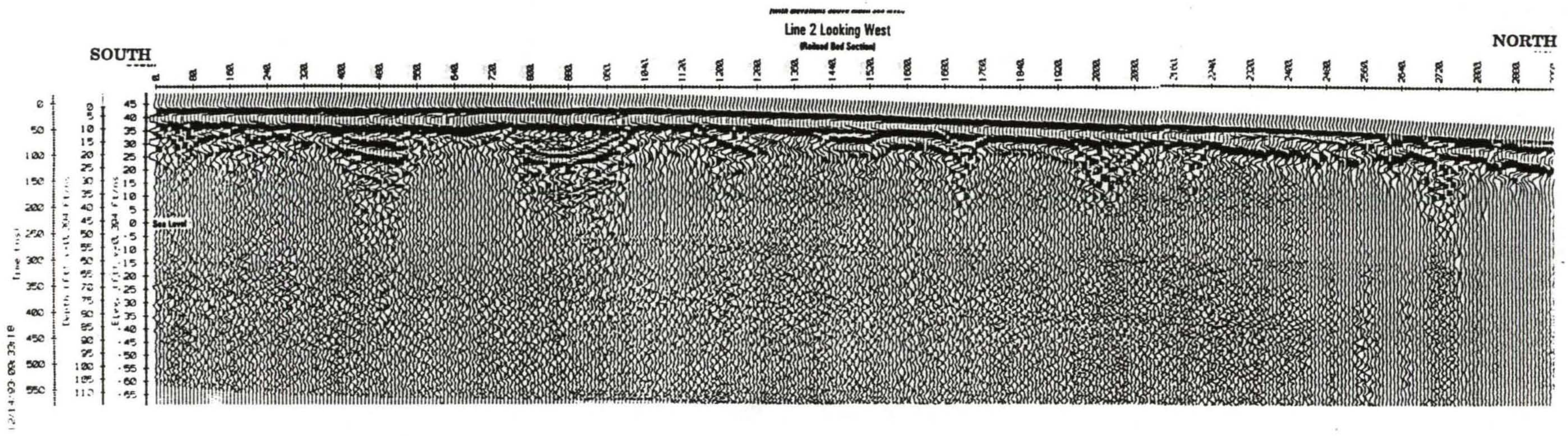
Figure 17. Locations of GPR profiles collected during this investigation.

JACKSONVILLE SOUTH 7.5 QUADRANGLE



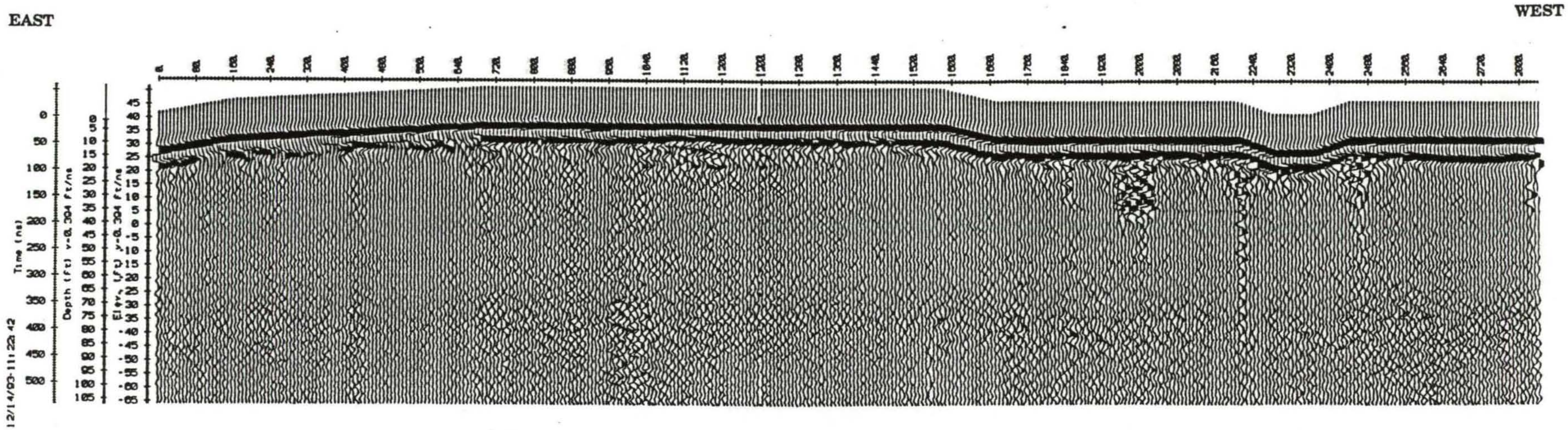
Geophex

Figure 21. Original and interpreted profiles of GPR data collected on GPR-9 along the eastern side of the former rail bed between Southwest Creek and Mett-T Road.



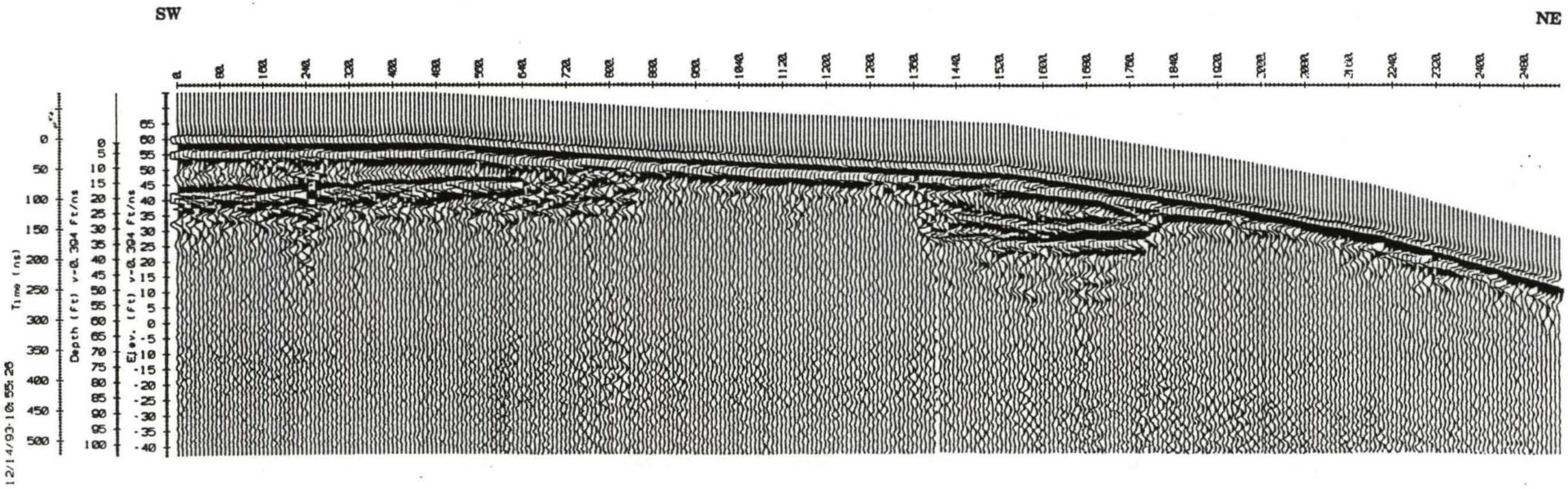
Geophex

GPR Line 2. Located along abandoned railroad bed between Mett-T road and Southwest Creek. (see index map, Figure 6)



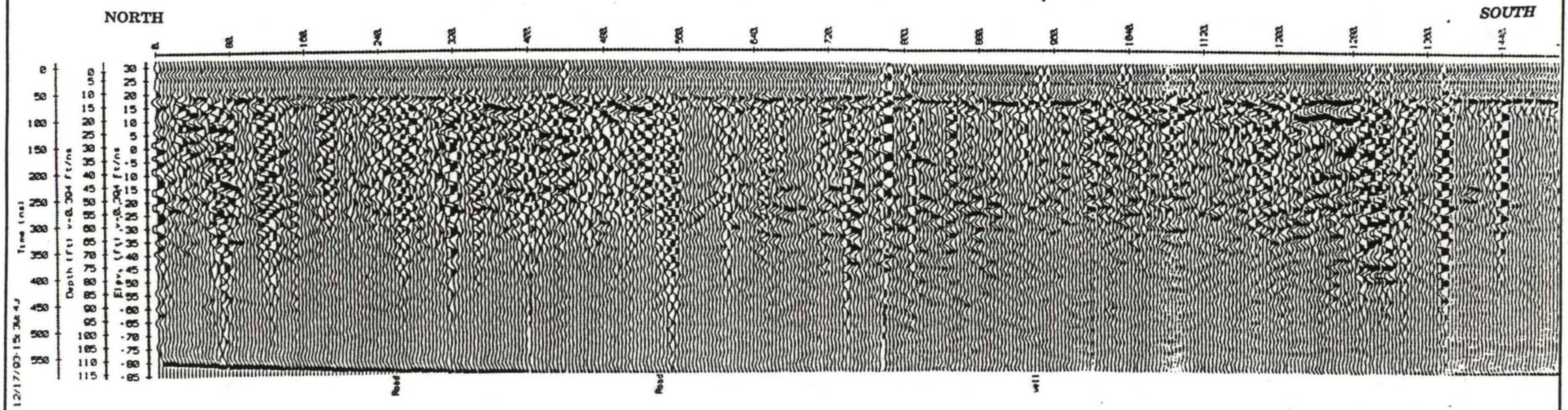
Geophex

GPR Line 4 Located on Mett-T road between Mill Run and railroad bed.
(see index map,Figure 6)



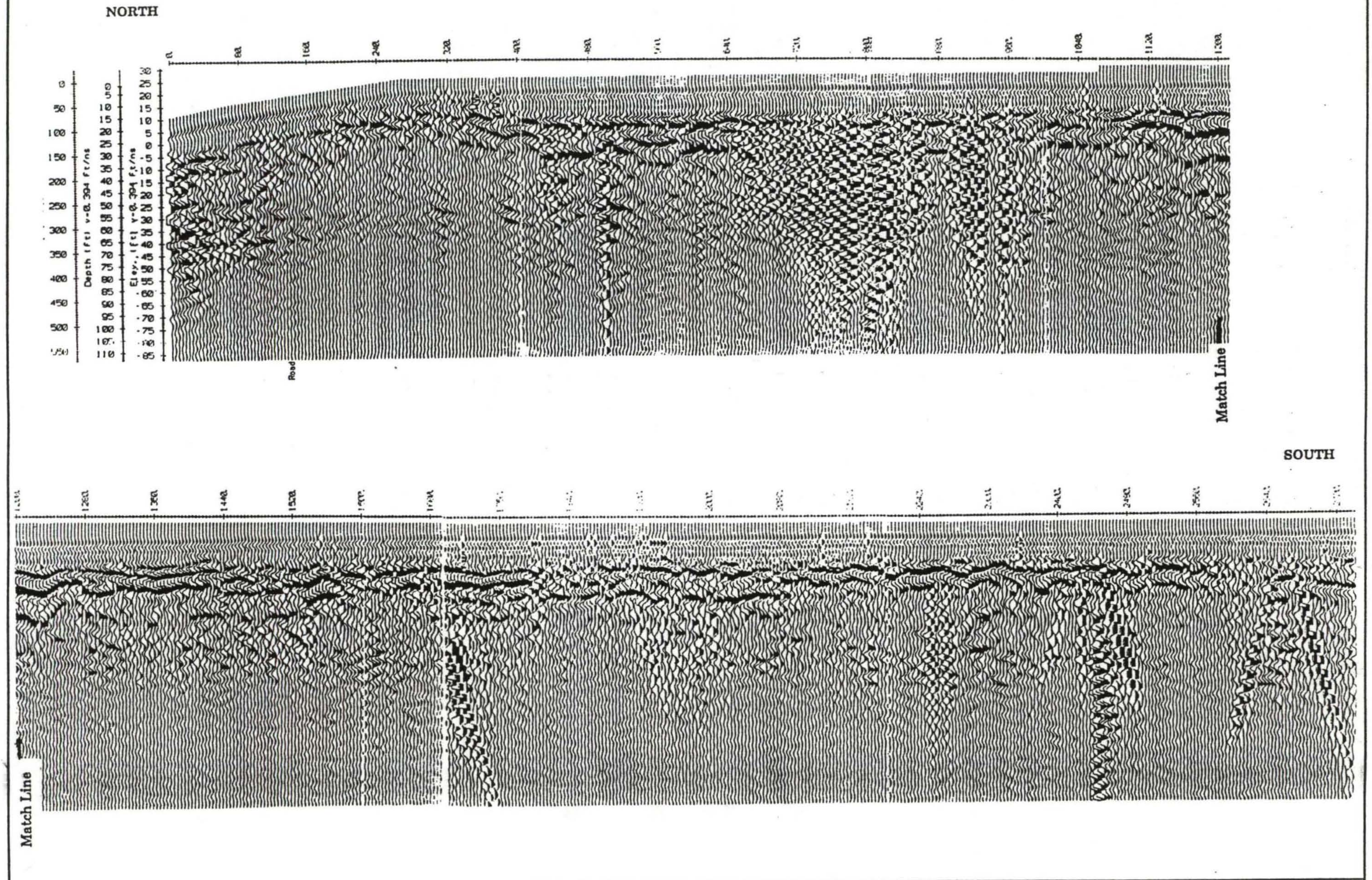
Geophex

GPR Line 6 Located on Maple Landing road. (see index map,Figure 6)



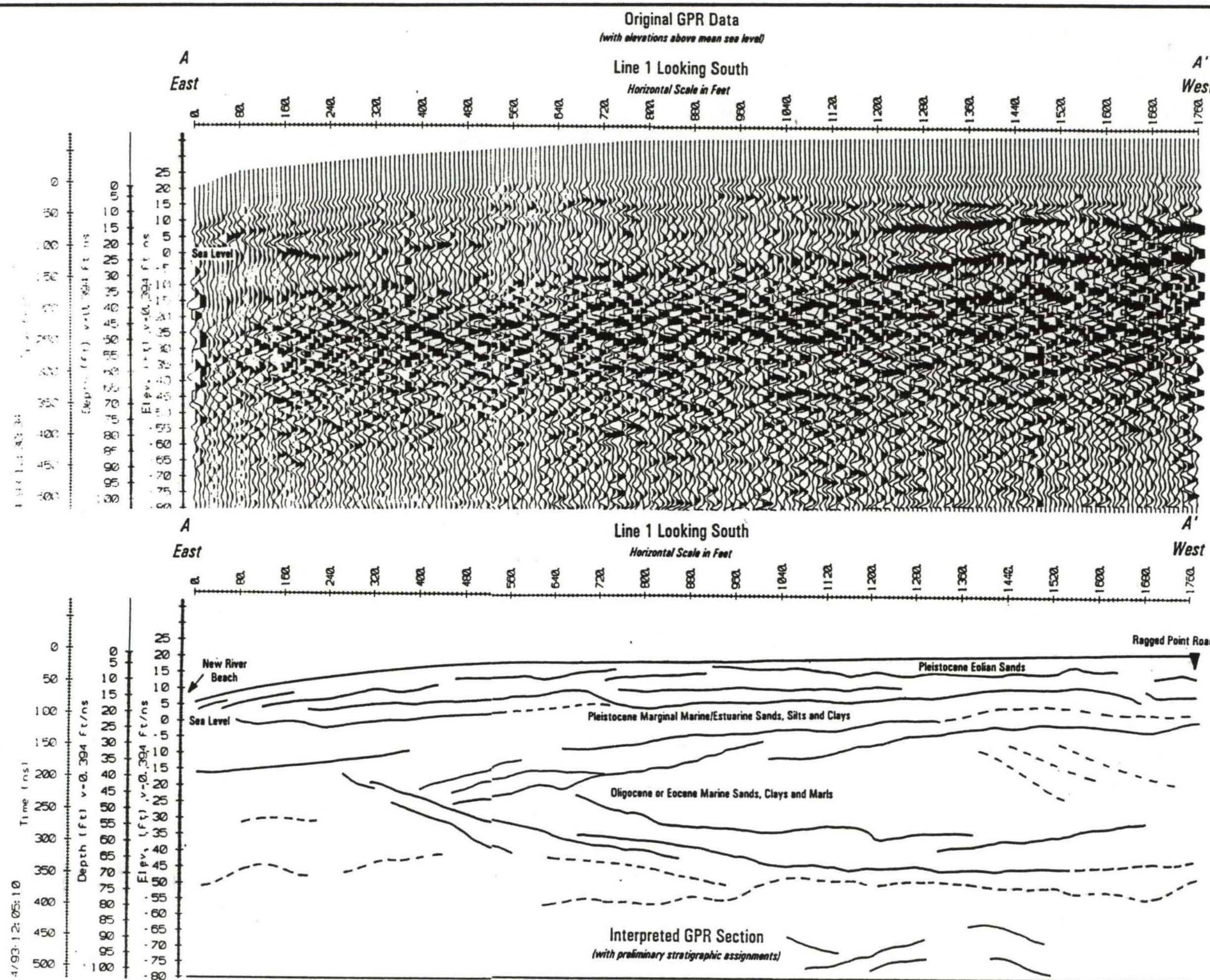
Geophex

GPR Line 7 Located On Ragged Point road, about 1.7 miles north of Mett-T road. (see index map,Figute 6)



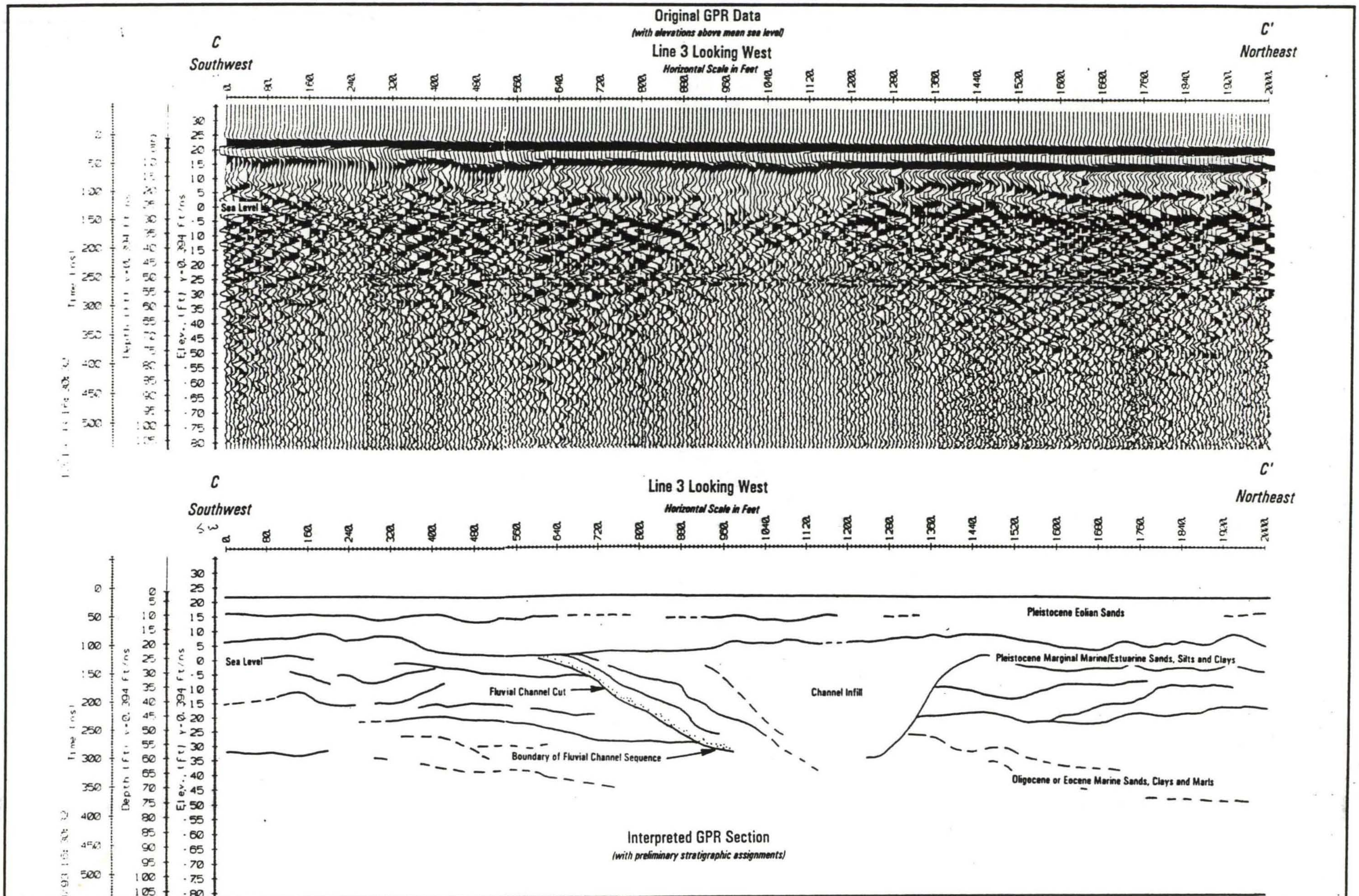
Geophex

GPR Line 8 Located on dirt road paralleling railroad bed, between Mett-T road and Southwest Creek. (see index map, Figure 6)



Geophex

Figure 18. Original and interpreted profiles of GPR data collected on GPR-1 near Ragged Point.



Geophex

Figure 19. Original and interpreted profiles of GPR data collected on GPR-3 along Perimeter Road in Camp Devildog.

determining aquifer transmissivity and storage coefficient which are needed to design an efficient well field. The drilling program also permits us to "ground truth" our interpretations of geophysical surveys by directly examining rocks beneath the site. Combined, these data allow us to extrapolate our assumptions about the distribution and character of water bearing units over a broader area with minimal intrusive activity. Ultimately, our objective was to formulate a conceptual model of the geology and hydrogeology of the area that could be used to determine the optimal design parameters for the future well field.

7.1 Core Drilling and Observation Well Installation

For the test well site, we selected an area adjacent to the east side of the former railroad bed, 1,300 feet south of Southwest Creek (Figure 29). We chose this location because it marks the northern limit of the well field where we could reasonably expect to avoid surface water recharge as a consequence of pumping and it provided access to a nearby ditch where water could be discharged. A summary of the borings and wells is presented in Figure 30 and Table 2. Detailed boring logs are included in Appendix B.

Geophex commenced drilling operations on March 4, 1994 with the drilling and installation of shallow observation well (SOW-1) to a depth of 37 feet. During drilling operations, we collected split spoon samples every five feet. We installed a four-inch well in the bore hole and screened it between +2 and -13 feet msl in the Surficial Aquifer. Cardinell and others, 1993 mapped the top of the CHAS (which includes the Pollocksville Member of the Belgrade Formation and Riverbend Formation strata) at 0 to +5 feet msl in the Verona loop area; thus SOW-1 is screened in the uppermost portion of this hydrogeologic unit. We did not encounter a confining unit between the surficial aquifer and the upper portion of the CHAS.

After completing SOW-1, we advanced a deep (341 ft) exploratory core hole and observation well called Beaufort Observation Well #1 (BOW-1) 20 feet northeast of SOW-1. Together, these two borings form a composite stratigraphic section of site strata. Corresponding geophysical logs, observation well construction diagrams, and preliminary water quality and hydrogeologic data for SOW-1 and BOW-2 are also summarized in Figure 30 and Table 2.

We collected core samples from BOW-1 at depths of -10 to -317 feet msl (341 feet below land surface) using a Christensen 94 mm wire-line coring rig and the mud rotary drilling method. Samples were recovered from the surficial aquifer, the CHAS and the Beaufort Confining Unit. Core recovery rates over each 10-foot sample interval varied between 15 and 100 percent Most core runs exceeded 50% recovery. We obtained highest recoveries in unindurated silty and clayey zones of the upper CHAS (Belgrade and Riverbend Formations) but achieved considerably lower recoveries in loose shelly zones of the Castle Hayne Formation (lower CHAS). Indurated 'hardrock' zones in Castle Hayne Formation yielded moderately good (50-75 percent) recovery rates. Photographs of each lithology are shown in Figures 31a through 31d.

BOW-1 penetrated a sequence of fluvial, marine, and estuarine sediments ranging from unconsolidated sands, silts and clays to indurated impure limestones. As in SOW-1, the uppermost 20 feet of sediments consist of interbedded fine sands, silts and clayey silts that comprise the Surficial Aquifer. We assign these beds to undifferentiated Pleistocene and Holocene strata described by Cardinell and others (1993). Soils developed in near-surface strata are clayey and appear to have relatively low permeabilities. We observed similar soil profiles at several outcrop and hand auger sites sitewide during our Task 3 investigation.

Surficial Aquifer sediments are underlain by 120 feet of fine sands that grade downward into silts and clayey silts. We assign the upper strata of this sequence to the Oligocene age Pollocksville Member of the Belgrade Formation and the lower portion to the River Bend Formation of Ward and others (1986). Because lithology is somewhat dissimilar from the type section, this lower stratum may be only partially assignable to the River Bend Formation but for simplicity we will retain this formational name. Harned and others (1989) and Cardinell and others (1993) included the Belgrade and River Bend Formations in their CHAS.

Several thin (2-10 ft) shell beds are interspersed with fine to medium sand beds in the upper Pollocksville Member between +4 and -36 feet msl. Porosity and permeability in these beds appear higher than those in intervening sand beds. Porosity abruptly decreases downward at the contact with the underlying Riverbend Formation (-36 to -121 ft) which consists of very fine sand grading downward into fine clayey silt.

We encountered indurated shelly limestone at -121 feet msl. The uppermost 2 feet of this material consists of very porous shell hash limestone that may be assignable to overlying Oligocene age strata. A thin (2-3 inch thick) dark green to black, very well-indurated phosphate/glauconite crust occurs at 124 feet and overlies 20 feet of hard light gray moldic limestone. We consider the phosphatic crust to mark the upper erosional surface of the Castle Hayne Formation as described by Ward, Lawrence and others (1978).

The uppermost 20 feet of Castle Hayne Formation limestone appears to have moderate to high secondary moldic porosity. Poor core recovery in this interval suggests that some interbeds are only loosely consolidated and may have very high porosity.

A 35-foot thick section of light gray to tan, dense but friable muddy limestone occurs between -146 and -281 feet msl. Porosity appears greatly reduced in this zone which probably forms a confining or semi-confining layer between the uppermost Castle Hayne Aquifer zone and the lower portion of the aquifer. A thin (2-3 inch thick) dark green to black, very well-indurated phosphate/glauconite crust marks the base of the confining layer.

Beneath the phosphate crust, is a 120-foot thick sequence of hard, gray moldic limestone interbedded with hard shell-hash limestone and unindurated shell hash zones. Porosity is extremely high over much of this interval with the exception of a 10-foot thick section of very muddy, unindurated limestone between -226 and -236 feet msl. Reduced porosity in this zone probably creates a semi-confining zone that separates highly porous middle Castle Hayne Aquifer beds from the lowermost part of the aquifer.

At 326 feet msl, a thin (2 to 3-inch) lens of dark brown chert marks the base of the Castle Hayne Aquifer. Sediments directly overlying the chert consist of silty unindurated limestone with scattered well-preserved scattered oyster shells. Below the chert lens is a light gray sandy silt with minor fossil (bryozoan) content. Porosity in the sandy silt appears very low and it is our conclusion that this horizon represents the Beaufort Confining Unit of Cardinell and others (1993) although lithologically, the sediment is probably a basal facies of the Castle Hayne Formation. We did not encounter any strata that we consider assignable to the Beaufort Formation.

We screened the BOW-1 observation well between -313 and -318 feet msl with 2-inch PVC screen. This screen position places BOW-1 in what we will refer to as the Beaufort Confining Unit.

A third observation well called CHOW-1 (for Castle Hayne Observation Well) was installed 20 feet northeast of BOW-1 and screened in three highly porous zones of the CHAS between -121 and -276 feet msl. Each zone is separated by zones that we considered low in porosity based on our visual inspection of the core material.

7.2 Borehole Logging

Geophex ran geophysical logs on both BOW-1 and CHOW-1 including single point resistivity, spontaneous potential (SP) and natural gamma. The resistivity and gamma logs are presented on the left column of Figure 30. A copy of the original log is provided in Appendix E. Although SP varied over a small range throughout the test interval, resistivity and gamma logs correspond to lithologic changes recognized in the core.

In near surface intervals, we encountered highest resistivity values (125 ohm-meters or Ω -m) in saturated fine to medium quartz sands of the Surficial Aquifer. Resistivity varies between 25 and 110 Ω-m downward throughout the upper CHAS, increasing intermittently in response to shelly interbeds within the Pollocksville Member. A sudden increase in resistivity at 145 feet marks the top of a thin bed of shelly limestone that is probably a pre-Riverbend Formation unit. Resistivity continues to increase downward into the Castle Hayne Formation which is capped with well-indurated moldic limestone. Between 150 and 300 feet, seven prominent resistivity peaks correspond to well-indurated limestone beds that alternate with loosely consolidated shelly limestone and clayey limestone.

Natural gamma peaks coincide with two different lithologic features. The first, occurs at -27 feet msl in the Pollocksville Member where thin shell hash beds are interbedded with otherwise clean quartz sands. The most prominent peak coincides with a five-foot thick layer of barnacle and echinoid hash that marks the base of the unit. It is not clear which lithologic constituents at this interval produce a gamma response although it is possible that abundant carbonate shell material at this interval contains gamma emitting isotopes. The second peak-producing lithology is the thin phosphatic crust that mark the top and middle of the Castle Hayne Formation at -122 and -182 feet msl respectively. These anomalies are particularly useful geophysical markers for determining the depth to highly porous water-bearing zones.

7.3 Regional Aquifer Trends

Figure 32 is a composite structure contour map of the upper surface of the Castle Hayne Formation based on borings and observation well data at our test site and from other drill-holes advanced by the Base and interpreted by Harned and others (1989), and from cross-sections prepared from test borings drilled by the US Geological Survey (Brown and others, 1972). The map shows the VLTC site is located in an embayment formed in the upper surface of the Castle Hayne Formation. The Oligocene age Belgrade and Riverbend Formations were deposited in this relatively quiet basin where they were preserved as a sequence of mostly fine-grained sediments.

This map is different from the structure contour maps of Cardinell and others (1993) in that it represents the upper surface of the porous limestone within the Castle Hayne Formation rather than the CHAS as a whole. Tracing the top of the Castle Hayne Formation is important because its limestone beds comprise the most prolific aquifers within the CHAS.

7.4 Observation Well Aquifer Testing and Analysis

7.4.1 Pre-pumping Conditions

Immediately following construction, both CHOW-1 and BOW-1 flowed freely when cased to land surface. The addition of nearly 5 feet of riser, allowed water levels in both wells to rise to 5 feet above the surrounding land surface, an elevation of +27.5 feet msl.

We continued to monitor static water levels in the observation wells during the period March 3 through May 5, 1993 and found that the lower CHAS exists under artesian conditions, confined beneath the overlying silty sediments of the upper CHAS (Riverbend Formation).

Figure 33 is a hydrograph for the observation wells for the period March 23 through May 5, 1994. Following record rainfalls in early March, both SOW-1 and RBOW-1, which are screened in the Surficial Aquifer and upper CHAS respectively, maintained static heads that were 7 to 13 feet lower in elevation than those measured in the deeper CHOW-1 and BOW-1 wells which are both screened in the lower CHAS. During the same period, heads declined by almost 4 feet in the SOW-1 and RBOW-1 while they rose by 2.5 feet in the deeper wells.

pole/corer, we measured mid-channel depths in Southwest Creek at nine locations starting the trestle eastward for 1,500 feet. Water depths range from 12 to 19.5 feet at the center of the main channel (points 1-6 in Figure 16). We encountered shallower depths in subordinate channels that parallel the southwestern side of the main channel.

At each sounding point, we probed beneath the creek bed through soft peat deposits until the hard basal formation was encountered. At several locations, as much as 10 feet of peat overlie fine-brown, organic-stained sand that presumably forms the basal formation or paleo-stream bed. The average depth to the sand sub-bottom is 14 feet with some areas as deep as 19.5 feet where the basal formation is completely scoured bare of all peat. Fossiliferous sands containing echinoid plates and spines are exposed on the creek bed 900 feet east of the trestle, suggesting that the exposure is correlative with similar sediments encountered in auger holes (HA-2a and HA-2b) south of Camp Devildog. These sediments are probably part of the Pollocksvile Member of the Belgrade Formation.

Assuming the level of the creek was at or near sea level at the time of our survey, these measurements indicate that the channel has cut into the upper CHAS to a considerable depth and therefore may provide a hydraulic connection between the creek and the upper aquifer.

6.0 Site Geophysical Surveys

Geophysical surveys were conducted to determine the distribution and geometry of post CHAS strata and to detect the presence of elevated chlorides at depth. A ground-penetrating radar (GPR) survey was conducted at select locations across the site in an effort to meet the first of these objectives. The second objective was addressed by a vertical electrical sounding survey conducted at broadly distributed points.

6.1 Ground-penetrating Radar Survey

GPR surveys were conducted at eight sites in or near the boundary of the area. The locations of the surveys are shown in Figure 17. The data and corresponding interpretations of profiles GPR-1, -3, -5, and -9 are shown in Figures 18, 19, 20, and 21 respectively. Other profiles are included in Appendix C.

6.1.1 GPR Technology Review

GPR employs an extremely short electromagnetic pulse that is directed into the earth. A small portion of the pulse energy is reflected back to the surface where the return signal is continuously recorded in a digital storage device. Amplitude of the reflected pulse depends primarily on dielectric constant, a basic property of the geologic material. GPR reflections occur when there is a contrast in bulk dielectric properties between adjacent materials, such as sedimentary formations having different mineralogical compositions or fluid contents. In the case of this study, GPR reflections are likely to occur where sand, clay or limestone layers are in direct contact with each other.

6.1.2 GPR Survey Data

GPR-1 is a 1,760 foot, east-west traverse located on a dirt road extending from Ragged Point Road near TLZ Eagle, to the shore of New River, a short distance north of the mouth of Lewis Creek (Figures 17 and 18). Although it is outside the area, we selected this location because of its proximity to outcropping strata on the bluffs along the shore of the peninsula, and to the nearby USGS #4 monitor well.

Two relatively strong sub horizontal reflectors occur in the uppermost 40 feet. As indicated in Section 5.1, these beds are interpreted to represent post-CHAS strata, deposited in a marginal marine or estuarine environment. Our observations of nearby outcrops suggest that the upper part of the sequence is capped by a thin discontinuous veneer of eolian (windblown) sand. The upper reflector (at approximately sea level) coincides with a dense, gray, clay bed that crops out on the bluff shoreline at New River Beach; the second strong reflector coincides with the first shelly limestone bed within the upper CHAS (Pollocksville Member) that occurs in USGS #4 at a depth of -15 feet (msl). Several additional, but weaker reflectors are evident in the profile below -15 feet to as deep as elevation -95 feet. These reflectors are suggestive of interbedded marine sands, clays and limestone beds within the deeper subsurface, presumably within the CHAS.

GPR-3 is located along Perimeter Road on the northwest side of Camp Devildog (Figures 17 and 19). It is approximately 2,000 feet in length and is oriented southwest-northeast. Our geologic interpretation is based, in part on observations of boring samples collected from HA-3 and HA-5. Detailed logs of these borings are presented in Appendix B.

A sequence of mostly discontinuous horizontal and sub-horizontal reflectors are discernible between -30 to +20 feet but are diagonally truncated by several strong reflections suggestive of a fluvial (stream-cut) paleo-channel. Reflectors within the channel infill sequence are not obvious and we are uncertain of how lithologically different this material is from the surrounding horizontal strata.

Reflective strata denoting the upper surface of the CHAS are not recognizable although it is presumed that material beneath an elevation of 0 feet msl is probably within the upper CHAS. If this assumption is correct, the paleo-channel cuts completely through the post-CHAS strata and possibly into the sands and sandy limestones of the Belgrade and River Bend Formations.

GPR-5 is located on the northwestern extension of Mett-T Road, paralleling US 17 on the west and Hicks Run on the east (Figures 17 and 20). The north-south profile is 4,200 feet in length. The upper 10-20 feet of section encountered in profile GPR-5 are closely correlative with strata encountered in the Hicks Run outcrop (Figure 13 and Appendix B).

Subhorizontal reflectors, presumably within the Pleistocene marginal marine or estuarine sequence are deeply incised by a paleo-channel sequence. Unlike other paleochannel structures observed at the site, strong horizontal reflectors are visible within the confines of the channel boundaries, suggesting the existence of vertically contrasting infill lithologies. Because we do not have parallel corresponding profiles, the channel orientation and dimensions cannot be determined, although it is likely that the channel axis is parallel or sub-parallel to the existing drainage. The base of the paleo-channel penetrates to an elevation of at least -25 feet msl, into the underlying upper CHAS strata.

Geophex conducted a GPR survey across the most favorable site for well field development in Sub-area I. The trackline, called GPR-9, is located parallel to, and 100 feet east of the former railroad track and from the northern edge of Subarea I (Figures 17 and 21). GPR-9 parallels the previously collected GPR-2 and GPR-8 tracklines (Appendix C).

Two prominent reflectors are present along the entire GPR-9 line in the shallow subsurface. The first, occurs at a depth of 25 to 30 feet below land surface, and consists of a continuous, nearly flat-lying reflector. Several weak, discontinuous reflectors are discernible in the uppermost 25 feet of soil. The strong reflector is underlain by a sequence of weaker parallel and sub-parallel reflectors that are occasionally incised by small-scale (<100 ft wide) channel structures to a depth of 55 to 65 feet where a second strong reflector occurs. The second strong reflector is more discontinuous and irregular than the upper one. Several weak, parallel and sub-parallel reflectors are also discernible in the 60 to 110 ft interval.

We interpret the first strong reflector as the lower boundary of the Surficial Aquifer. We infer that from the base of this section, down to the second strong reflector at 55 to 65 feet, are marine sediments within the Pollocksville Member of the Belgrade Formation, the uppermost lithologic unit in the CHAS. The second strong reflector is probably the upper surface of the River Bend Formation. Reflectors within the River Bend Formation are very weak suggesting either poor penetration or little stratification in the section. No major (>100 feet wide) paleochannel structures were identified in the GPR-9 profile.

6.1.3 Results of GPR Survey

Although the primary objective of the GPR survey was to map the distribution and geometry of the upper surface of the CHAS, we were only able to recognize boundaries of the upper units in the aquifer. We did not obtain enough penetration to detect the upper surface of the Castle Hayne Formation (lower CHAS) which is the most important water-bearing zone). The surveys did, however, reveal the presence of paleo-channel, cut and fill sequences at elevations corresponding to the upper zone of the CHAS. Depending upon the hydraulic characteristics of the channel deposits, these features may provide pathways for accelerated vertical groundwater movement into, or out of, the upper CHAS, or they may act as plugs, retarding vertical and horizontal groundwater flow.

6.2 Vertical Electrical Soundings (VES)

6.2.1 Vertical Electrical Sounding Technology

One of the principal objectives in planning a new well field for the Air Station was to avoid groundwater having a high chloride content, thereby reducing the potential for