

PROJECT: U-4756 ID:

# STATE OF NORTH CAROLINA

## DEPARTMENT OF TRANSPORTATION

### DIVISION OF HIGHWAYS

### GEOTECHNICAL UNIT

# STRUCTURE SUBSURFACE INVESTIGATION

STATE PROJECT U-4756 I.D. NO. \_\_\_\_\_

F.A. PROJECT \_\_\_\_\_

COUNTY CUMBERLAND

PROJECT DESCRIPTION BRIDGE ON MORGANTON  
ROAD OVER ALL AMERICAN FREEWAY

SITE DESCRIPTION \_\_\_\_\_

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STATE	STATE PROJECT REFERENCE NO.	SHEET NO.	TOTAL SHEETS
N.C.	U-4756	1	16
STATE PROJ. NO.	F.A. PROJ. NO.	DESCRIPTION	
U-4756		P.E. CONST.	

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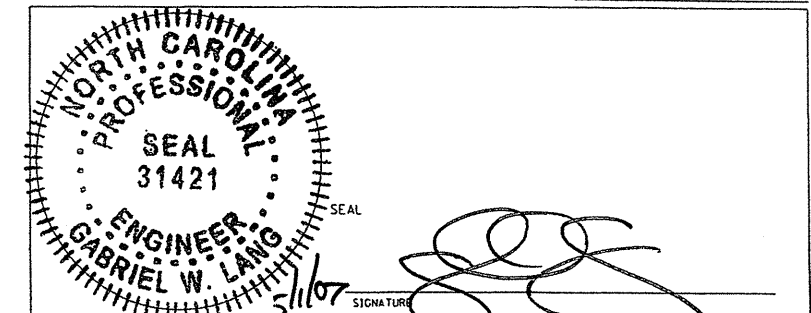
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INVESTIGATED BY S. HAN PERSONNEL S. HAN

CHECKED BY G. LANG, P.E. B. SAWASKA

SUBMITTED BY TIERRA, INC.

DATE MAY, 2007



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DRAWN BY: P. ZHANG

STATE	STATE PROJECT REFERENCE NO.	SHEET NO.	TOTAL SHEETS
N.C.	U-4756		
WBS NO.	P.A. PROJ. NO.	DESCRIPTION	
39750.1.1	STP-1404(9)	P.E.	
39750.2.1	STP-1404(9)	RW, UTL	
39750.3.1	STP-1404(9)	CONST	

PROJECT NO. : U-4756

COUNTY: Cumberland

LOCATION	EVCAVATION					EMBANKMENT				BORROW	WASTE			
	TOTAL EXCAVATION	ROCK	UNDERCUT	UNSUITABLE	SUITABLE	TOTAL EMBANKMENT	ROCK	EARTH EMBANKMENT	EMBANKMENT PLUS 25%		ROCK	SUITABLE	UNSUITABLE	TOTAL
-L-														
27+92.30 to 43+67.18	1033				1033	11263		11263	14079	13046				
-RPC-														
10+00 to 17+61.75	504				504	1340		1340	1675	1171				
-RPD-														
10+00 to 21+00.30	340				340	982		982	1228	888				
SUBTOTAL	1877				1877	13585		13585	16982	15105				
-L-														
46+10.52 to 59+50.00	679				679	8783		8783	10979	10300				
-RPA-														
10+00 to 11+95.94						124		124	155	155				
-RPB-														
10+00 to 19+47.77	220				220	482		482	603	383				
-Y3-														
10+00 to 13+67.41	222				222	2		2	3			219		219
-Y5-														
21+00 to 26+50	232				232	200		200	250	18				
SUBTOTAL	1353				1353	9591		9591	11990	10856			219	219
TOTAL	3230				3230	23176		23176	28972	25961			219	219
LOSS DUE TO CLEAR & GRUB														
EST. SHOULDER MATERIAL														
WASTE TO REPLACE BORROW										-219		-219		-219
ADDITIONAL UNDERCUT														
PROJECT TOTAL	3230				3230	23176		23176	28972	25742				
5% TO REPLACE BORROW										1290				
GRAND TOTAL	3230				3230	23176		23176	28972	27032				
SAY	3400									27400				

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**TIP PROJECT: U-4756**  
**CONTRACT: C201461**

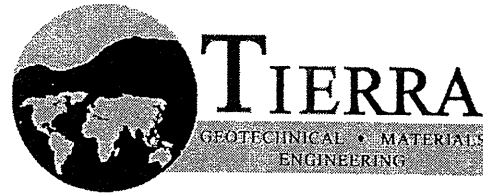
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION  
DIVISION OF HIGHWAYS  
GEOTECHNICAL ENGINEERING UNIT

ID	STATE PROJECT NO.	SHEET NO.	TOTAL SHEETS
	U-4756	2	16

## SUBSURFACE INVESTIGATION

### SOIL AND ROCK LEGEND, TERMS, SYMBOLS, AND ABBREVIATIONS

SOIL DESCRIPTION				GRADATION				ROCK DESCRIPTION				TERMS AND DEFINITIONS							
SOIL IS CONSIDERED TO BE THE UNCONSOLIDATED, SEMI-CONSOLIDATED OR WEATHERED EARTH MATERIALS WHICH CAN BE PENETRATED WITH A CONTINUOUS FLIGHT POWER AUGER, AND WHICH YIELDS LESS THAN 100 BLOWS PER FOOT ACCORDING TO STANDARD PENETRATION TEST (ASHTO T206, ASTM D-1586). SOIL CLASSIFICATION IS BASED ON THE AASHTO SYSTEM AND BASIC DESCRIPTIONS GENERALLY SHALL INCLUDE: CONSISTENCY, COLOR, TEXTURE, MOISTURE, AASHTO CLASSIFICATION, AND OTHER PERTINENT FACTORS SUCH AS MINERALOGICAL COMPOSITION, ANGULARITY, STRUCTURE, PLASTICITY, ETC. EXAMPLE: VERY STIFF, GRAY SILTY CLAY, MIXT WITH INTERBEDDED FINE SAND LAYERS, HIGHLY PLASTIC, A-7-6				WELL GRADED: INDICATES A GOOD REPRESENTATION OF PARTICLE SIZES FROM FINE TO COARSE UNIFORM. INDICATES THAT SOIL PARTICLES ARE ALL APPROXIMATELY THE SAME SIZE. (ALSO POORLY GRADED) GAP-GRADED: INDICATES A MIXTURE OF UNIFORM PARTICLES OF TWO OR MORE SIZES. ANGULARITY OF GRAINS THE ANGULARITY OR ROUNDNESS OF SOIL GRAINS ARE DESIGNATED BY THE TERMS: ANGULAR, SUBANGULAR, SUBROUNDED, OR ROUNDED.				HARD ROCK IS NON-COASTAL PLAIN MATERIAL THAT WHEN TESTED, WOULD YIELD SPT REFUSAL, AN INFERRED ROCK LINE INDICATES THE LEVEL AT WHICH NON-COASTAL PLAIN MATERIAL WOULD YIELD SPT REFUSAL. SPT REFUSAL IS PENETRATION BY A SPLIT SPOON SAMPLER EQUAL TO OR LESS THAN 0.1 FOOT PER 60 BLOWS. IN NON-COASTAL PLAIN MATERIAL, THE TRANSITION BETWEEN SOIL AND ROCK IS OFTEN REPRESENTED BY A ZONE OF WEATHERED ROCK. ROCK MATERIALS ARE TYPICALLY DIVIDED AS FOLLOWS:				ALLUVIUM (ALLUV.) - SOILS WHICH HAVE BEEN TRANSPORTED BY WATER. ADUIFER - A WATER BEARING FORMATION OR STRATA. ARENACEOUS - APPLIED TO ROCKS THAT HAVE BEEN DERIVED FROM SAND OR THAT CONTAIN SAND. ARGILLACEOUS - APPLIED TO ALL ROCKS OR SUBSTANCES COMPOSED OF CLAY MINERALS, OR HAVING A NOTABLE PROPORTION OF CLAY IN THEIR COMPOSITION, AS SHALE, SLATE, ETC. ARTESIAN - GROUND WATER THAT IS UNDER SUFFICIENT PRESSURE TO RISE ABOVE THE LEVEL AT WHICH IS ENCOUNTERED, BUT WHICH DOES NOT NECESSARILY RISE TO OR ABOVE THE GROUND SURFACE. CALCAREOUS (CALC.) - SOILS WHICH CONTAIN APPRECIABLE AMOUNTS OF CALCIUM CARBONATE. COLLUVIUM - ROCK FRAGMENTS MIXED WITH SOIL DEPOSITED BY GRAVITY ON SLOPE OR AT BOTTOM OF SLOPE. CORE RECOVERY (REC.) - TOTAL LENGTH OF ALL MATERIAL RECOVERED IN THE CORE BARREL DIVIDED BY TOTAL LENGTH OF CORE RUN AND EXPRESSED AS A PERCENTAGE. DIKE - A TABULAR BODY OF IGNEOUS ROCK THAT CUTS ACROSS THE STRUCTURE OF ADJACENT ROCKS OR CUTS MASSIVE ROCK. DIP - THE ANGLE AT WHICH A STRATUM OR ANY PLANAR FEATURE IS INCLINED FROM THE HORIZONTAL. DIP DIRECTION (DIP AZIMUTH) - THE DIRECTION OR BEARING OF THE HORIZONTAL TRACE OF THE LINE OF DIP, MEASURED CLOCKWISE FROM NORTH. FAULT - A FRACTURE OR FRACTURE ZONE ALONG WHICH THERE HAS BEEN DISPLACEMENT OF THE SIDES RELATIVE TO ONE ANOTHER PARALLEL TO THE FRACTURE. FISSILE - A PROPERTY OF SPLITTING ALONG CLOSELY SPACED PARALLEL PLANES. FLOAT - ROCK FRAGMENTS ON SURFACE NEAR THEIR ORIGINAL POSITION AND DISLODGED FROM PARENT MATERIAL. FLOOD PLAIN (F.P.) - LAND BORDERING A STREAM, BUILT OF SEDIMENTS DEPOSITED BY THE STREAM. FORMATION (FM.) - A MAPPABLE GEOLOGIC UNIT THAT CAN BE RECOGNIZED AND TRACED IN THE FIELD. JOINT - FRACTURE IN ROCK ALONG WHICH NO APPRECIABLE MOVEMENT HAS OCCURRED. LEDGE - A SHELF-LIKE RIDGE OR PROJECTION OF ROCK WHOSE THICKNESS IS SMALL COMPARED TO ITS LATERAL EXTENT. LENS - A BODY OF SOIL OR ROCK THAT THINS OUT IN ONE OR MORE DIRECTIONS. MOTTLED (MOT.) - IRREGULARLY MARKED WITH SPOTS OF DIFFERENT COLORS. MOTTLING IN SOILS USUALLY INDICATES POOR AERATION AND LACK OF GOOD DRAINAGE. PERCHED WATER - WATER MAINTAINED ABOVE THE NORMAL GROUND WATER LEVEL BY THE PRESENCE OF AN INTERVENING IMPERVIOUS STRATUM. RESIDUAL SOIL - SOIL FORMED IN PLACE BY THE WEATHERING OF ROCK. ROCK QUALITY DESIGNATION (R.Q.D.) - A MEASURE OF ROCK QUALITY DESCRIBED BY: TOTAL LENGTH OF ROCK SEGMENTS EQUAL TO OR GREATER THAN 4 INCHES DIVIDED BY THE TOTAL LENGTH OF CORE RUN AND EXPRESSED AS A PERCENTAGE. SAPROLITE (SAP.) - RESIDUAL SOIL WHICH RETAINS THE RELIC STRUCTURE OR FABRIC OF THE PARENT ROCK. SILL - AN INTRUSIVE BODY OF IGNEOUS ROCK OF APPROXIMATELY UNIFORM THICKNESS AND RELATIVELY THIN COMPARED WITH ITS LATERAL EXTENT, WHICH HAS BEEN EMPLACED PARALLEL TO THE BEDDING OR SCHISTOSITY OF THE INTRUDED ROCKS. SLICKENSIDE - POLISHED AND STRIATED SURFACE THAT RESULTS FROM FRICTION ALONG A FAULT OR SLIP PLANE. STANDARD PENETRATION TEST (PENETRATION RESISTANCE) (SPT) - NUMBER OF BLOWS IN OR B.P.F. OF A 140 LB. HAMMER FALLING 30 INCHES REQUIRED TO PRODUCE A PENETRATION OF 1 FOOT INTO SOIL WITH A 2 INCH OUTSIDE DIAMETER SPLIT SPOON SAMPLER. SPT REFUSAL IS LESS THAN 0.1 FOOT PENETRATION WITH 60 BLOWS. STRATA CORE RECOVERY (SREC.) - TOTAL LENGTH OF STRATA MATERIAL RECOVERED DIVIDED BY TOTAL LENGTH OF STRATUM AND EXPRESSED AS A PERCENTAGE. STRATA ROCK QUALITY DESIGNATION (S.R.Q.D.) - A MEASURE OF ROCK QUALITY DESCRIBED BY: TOTAL LENGTH OF ROCK SEGMENTS WITHIN A STRATUM EQUAL TO OR GREATER THAN 4 INCHES DIVIDED BY THE TOTAL LENGTH OF STRATA AND EXPRESSED AS A PERCENTAGE. TOPSOIL (T.S.) - SURFACE SOILS USUALLY CONTAINING ORGANIC MATTER.							
SOIL LEGEND AND AASHTO CLASSIFICATION				MINERALOGICAL COMPOSITION				WEATHERING				MISCELLANEOUS SYMBOLS							
GRANULAR MATERIALS (>5% PASSING #200)      SILT-CLAY MATERIALS (>85% PASSING #200)      ORGANIC MATERIALS				MINERAL NAMES SUCH AS QUARTZ, FELDSPAR, MICA, TALC, KAOLIN, ETC. ARE USED IN DESCRIPTIONS WHENEVER THEY ARE CONSIDERED OF SIGNIFICANCE.				WEATHERED ROCK (WR)      CRYSTALLINE ROCK (CR)      NON-CRYSTALLINE ROCK (NCR)      COASTAL PLAIN SEDIMENTARY ROCK (CP)				FRESH      VERY SLIGHT (V. SL.)      SLIGHT (SL.)      MODERATE (MOD.)      MODERATELY SEVERE (MOD. SEV.)      SEVERE (SEV.)      VERY SEVERE (V. SEV.)      COMPLETE				ROADWAY EMBANKMENT WITH SOIL DESCRIPTION      SOIL SYMBOL      ARTIFICIAL FILL OTHER THAN ROADWAY EMBANKMENTS      INFERRED SOIL BOUNDARIES      INFERRED ROCK LINE      ALLUVIAL SOIL BOUNDARY      DIP/DIP DIRECTION OF ROCK STRUCTURES			
GROUP CLASS.      A-1, A-2, A-3, A-4, A-5, A-6, A-7, A-1, A-2, A-3, A-4, A-5, A-6, A-7				COMPRESSIBILITY      SLIGHTLY COMPRESSIBLE      MODERATELY COMPRESSIBLE      HIGHLY COMPRESSIBLE      LIQUID LIMIT LESS THAN 30      LIQUID LIMIT 31-50      LIQUID LIMIT GREATER THAN 50				FINE TO COARSE GRAIN METAMORPHIC AND NON-COASTAL PLAIN SEDIMENTARY ROCK THAT WOULD YIELD SPT REFUSAL IF TESTED. ROCK TYPE INCLUDES PHYLLITE, SLATE, SANDSTONE, ETC.      FINE TO COARSE GRAIN METAMORPHIC AND NON-COASTAL PLAIN SEDIMENTARY ROCK THAT WOULD YIELD SPT REFUSAL IF TESTED. ROCK TYPE INCLUDES GNEISS, GABBRO, SCHIST, ETC.      COASTAL PLAIN SEDIMENTS CEMENTED INTO ROCK, BUT MAY NOT YIELD SPT REFUSAL. ROCK TYPE INCLUDES LIMESTONE, SANDSTONE, CEMENTED SHELL BEDS, ETC.				SPT TEST BORING      AUGER BORING      CORE BORING      MONITORING WELL      PIEZOMETER INSTALLATION      SLOPE INDICATOR INSTALLATION      SPT N-VALUE      SPT REFUSAL							
PERCENTAGE OF MATERIAL      ORGANIC MATERIAL      GRANULAR SOILS      SILT-CLAY SOILS      OTHER MATERIAL      TRACE OF ORGANIC MATTER      LITTLE ORGANIC MATTER      MODERATELY ORGANIC      HIGHLY ORGANIC				GROUND WATER      WATER LEVEL IN BORE HOLE IMMEDIATELY AFTER DRILLING.      STATIC WATER LEVEL AFTER 24 HOURS.      PERCHED WATER, SATURATED ZONE OR WATER BEARING STRATA      SPRING OR SEEPAGE				SAMPLE DESIGNATIONS      S - BULK SAMPLE      SS - SPLIT SPOON SAMPLE      ST - SHELBY TUBE SAMPLE      RS - ROCK SAMPLE      RT - RECOMPACTED TRIAXIAL SAMPLE      CBR - CBR SAMPLE				AR - AUGER REFUSAL      BT - BORING TERMINATED      CL - CLAY      CPT - CONE PENETRATION TEST      CSE - COARSE      C.T. - CORING TERMINATED      DMT - DILATOMETER TEST      DPT - DYNAMIC PENETRATION TEST      e - VOID RATIO      F. - FINE      FOSS. - FOSSILIFEROUS      FRAC. - FRACTURED      FRAGS. - FRAGMENTS							
CONSISTENCY OR DENSENESS      PRIMARY SOIL TYPE      COMPACTNESS OR CONSISTENCY      RANGE OF STANDARD PENETRATION RESISTANCE (N-VALUE)      RANGE OF UNCONFINED COMPRESSIVE STRENGTH (TONS/FT <sup>2</sup> )				TEXTURE OR GRAIN SIZE      U.S. STD. SIEVE SIZE OPENING (MM)      4, 10, 40, 60, 200, 270      0.425, 0.075, 0.053				ROCK HARDNESS      VERY HARD      HARD      MODERATELY HARD      MEDIUM HARD      SOFT      VERY SOFT				ABBREVIATIONS      MED. - MEDIUM      PMT - PRESSUREMETER TEST      REF. - REFUSAL      SD. - SAND, SANDY      SL. - SILT, SILTY      S.LI. - SLIGHTLY      TCR - TRICONE REFUSAL      γ - UNIT WEIGHT      γ <sub>d</sub> - DRY UNIT WEIGHT      W - MOISTURE CONTENT      V. - VERY      VST - VANE SHEAR TEST							
SOIL MOISTURE - CORRELATION OF TERMS      SOIL MOISTURE SCALE (ATTERBERG LIMITS)      FIELD MOISTURE DESCRIPTION      GUIDE FOR FIELD MOISTURE DESCRIPTION				EQUIPMENT USED ON SUBJECT PROJECT      DRILL UNITS:      MOBILE B-      BK-51      CME-45      CME-550      PORTABLE HOIST      OTHER      OTHER				FRACTURE SPACING      TERM      SPACING      VERY WIDE      WIDE      MODERATELY CLOSE      CLOSE      VERY CLOSE				BEDDING      TERM      THICKNESS      VERY THICKLY BEDDED      THICKLY BEDDED      THINLY BEDDED      VERY THINLY BEDDED      THICKLY LAMINATED      THINLY LAMINATED							
PLASTICITY      PLASTICITY INDEX (PI)      DRY STRENGTH      NONPLASTIC      LOW PLASTICITY      MED. PLASTICITY      HIGH PLASTICITY				COLOR      DESCRIPTIONS MAY INCLUDE COLOR OR COLOR COMBINATIONS (TAN, RED, YEL.-BRN, BLUE-GRAY)      MODIFIERS SUCH AS LIGHT, DARK, STREAKED, ETC. ARE USED TO DESCRIBE APPEARANCE.				INDURATION      FRIABLE      MODERATELY INDURATED      INDURATED      EXTREMELY INDURATED				NOTES:							



May 1, 2007

Mr. Kevin Austin, P.E.  
Mulkey Engineers and Consultants  
6750 Tryon Road  
Cary, NC 27511

**Re: Geotechnical Subsurface Exploration Report**

Project ID.: U-4756  
County: Cumberland County  
Description: Bridge on Morganton Road over All American Freeway  
Tierra Inc. Proj. No.: 6211-07-018

Dear Mr. Austin:

As authorized, Tierra, Inc. (Tierra) has completed the geotechnical subsurface exploration for Bridge on Morganton Road over All American Freeway in Cumberland County, North Carolina. Our investigation was performed in general accordance with our proposal number TR-07-017, dated March 29, 2007. The purpose of this report is to present subsurface conditions and foundation design recommendations for the planned structure. Field and laboratory test results, site and boring location plans, and profiles depicting subsurface conditions may be found in this report.

**PROJECT DESCRIPTION**

According to a general drawing provided by Mulkey Engineers and Consultants, dated February 2007, the referenced project intends to replace and widen the existing two span, three bent bridge structure on Morganton Road over All American Freeway. Based upon the plans prepared by NCDOT, it is our understanding that the existing structure is supported by driven HP 12x53 steel piles at end bents and footings on driven 12 inch prestressed concrete piles at interior bent. These foundations are to be reutilized to support the proposed structure. The existing piles were designed for an allowable capacity of 30 tons each. However, construction records indicating production piles lengths, capacities and tip elevations were not available at the time of this report. We also understand that a previous subsurface investigation was performed by NCDOT and included a total of six (6) SPT borings, two (2) borings per bent.

The proposed structure is to consist of a two span, three bent bridge with a length of approximately 240 feet and a skew angle of approximately 73 degree. The structure is planned to be located along the same alignment as the existing structure but will be widened to the north and south. From our conversation with Mulkey Engineers and Consultants, we understand that due to existing utilities located immediately adjacent to the widening portion of the interior bent, drilled shaft foundations are desired. In addition, use of HP 12x53 piles at end bents in widened areas is also preferred. The end bent caps will be at an elevation of approximately 241 feet and interior bent at an elevation of 240 feet.

If any of the above information is incorrect or has changed, please inform Tierra so that we may amend the recommendations presented in this report if appropriate.

**SITE DESCRIPTION/GEOLOGY**

The proposed project site is located at intersection of Morganton Road and All American Freeway in Fayetteville, North Carolina. In general, the area is developed and contains an existing bridge structure, paved roadway and grassed shoulders and medians.

The project site is located in the Coastal Plain Physiographic Province of North Carolina. *The Geologic Map of North Carolina* (1985) indicates the bridge site is located within the Cape Fear Formation (Kc). The Cretaceous materials of this formation typically consist of sandstone, mudstone and continuous beds of micaceous and feldspar rich sands and blocky mottled red and yellow clays.

**FIELD EVALUATION PROCEDURE**

The subsurface exploration consisted of performing two (2) soil test borings along the proposed interior bent line. In addition, Tierra has reviewed previous test boring information obtained by NCDOT. Tierra's borings were performed with a CME 45 trailer mounted drill rig with a manual hammer. Due to the presence of subsurface and overhead utilities, the borings were offset approximately 20 to 25 feet from the proposed shaft locations. Standard Penetration Tests (SPT) and soil sampling were performed in general accordance with American Association of State Highway Transportation Officials (AASHTO T-206-87).

Groundwater measurement readings were taken within each borehole with a weighted 100-foot measuring tape from a reference location at the top of each boring. Readings were recorded immediately after boring termination and after a 24-hour waiting period. Test boring elevations were approximated from topographic information provided by Mulkey Engineers and Consultants.

**SUBSURFACE AND GROUNDWATER CONDITIONS**

Based upon the results of our subsurface exploration and the previous test borings drilled by NCDOT, subsurface soils penetrated beneath the site generally consist of roadway embankment soil underlain by coastal plain deposited materials to the boring termination depths.

**End Bents**

A total of four (4) borings (EB1-A, EB1-B, EB2-A and EB2-B) were drilled prior to the construction of the end bents. Copies of the original test boring logs are included in this report and our interpretation of their profiles is presented as well. The soils are noted to consist of very soft to hard silty/sandy clay (A-6, A-7-5) and very loose to very dense silty/clayey sand and fine to coarse sand (A-2-4, A-2-6, A-3, A-1-b). The borings were extended to depths of approximately 60 to 65 feet (elevations of approximately 160 feet to 166 feet).

**Interior Bent**

The results of our subsurface investigation indicate that soils beneath Interior Bent No. 1 consist of roadway embankment underlain by coastal plain materials. Roadway embankment soils were encountered at the ground surface and consist of approximately 3 feet of loose to medium dense silty sand and fine sand (A-2-4, A-3). Coastal plain soils were encountered below the roadway embankment and extended to the boring termination depths of approximately 79 to 80 feet (elevations of 146 to 147 feet). These soils consist of very soft to very stiff sandy/silty clay (A-6, A-7-5, A-7-6) and very loose to very dense silty/clayey sand and fine to coarse sand (A-2-4, A-2-6, A-3, A-1-b).

Groundwater across the site ranged from elevations of approximately 218 to 220 feet. In addition, a loss of drilling fluids occurred in boring B1A between the depths of 50 to 60 feet below ground surface.

**LABORATORY TESTING**

Representative split-spoon samples were selected from soil test borings to verify visual field classifications and determine soil index properties. A total of four (4) samples were analyzed in our laboratory for natural moisture determination, Atterberg limits, and grain size analysis. All testing was performed in accordance with the following American Society for Testing and Materials (ASTM), (NCDOT) Modified and/or (AASHTO) procedures:

- AASHTO T-88-00 (As Modified) "Particle Size Analysis of Soil"
- AASHTO T-89-902(As Modified) "Determining the Liquid Limits of Soil"
- AASHTO T-90-00 "Determining the Plastic Limit and Plasticity of Soils"
- AASHTO T-265-93 "Laboratory Determination of Moisture Content of Soils"

The results of the laboratory testing indicate that the site soils tested ranged from sandy clay (A-6) to silty sand (A-2-4).

**CONCLUSIONS**

The results of our subsurface investigation and review of previous subsurface investigation by NCDOT indicate that the subsurface conditions consist predominately of coastal plain deposits of very soft to hard clay and very loose to very dense sand. The coastal plain deposited soils extended to the boring termination depths ranging from approximately 60 to 80 feet. Considering the depth of competent bearing materials and close proximity of existing utilities, it is anticipated that driven HP steel piles will be suitable for support of the bridge end bents and are anticipated to have reduced vibration impacts in comparison to driven concrete piles. In addition, due to potential utility issues and vibrations, drilled piers bearing in very dense sandy material will be utilized for the interior bent.

**FOUNDATION RECOMMENDATIONS**

Based on the subsurface conditions and our analysis, the end bents for the proposed bridge may be supported by driven HP 12x53 steel piles and interior bent by 42 inch diameter drilled piers. The piles for the end bents may be designed using an allowable capacity of 45 tons. The allowable pile capacities were estimated utilizing static methods and a safety factor of 2. The actual capacity of the piles should be verified during installation using pile driving criteria, from wave equation analysis, established by the Geotechnical Engineer. The piers for the interior bent should be designed to bear in very dense sandy material beginning at elevations of approximately 168 to 169 feet and have a tip elevation no higher than 151 feet. The piers should also be designed using an allowable capacity of 310 tons with a safety factor of 2.5. For more information, refer to the attached "Summary of Foundation Recommendations".

The piles and piers shall be spaced at a minimum of three times the pile diameter to prevent reductions due to group effects. During construction of the end bent caps, the embankment soils should be laid back at no steeper than (2H:1V) or as required by OSHA. Temporary shoring may also be required. Backfill behind the end bent caps shall be replaced in accordance with Section 410-8 and 410-9 of the Standard Specifications.


From the information provided, we understand the structure will be constructed at or near existing site grades. Provided that the embankments are constructed in accordance with NCDOT specifications and suitable slope protection measures are incorporated, the slopes may be reconstructed as planned.

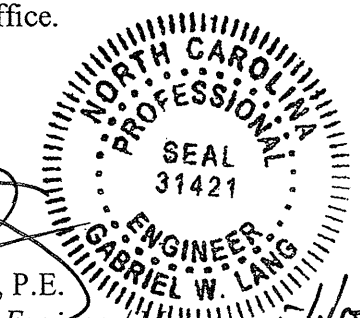
**CLOSURE**

Recommendations and evaluations provided by Tierra are based upon previous subsurface information prepared by NCDOT, the General Drawing dated February 2007, and information provided by Mulkey Engineers and Consultants. Modifications of our recommendations and evaluations may be required if there are changes to the design or location of the structure. Recommendations in this report are based on data obtained from current and previous soil borings. The nature and extent of variations between borings may not become evident until construction.

Our professional services for this project have been performed in accordance with generally accepted engineering practices. No other warranty, expressed or implied, is made. Tierra appreciates this opportunity to have provided you with geotechnical engineering services for this project. If you have any questions regarding this report, please contact our office.

Sincerely,  
**TIERRA, INC.**

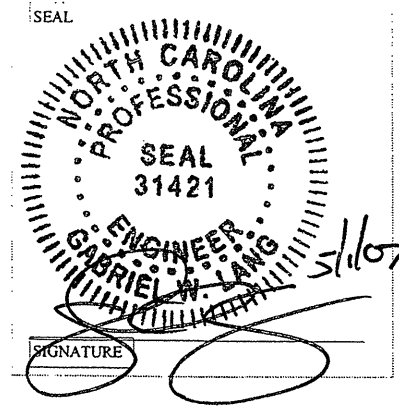
  
Seungwoon (Sean) Han, Ph.D., P.E.  
Geotechnical Engineer

  
Gabriel W. Lang, P.E.  
Sr. Geotechnical Engineer/Manager 5/1/07

## SUMMARY OF FOUNDATION RECOMMENDATIONS

NCDOT PROJ. NO.: U-4756 PROJECT DESCRIPTION: Bridge on Morganton Road  
 T.I.P. NO.: \_\_\_\_\_ over All American Freeway  
 COUNTY: Cumberland  
 STATION: 44+88 -L-

PREPARED BY: SWH DATE: 4/27/07  
 CHECKER: GWL DATE: 5/1/07



### Note on Plans:

1. Drive piles at End Bents No. 1 and 2 to a required bearing capacity of 90 tons per pile. The required bearing capacity is equal to the allowable bearing capacity with a minimum factor of safety of two.
2. The allowable bearing capacity for piles at End Bents No. 1 and 2 is 45 tons per pile.
3. Drilled piers at Bent No. 1 are designed for both skin friction and end bearing. Check field conditions for the required end bearing capacity of 30 tsf.
4. Drilled piers at Bent No.1 are designed for an applied load of 265 tons at the top of the column.
5. Drilled piers at Bent No. 1 shall extend to an elevation no higher than 151 ft and satisfy the required end bearing capacity.
6. SPT testing is required to determine the end bearing capacity of the drilled piers at Bent No. 1.
7. Slurry construction is required for drilled piers at Bent No. 1. See Drilled Piers Special Provision.
8. Do not use polymer slurry for drilled piers at Bent No. 1.
9. SID inspections are required to inspect the bottom cleanliness of the drilled piers at Bent No.1. See Drilled Piers Special Provision.
10. CSL tubes are required and CSL testing may be required for the drilled piers. The Engineer will determine the need for CSL testing. See Crosshole Sonic Logging Special Provision.
11. For drilled piers, see Drilled Piers Special Provision.

### Comments:

1. Considering a maximum lateral force of 8.1 kips, the elevation of the point of fixity for Bent No. 1 is 208 ft.
2. Pile recommendations are based upon previous subsurface information at site by NCDOT as presented in their plans, Sheet S-31, Project No. 8.2326309; and our assumptions on the embankment fill.
3. A loss of drilling fluids occurred in boring B1A between the depths of 50 to 60 feet.

	STATION	FOUNDATION TYPE	ALLOWABLE LOAD	FOUNDATION DETAILS
END BENT 1	43+67 -L-	Cap on HP 12x53 Steel Pile	45 tons/Pile	Assumed Bottom of Cap = 241 ft ± Recommended Length of Pile = 75 ft
BENT 1	44+88 -L-	42" Drilled Pier	310 tons/Pier	Assumed Bottom of Cap = 240 ft ± Assumed Top of Pier = 224 ft Tip Elevation No Higher Than = 151 ft Recommended Length of Pier = 73 ft
END BENT 2	46+10 -L-	Cap on HP 12x53 Steel Pile	45 tons/Pile	Assumed Bottom of Cap = 241 ft ± Recommended Length of Pile = 75 ft

COMMENTS & NOTES (Attached)

## DRILLED PIER PAY ITEM QUANTITIES

PROJECT NO. U-4756 DATE 5/1/2007  
 TIP NO. \_\_\_\_\_ DESIGNED BY SWH  
 COUNTY Cumberland CHECKED BY GWL  
 STATION \_\_\_\_\_

DESCRIPTION Bridge on Morganton Road over All American Freeway

NUMBER OF BENTS WITH DRILLED PIERS 1  
 NUMBER OF PIERS PER BENT 4

BENT #	DRILLED PIER PAY ITEMS					
	PERMANENT STEEL CASING FOR 42" DIA. DRILLED PIER (yes/no/maybe)	42" DIA. DRILLED PIERS NOT IN SOIL (feet)	SPT TESTING (each)	SID INSPECTION (each)	CROSSHOLE SONIC LOGGING* (each)	CSL TUBES* (yes/no)
1	No	0	4	4	4	YES
2						
3						
4						
5						
6						
7						
8						
9						
10						
<b>TOTALS</b>	<del>XXXXXX</del>	0	4	4	4	<del>XXXXXX</del>

\* Pay items, "Crosshole Sonic Logging" and "CSL Tubes" are not required unless CSL testing is required with a Note on Plans.

Notes:

Blanks or no represent quantity of zero.

If permanent steel casing is required or may be required, Structure Design should calculate the pay item quantity, "Permanent Steel Casing for \_\_\_ Dia. Drilled Pier", as the difference between the top of drilled pier elevation or the top of permanent steel casing elevation (whichever is lower) and the elevation the permanent steel casing can not extend below as shown with a Note on Plans.

Structure Design should determine the pay item quantity, "\_\_\_ Dia. Drilled Piers in Soil", based upon the total drilled pier length per bent minus the "\_\_\_ Dia. Drilled Piers not in Soil" per bent shown in the table above.

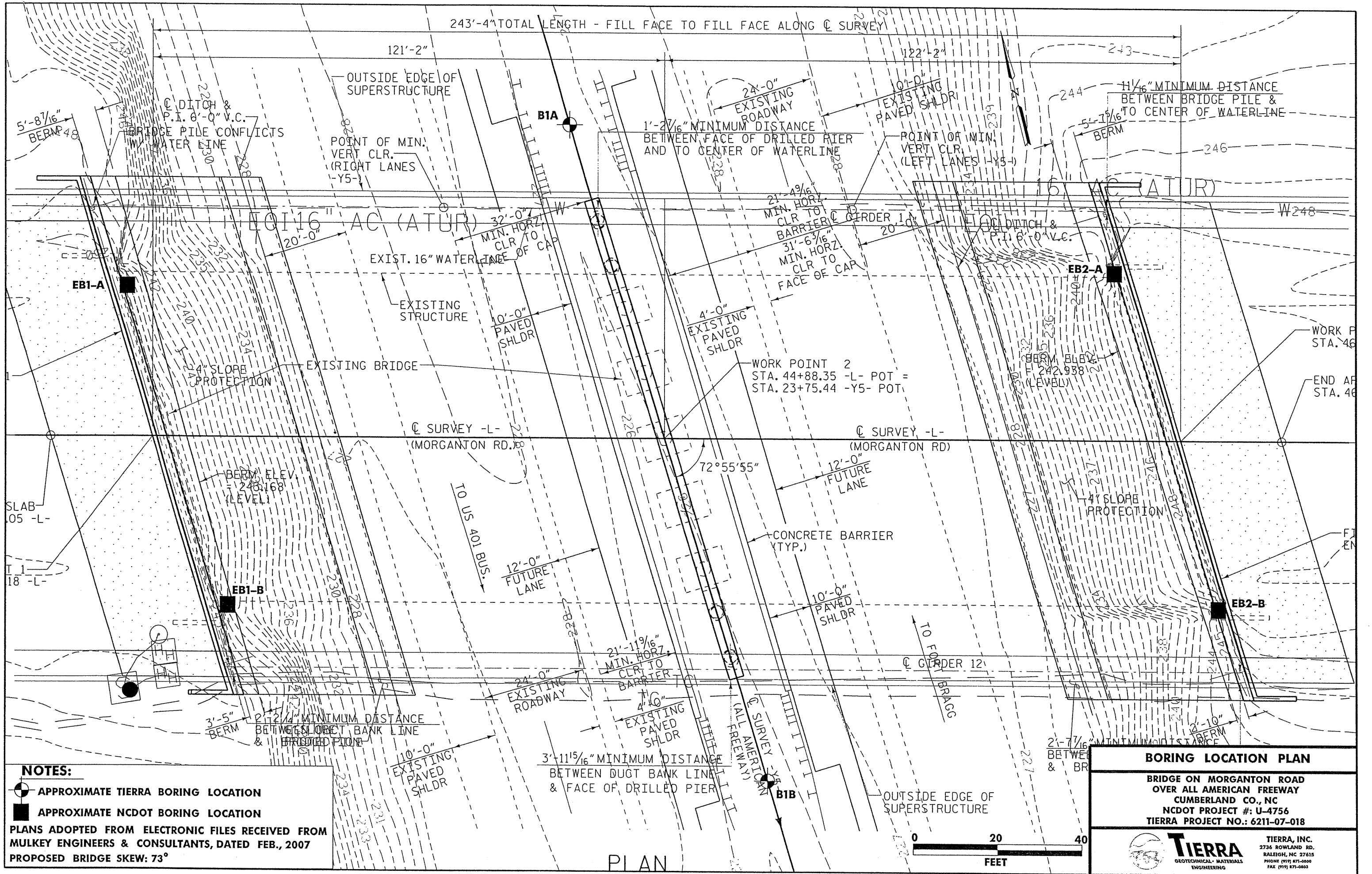
If CSL tubes are required, Structure design should calculate the pay item quantity, "CSL Tubes", as follows:

"CSL Tubes" per bent = (drilled pier length + 2.5 feet) x number of CSL tubes per pier

The number of CSL tubes per pier is dependent upon the drilled pier diameter. For drilled piers with a diameter of 5 feet or less, use 4 tubes. For drilled piers with a diameter greater than 5 feet, use 6 tubes.







**NOTES:**

- APPROXIMATE TIERRA BORING LOCATION
- APPROXIMATE NCDOT BORING LOCATION

PLANS ADOPTED FROM ELECTRONIC FILES RECEIVED FROM MULKEY ENGINEERS & CONSULTANTS, DATED FEB., 2007

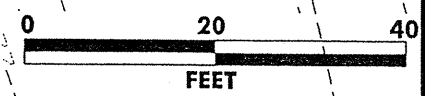
PROPOSED BRIDGE SKEW: 73°

**BORING LOCATION PLAN**

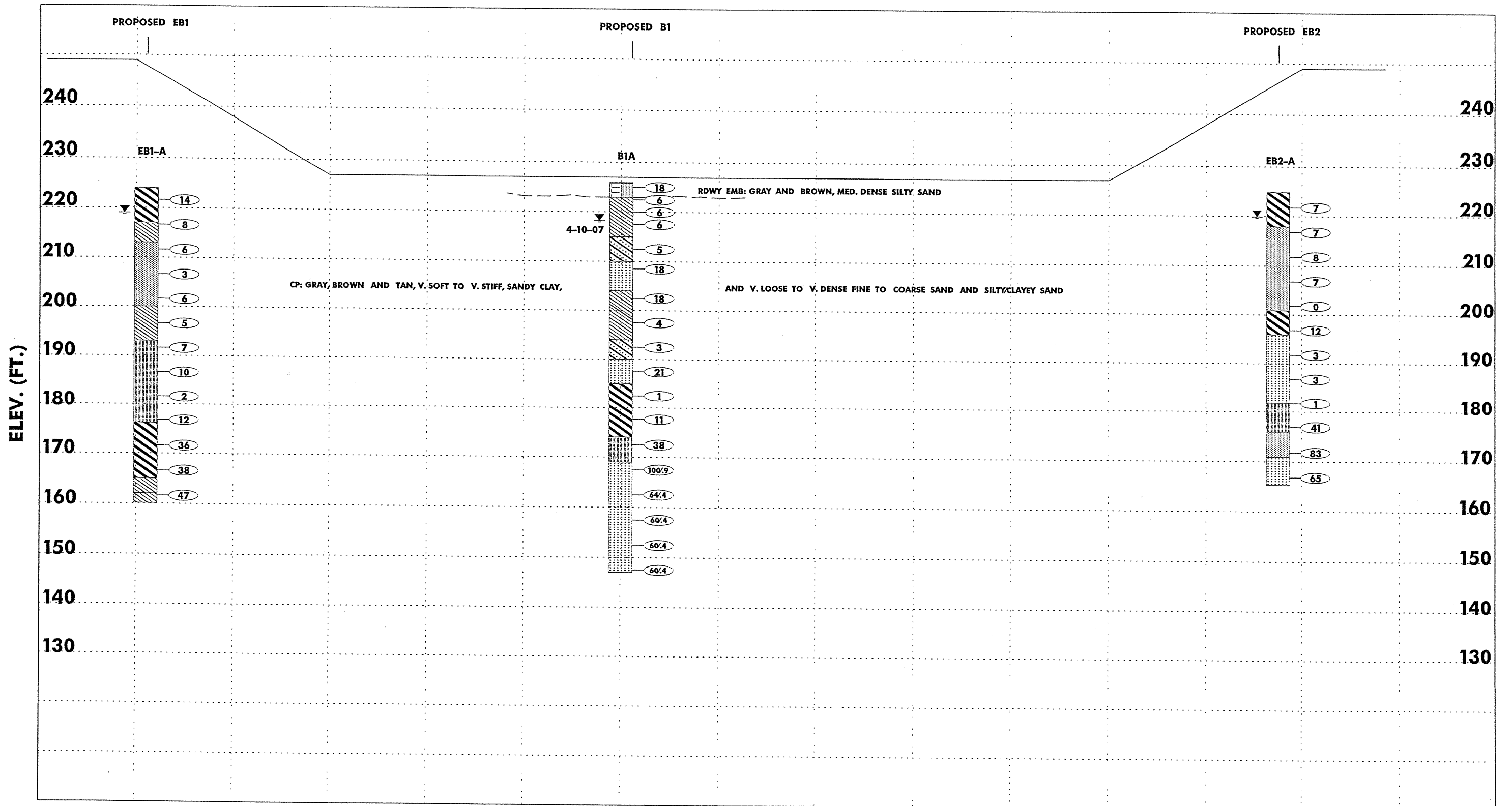
BRIDGE ON MORGANTON ROAD  
OVER ALL AMERICAN FREEWAY  
CUMBERLAND CO., NC  
NCDOT PROJECT #: U-4756  
TIERRA PROJECT NO.: 6211-07-018

**TIERRA**  
ENGINEERING

TIERRA, INC.  
2736 ROWLAND RD.  
RALEIGH, NC 27615  
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FAX (919) 871-0803



PLAN



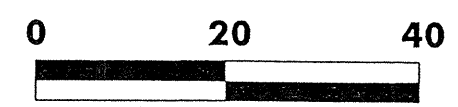
ELEV. (FT.)

44+00

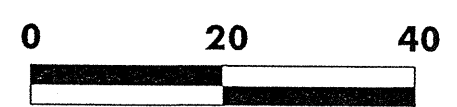
45+00

46+00

VERTICAL SCALE



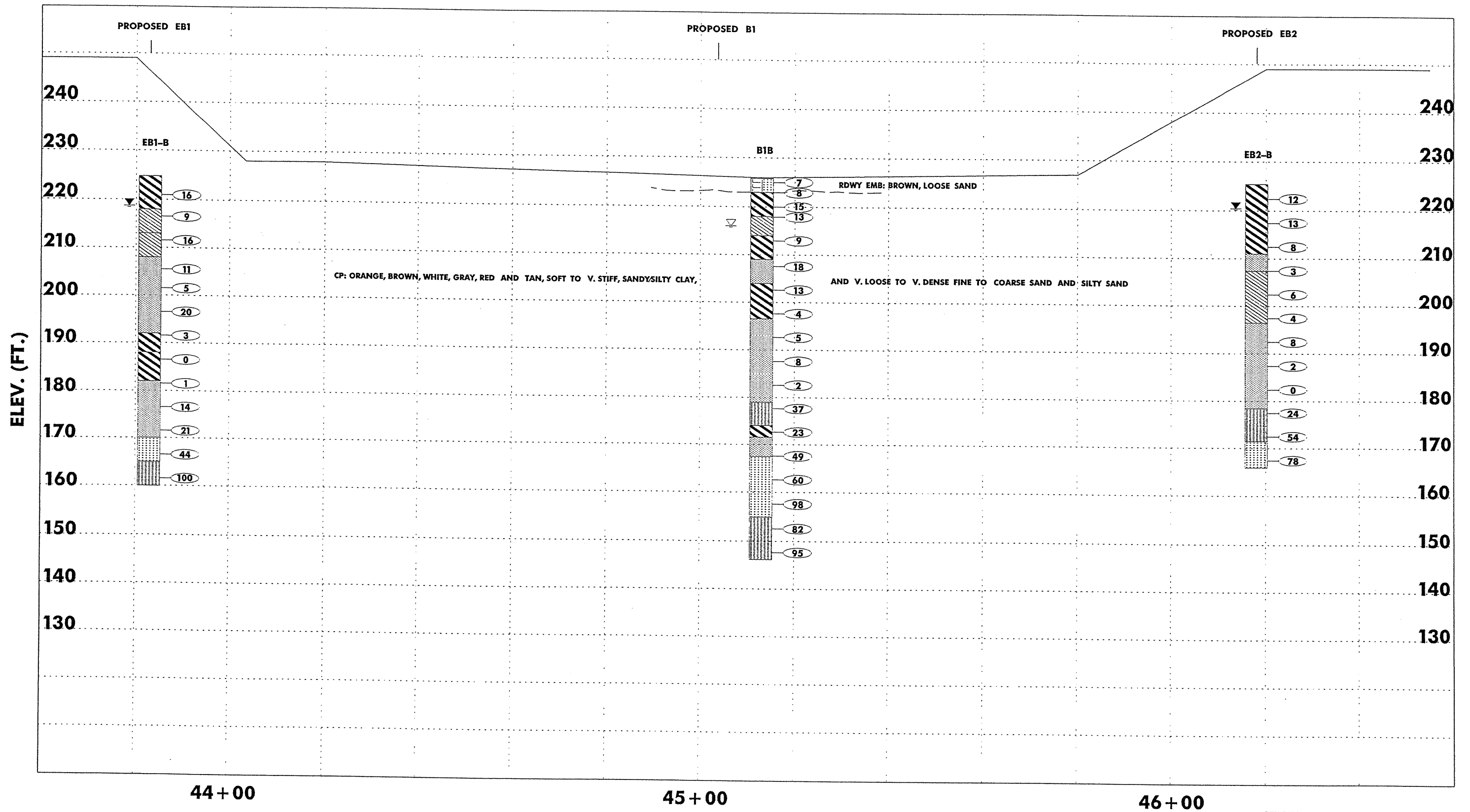
HORIZONTAL SCALE



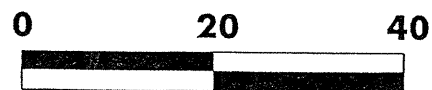
PROFILE 39' LEFT OF -L-

BRIDGE ON MORGANTON ROAD  
OVER ALL AMERICAN FREEWAY  
CUMERLAND CO., NC  
NCDOT PROJECT #: U-4756  
TIERRA PROJECT NO.: 6211-07-018

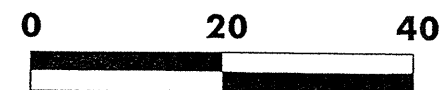




VERTICAL SCALE



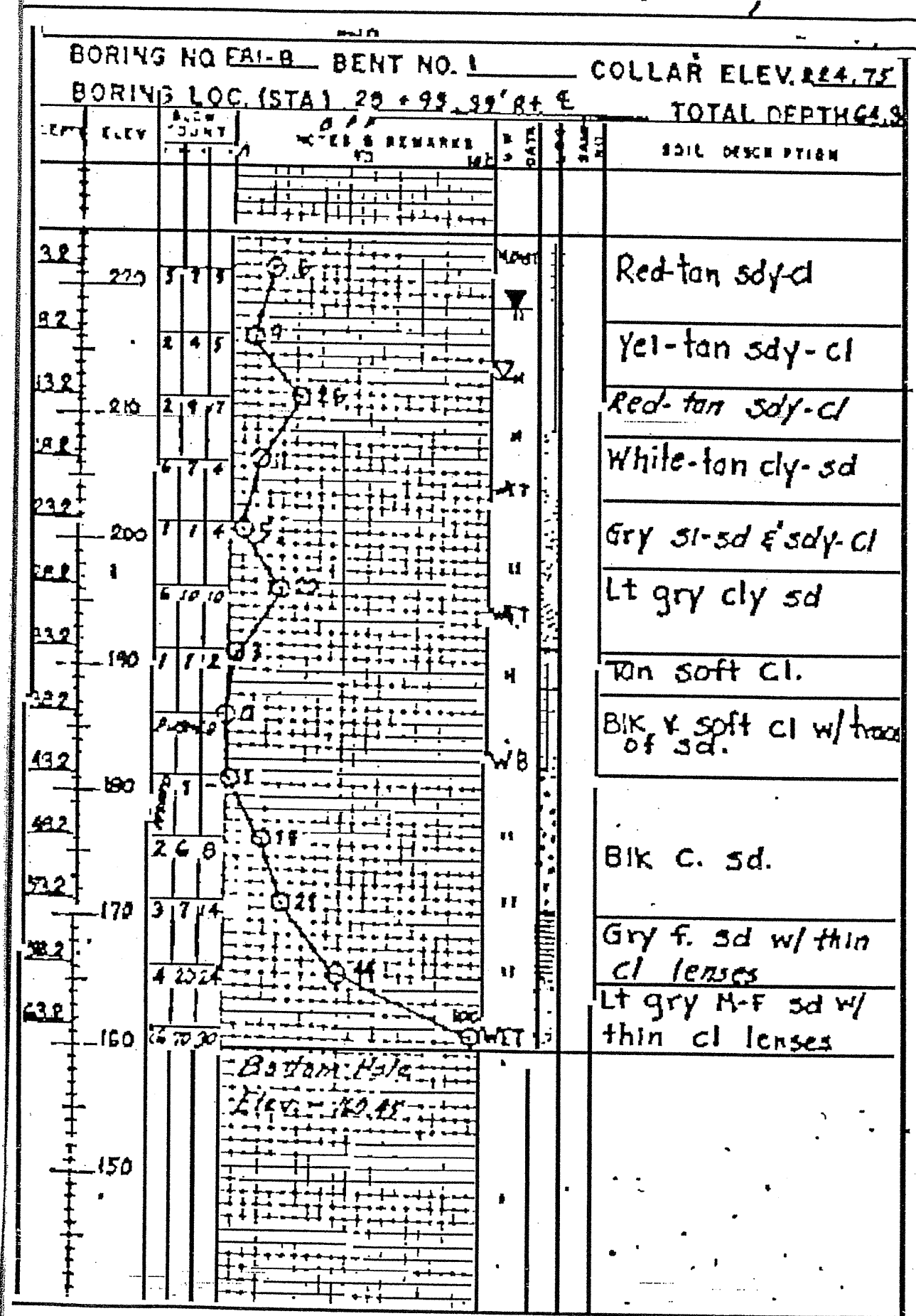
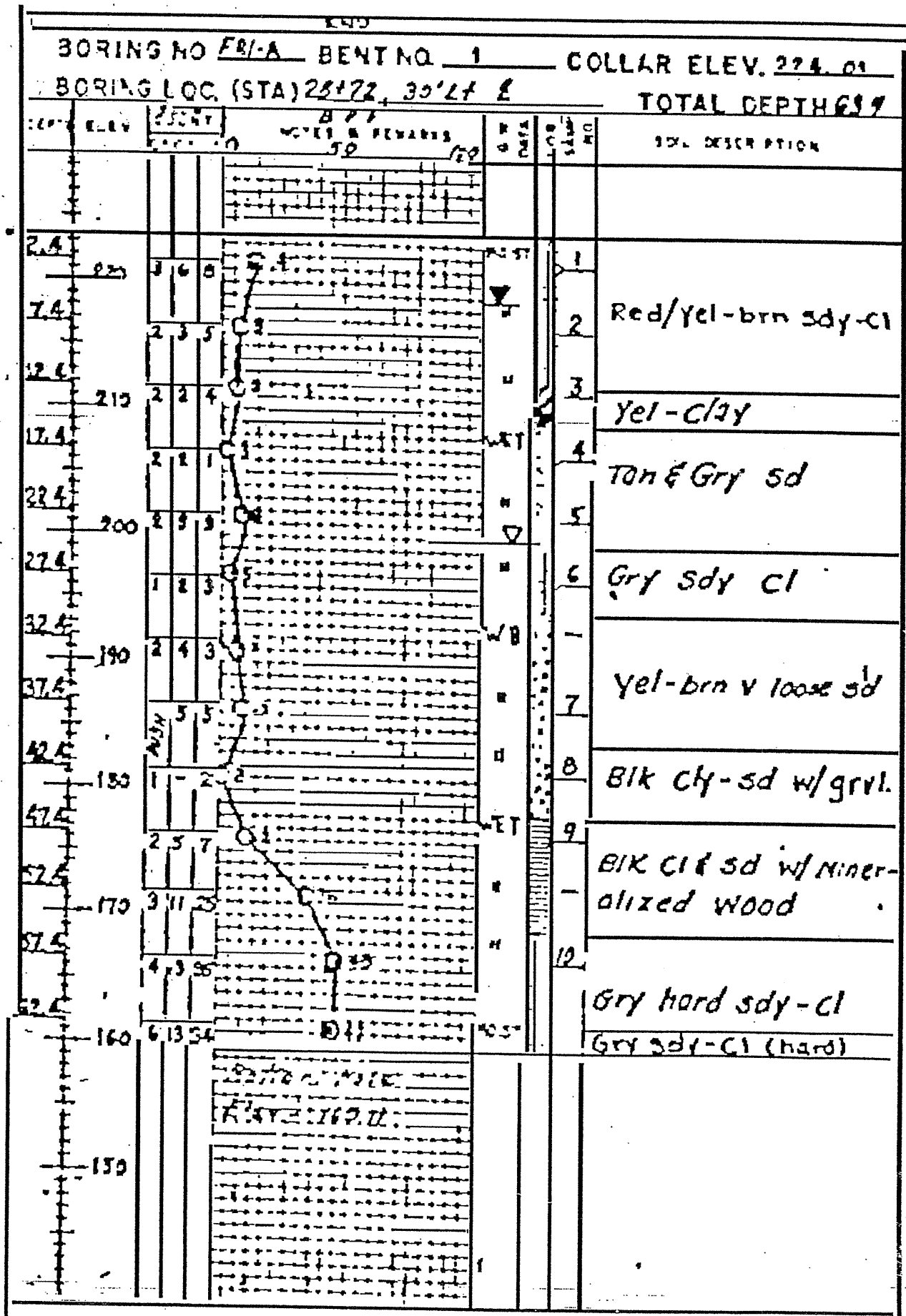
HORIZONTAL SCALE



PROFILE 39' RIGHT OF -L-

BRIDGE ON MORGANTON ROAD  
OVER ALL AMERICAN FREEWAY  
CUMERLAND CO., NC  
NCDOT PROJECT #: U-4756  
TIERRA PROJECT NO.: 6211-07-018

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2736 ROWLAND ROAD  
RALEIGH, NORTH CAROLINA 27615  
Phone (919) 871-0800 Fax (919) 871-0803

BORING LOG

SHEET 1 OF 1

PROJECT NO. U-4756		ID.		COUNTY CUMBERLAND, NC		GEOLOGIST S. HAN							
SITE DESCRIPTION BRIDGE ON MORGANTON ROAD OVER ALL AMERICAN FREEWAY													
BORING NO. B1A		BORING LOCATION 44+60		OFFSET 73' LT		ALIGNMENT							
COLLAR ELEV. 226 ft		NORTHING		EASTING		GROUND WATER (ft) 0 HR. 12 24 HR. 7.8							
TOTAL DEPTH 79.0 ft		DRILL MACHINE CME 45		DRILL METHOD MUD ROTARY		HAMMER TYPE MANUAL							
DATE STARTED 4-9-07		COMPLETED 4-9-07		SURFACE WATER DEPTH N/A									
ELEV. (ft)	DEPTH (ft)	BLOW COUNT			BLOWS PER FOOT					SAMP. NO.	LOG	SOIL AND ROCK DESCRIPTION	
		0.5ft	0.5ft	0.5ft	0	20	40	60	80				100
226.0													EXISTING GROUND
225	1.0	12	9	9									225.8 ROOTMAT
	3.5	2	3	3									223.0 RDWY EMB: GRAY AND BROWN, MED. DENSE, SILTY SAND (A-2-4) CP: GRAY, MED. STIFF, SANDY CLAY (A-6)
220	6.0	3	3	3									215.0 CP: GRAY, LOOSE, CLAYEY SAND (A-2-6)
	8.5	2	3	3									210.0 CP: GRAY, MED. DENSE, SAND (A-3)
215	13.5	3	2	3									204.0 CP: GRAY, V. STIFF TO SOFT, SANDY CLAY (A-6)
	17.5	5	6	12									194.0 CP: GRAY, V. LOOSE, CLAYEY SAND (A-2-6)
210	23.5	3	8	10									190.0 CP: GRAY, MED. DENSE, SAND (A-3)
	28.5	1	1	3									185.0 CP: GRAY AND TAN, V. SOFT TO STIFF, SANDY CLAY (A-7-5)
205	33.5	2	2	1									174.0 CP: GRAY, DENSE, COARSE SAND (A-1-b)
	38.5	9	10	11									169.0 CP: GRAY AND BROWN, V. DENSE, SAND (A-3)
200	43.5	WOH	WOH	1									147.0 BORING TERMINATED AT 79.0' IN CP: SAND
	48.5	4	5	6									NOTE: A LOSS OF DRILLING FLUIDS OCCURRED BETWEEN 50 TO 60 FEET.
195	53.5	6	10	28									
	58.5	31	57	43/4									
190	63.5	36	64/4										
	68.5	60/4											
185	73.5	60/4											
	78.5	60/4											

NCDOT\_BORE 07-018.GPJ NCDOT.GDT 5/1/07



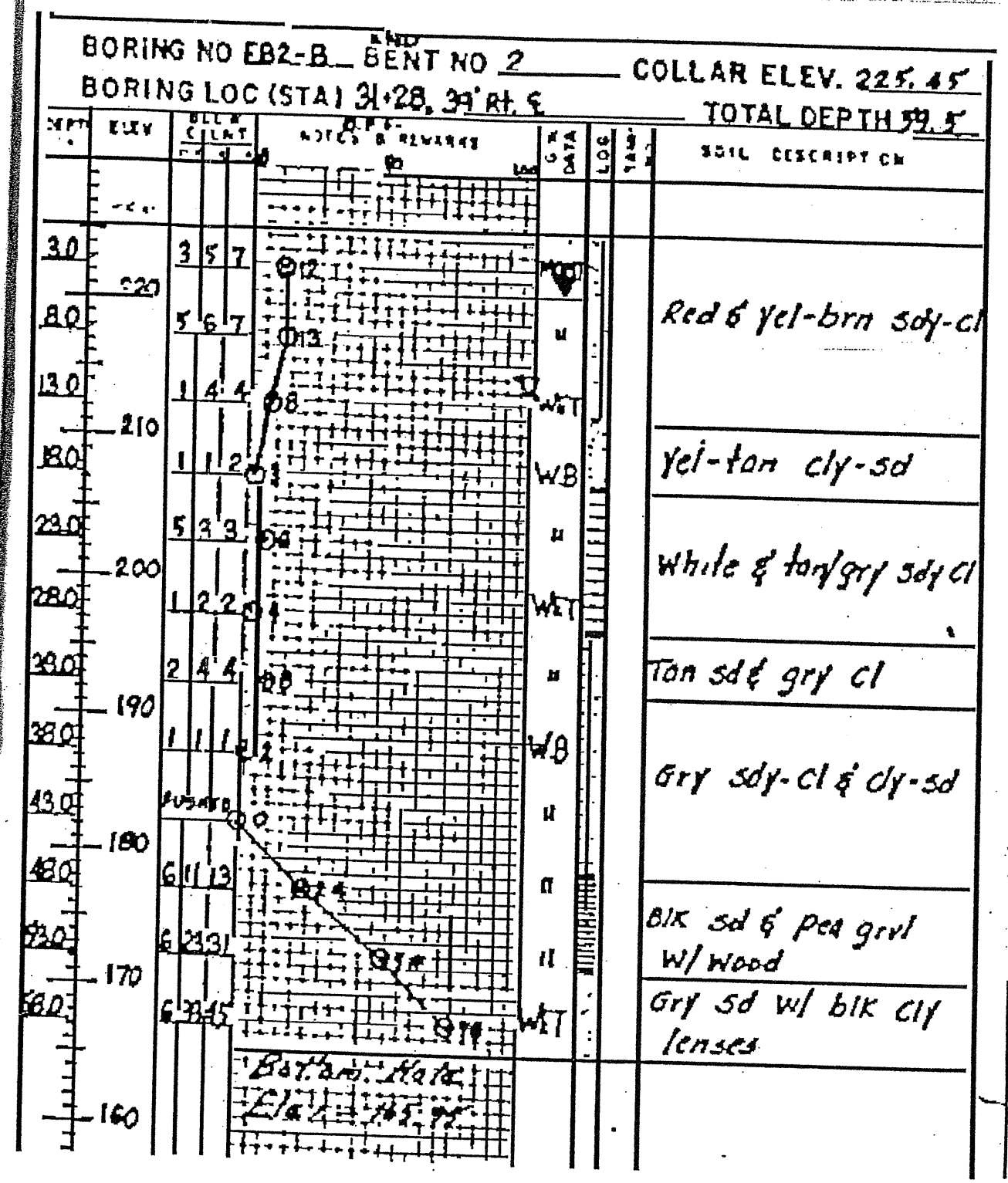
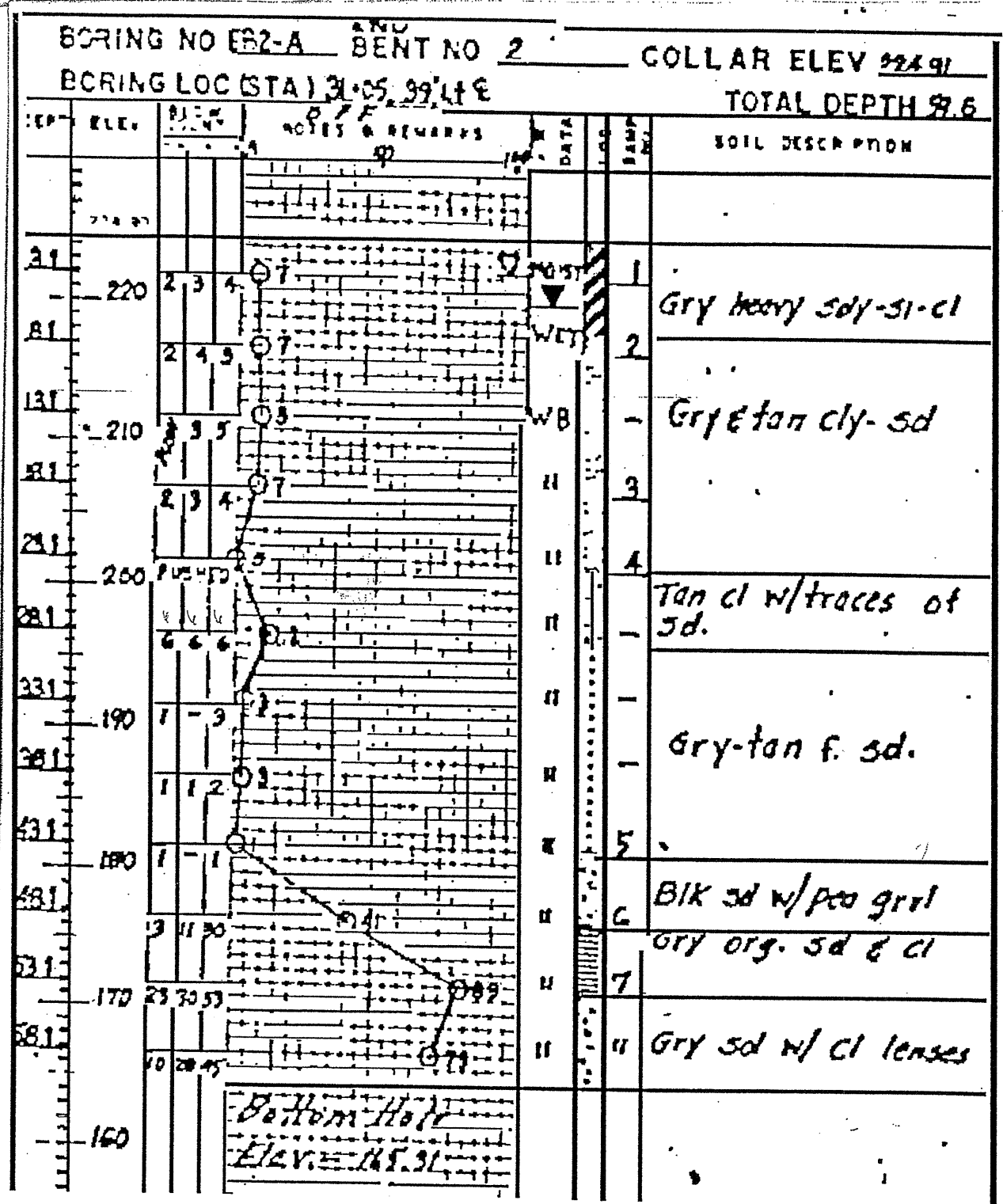
2736 ROWLAND ROAD  
RALEIGH, NORTH CAROLINA 27615  
Phone (919) 871-0800 Fax (919) 871-0803

BORING LOG

SHEET 1 OF 1

PROJECT NO. U-4756		ID.		COUNTY CUMBERLAND, NC		GEOLOGIST S. HAN							
SITE DESCRIPTION BRIDGE ON MORGANTON ROAD OVER ALL AMERICAN FREEWAY													
BORING NO. B1B		BORING LOCATION 45+13		OFFSET 80' RT		ALIGNMENT							
COLLAR ELEV. 226 ft		NORTHING		EASTING		GROUND WATER (ft) 0 HR. 9.8 24 HR. BACKFILL							
TOTAL DEPTH 79.9 ft		DRILL MACHINE CME 45		DRILL METHOD MUD ROTARY		HAMMER TYPE MANUAL							
DATE STARTED 4-10-07		COMPLETED 4-10-07		SURFACE WATER DEPTH N/A									
ELEV. (ft)	DEPTH (ft)	BLOW COUNT			BLOWS PER FOOT					SAMP. NO.	LOG	SOIL AND ROCK DESCRIPTION	
		0.5ft	0.5ft	0.5ft	0	20	40	60	80				100
226.0													EXISTING GROUND
225	1.0	1	2	5									225.8 ROOTMAT
	3.1	1	3	5									223.0 RDWY EMB: BROWN, LOOSE, SAND (A-3) CP: ORANGE AND GRAY, MED. STIFF TO STIFF, SILTY CLAY (A-7-5)
220	6.0	5	7	8									218.0 CP: BROWN, STIFF, SANDY CLAY (A-6)
	8.1	5	6	7									214.0 CP: TAN AND GRAY, STIFF, SANDY CLAY (A-7-5)
215	13.1	3	4	5									209.0 CP: RED AND TAN, MED. DENSE, CLAYEY SILTY SAND (A-2-4)
	18.4	18	13	5									204.0 CP: WHITE AND TAN, STIFF TO SOFT, SANDY SILTY CLAY (A-7-5)
210	23.4	7	4	9									196.5 CP: BROWN, GRAY WHITE AND RED, LOOSE TO V. LOOSE, SILTY SAND (A-2-4)
	28.4	1	1	3									179.0 CP: DARK GRAY, DENSE, COARSE SAND (A-1-b)
205	33.4	1	2	3									174.0 CP: DARK GRAY, V. STIFF, SANDY SILTY CLAY (A-7-6)
	38.4	4	3	5									171.5 CP: DARK GRAY, MED. DENSE, CLAYEY SILTY SAND (A-2-4)
200	43.4	1	1	1									167.5 CP: LIGHT GRAY, DENSE TO V. DENSE, SAND (A-3) WITH CLAY SEAMS
	48.4	15	20	17									155.0 CP: GRAY, V. DENSE, MED. TO COARSE SAND (A-1-b)
195	53.4	10	9	14									146.1 BORING TERMINATED AT 79.9' IN CP: SAND
	58.4	23	25	24									
190	63.4	10	9	14									
	68.4	21	38	60									
185	73.4	40	44	38									
	78.4	30	46	49									

NCDOT\_BORE 07-018.GPJ NCDOT.GDT 5/1/07



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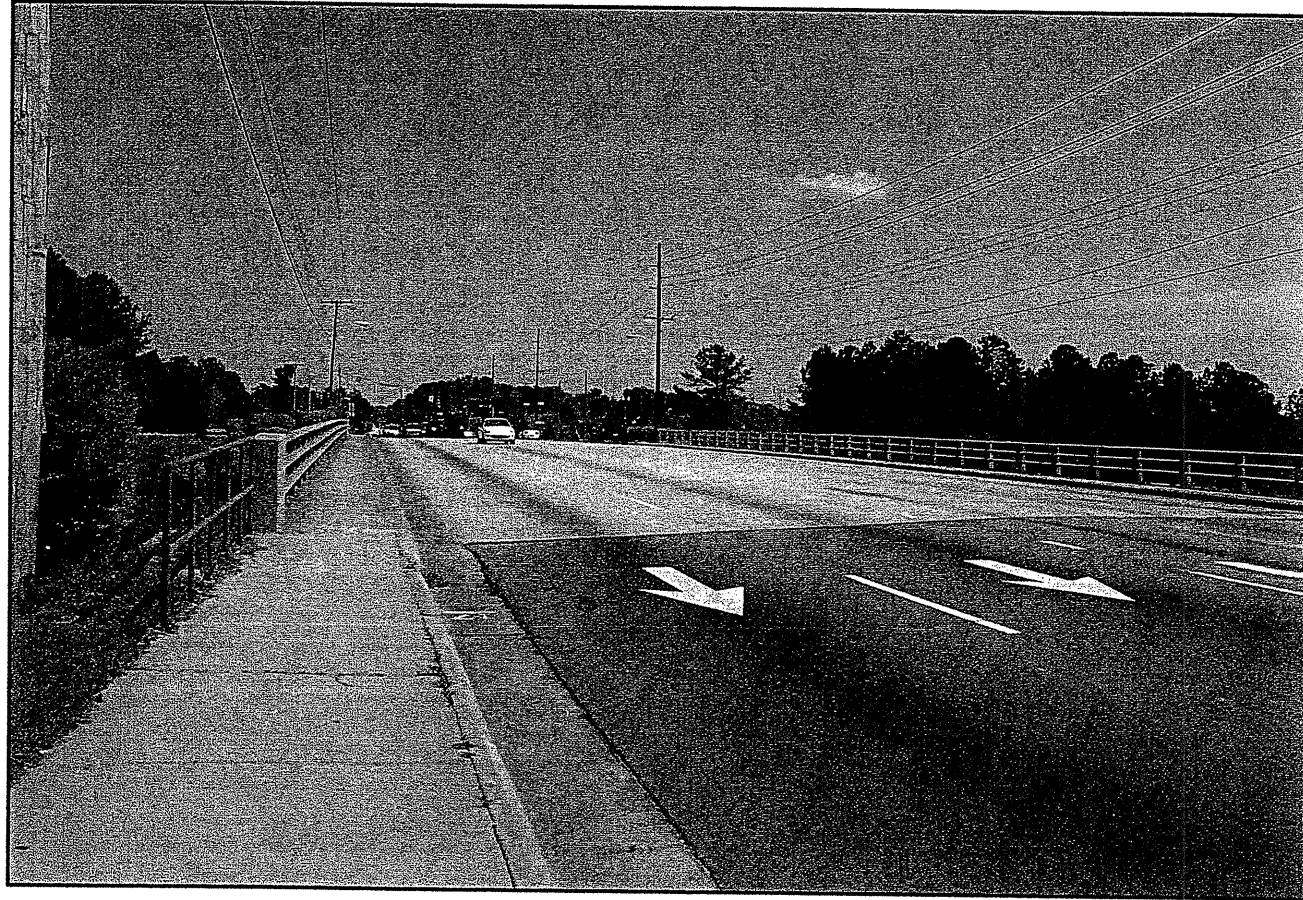
SOIL CLASSIFICATION AND GRADATION SHEET

BRIDGE ON MORGANTON ROAD OVER ALL AMERICAN FREEWAY  
 NCDOT PROJECT NO.: U-4756

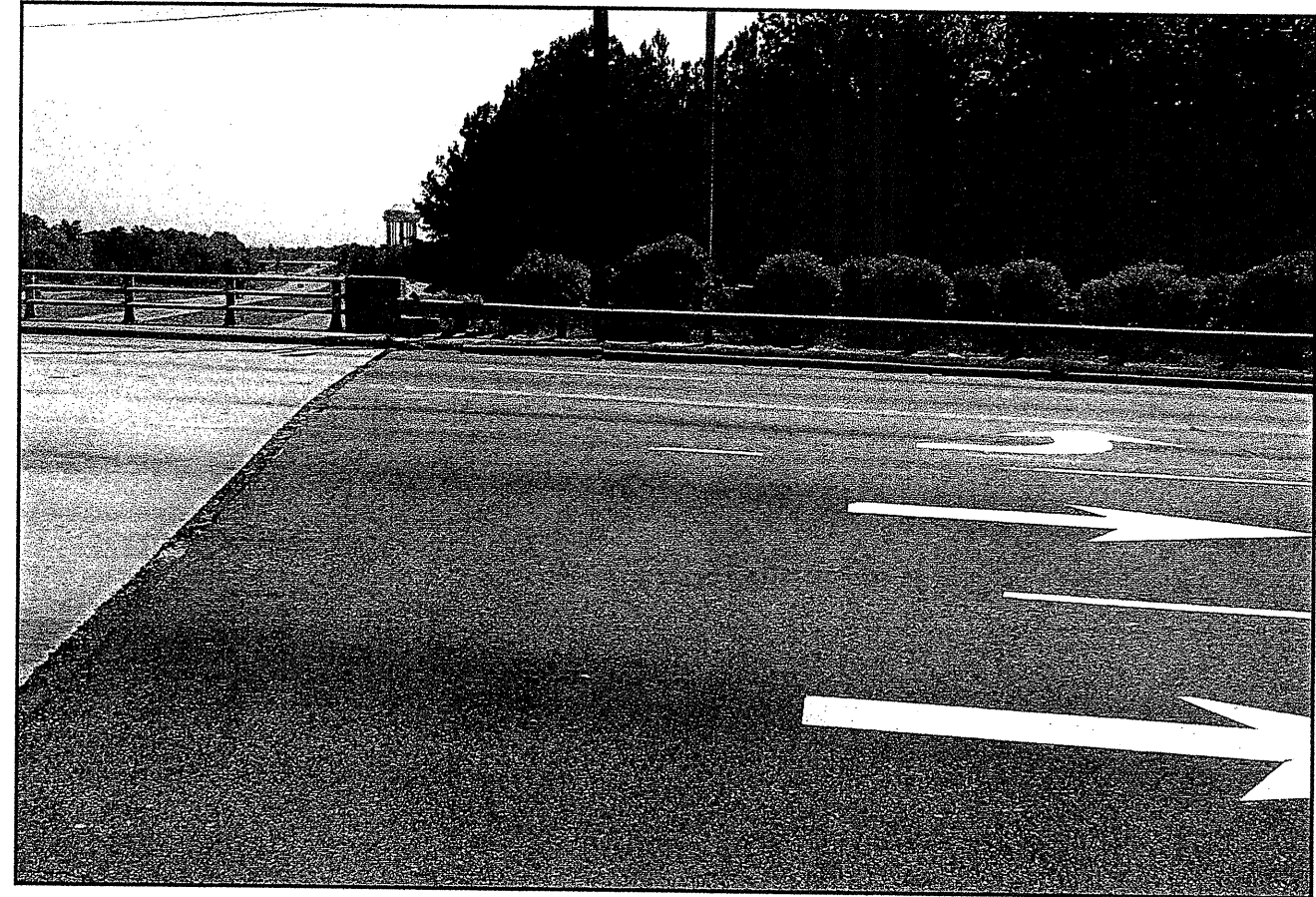
CUMBERLAND COUNTY

TIERRA, INC. PROJECT NO: 6211-07-018

BORING #		SAMPLE #	NATURAL MOISTURE CONTENT	TOTAL SAMPLE			ATTERBERG LIMIT		
AASHTO Classification				PERCENT PASSING			LIQUID LIMIT	PLASTIC LIMIT	PLASTIC INDEX
STATION #	OFFSET (FEET)	DEPTH (FEET)	#10	#40	#200				
B1A		SS-1	23.5%	99	84	50	38	18	20
A-6									
44+60	73 LT	3.5-5.0							
B1A		SS-2	24.4%	100	90	50	34	14	20
A-6									
44+60	73 LT	23.5-25.0							
B1B		SS-3	21.4%	100	75	36	31	12	19
A-6									
45+13	80 RT	8.1-9.6							
B1B		SS-4	33.9%	92	56	14	NP	NP	NP
A-2-4									
45+13	80 RT	43.4-44.9							



**PHOTO 1: PROFILE 39' LEFT OF -L-, LOOKING UPSTATION**



**PHOTO 2: END BENT 1, LOOKING FROM LEFT TO RIGHT**

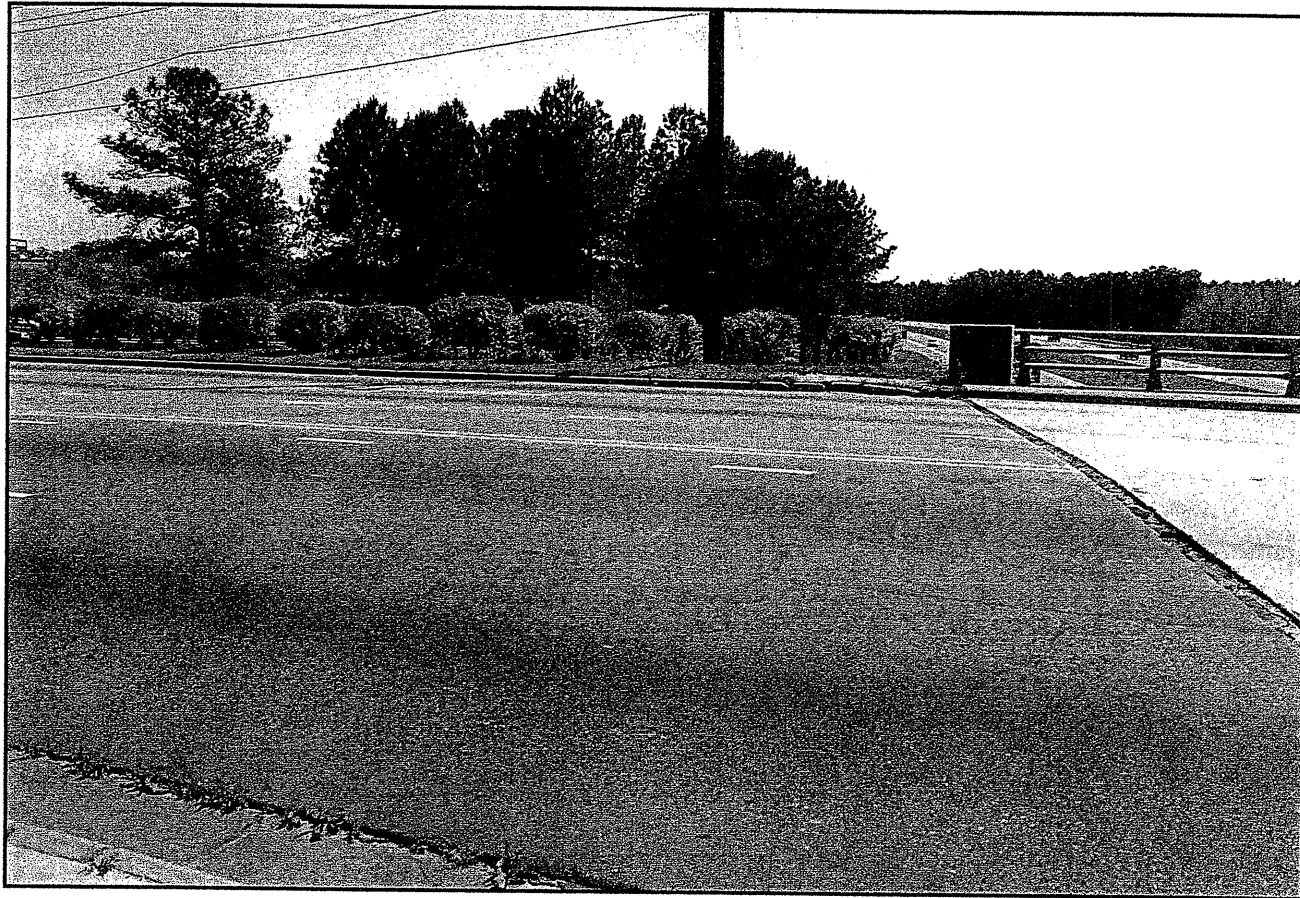
**SITE PHOTOGRAPHS**

**BRIDGE ON MORGANTON ROAD  
OVER ALL AMERICAN FREEWAY  
CUMBERLAND CO., NC  
NCDOT PROJECT #: U-4756  
TIERRA PROJECT #: 6211-07-018**

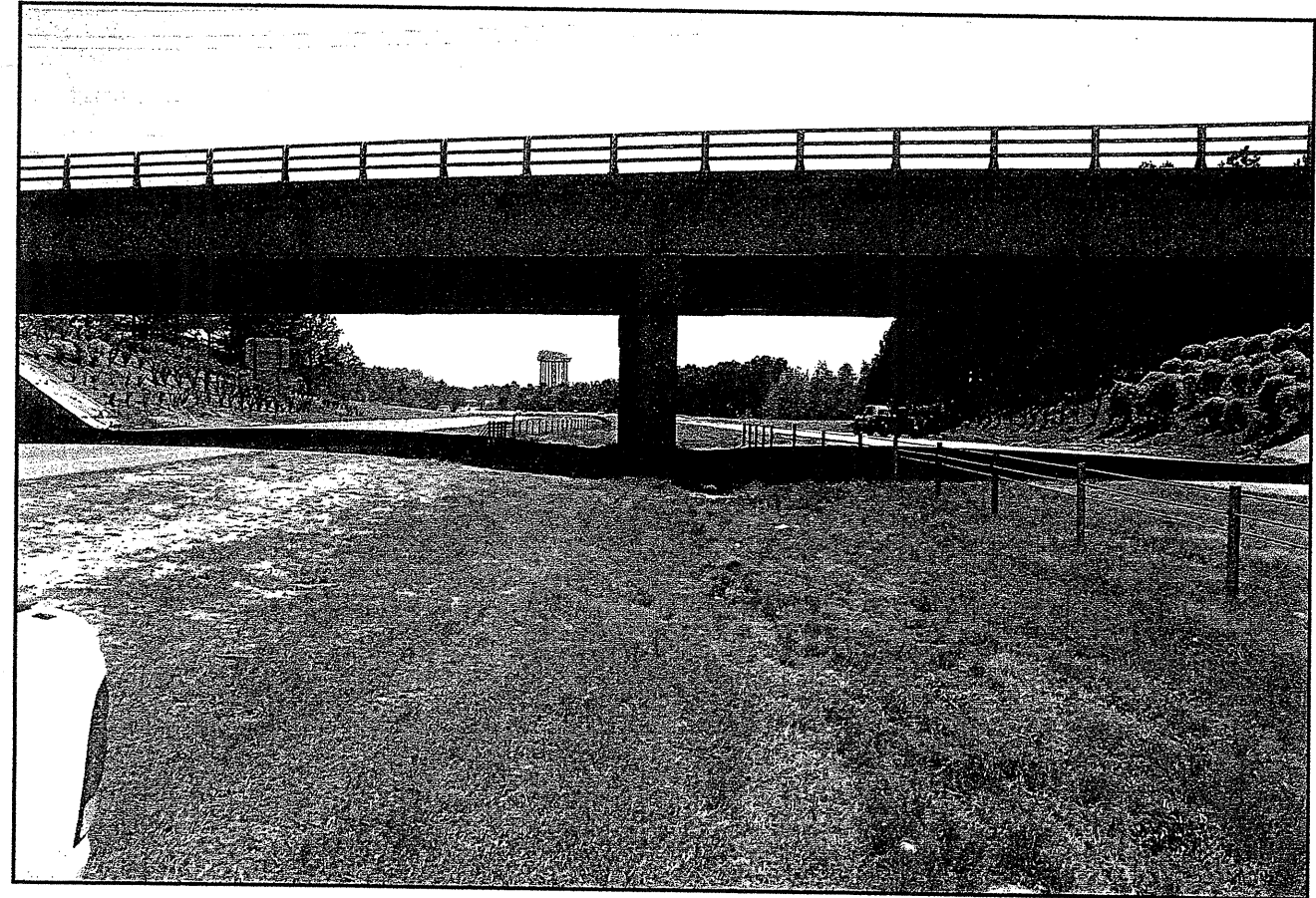


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FAX (919) 871-0803





**PHOTO 3: END BENT 2, LOOKING FROM LEFT TO RIGHT**



**PHOTO 4: BENT 1, LOOKING SOUTH TOWARD BORING B1A**

**SITE PHOTOGRAPHS**

**BRIDGE ON MORGANTON ROAD  
OVER ALL AMERICAN FREEWAY  
CUMBERLAND CO., NC  
NCDOT PROJECT #: U-4756  
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