FROEHLING & ROBERTSON, INC.

SUBSURFACE INVESTIGATION AND BRIDGE FOUNDATION DESIGN RECOMMENDATIONS

WBS Element No. 45360.1.33 Tip No. BD-5114AG
Structure No. 550064 – Bridge on SR 1328 over Watauga Creek
Macon County, North Carolina
F&R PROJECT NO. 63P-0310-0064

Prepared for:

Vaughn & Melton Consulting Engineers
1318-F Patton Avenue
Asheville, North Carolina 28806

August 29, 2014

2505 Hutchison-McDonald Road Charlotte, North Carolina 28269 704.596.2889

SINCE 1881

FROEHLING & ROBERTSON, INC.

Engineering Stability Since 1881

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August 29, 2014

Mr. Hardy Willis, P.E.
Vaughn & Melton Consulting Engineers
1318-F Patton Avenue
Asheville, North Carolina 28806

Re: **Subsurface Investigation and Bridge Foundation Design Recommendations**
Bridge Structure No. 550064 on SR 1328 over Watauga Creek

WBS Element No.:	45360.1.33
TIP No.:	BD-5114AG
County:	Macon
F&R Project No.:	63P-0310-0064

Dear Mr. Willis,

Froehling & Robertson, Inc. (F&R) has completed the subsurface investigation and bridge foundation design recommendations for the new structure proposed on SR 1328 over Watauga Creek. Our design is based on using NCDOT Standard Loads and information provided to us by Vaughn & Melton. This work was performed in general accordance with F&R's Proposal No. 1363-164G, dated August 9, 2012. This report contains the foundation recommendations, Structure Subsurface Investigation Report, and supporting calculations.

Please do not hesitate to contact us if you have any questions regarding this report or if you need additional services.

Sincerely,

FROEHLING & ROBERTSON, INC.

D. Matthew Brewer, E.I.
Transportation Staff Professional

Michael J. Walko, P.E.
Senior Engineer
N.C. Registration No. 26917

NORTH CAROLINA PROFESSIONAL SEAL 026917 ENGINEER MICHAEL J. WALKO

8/29/14

APPENDIX A

FOUNDATION RECOMMENDATIONS

FOUNDATION RECOMMENDATIONS

WBS # 45360.1.33

DESCRIPTION Bridge 550064 - SR 1328 over Watauga Creek

T.I.P. NO. BD-5114AG

COUNTY Macon

STATION -L- 14+14.77

SEAL
NORTH CAROLINA PROFESSIONAL SEAL 026917 ENGINEER MICHAEL J. WALKO
SIGNATURE 8/29/14

	INITIALS	DATE
DESIGN	DMB	Aug-14
CHECK	MJW	Aug-14
REVISED		

BENT	STATION	FOUNDATION TYPE	FACTORED RESISTANCE	MISCELLANEOUS DETAILS
END BENT NO. 1	13+86.14	Cap on HP 12X53 Steel Piles	85 Tons/Pile	BOC Elevation = 1,997.6 ft. Avg. Pile Length = 15 ft. 5 vertical piles @ 8'-3" spacing
END BENT NO. 2	14+43.39	Cap on HP 12X53 Steel Piles	85 Tons/Pile	BOC Elevation = 1,998.6 ft. Avg. Pile Length = 20 ft. 5 vertical piles @ 8'-3" spacing

NOTES ON PLANS & COMMENTS (See following page)

WBS # 45360.1.33 **County** Macon

FOUNDATION RECOMMENDATION NOTES ON PLANS

1) For Piles, see Section 450 of the Standard Specifications.

2) Piles at End Bent No. 1 and End Bent No. 2 are designed for a factored resistance of 85 tons per pile.

3) Drive piles at End Bent No. 1 and End Bent No. 2 to a required driving resistance of 145 tons per pile.

4) Steel H-pile points are required for steel H-piles at End Bent No. 2. For steel pile points, see Section 450 of the Standard Specifications.

5) It has been estimated that a hammer with an equivalent rated energy in the range of 30 to 45 ft-kips per blow will be required to drive piles at End Bent No. 1. The estimated energy range does not release the contractor from providing driving equipment in accordance with Subarticle 450-3(D)(2) of the Standard Specifications.

6) Pile excavation is required to install piles at End Bent No. 1. Excavate holes at pile locations to Elevation 1,984 ft. (Lt) and Elevation 1,987 ft. (Rt) and have at least 5 feet of penetration into weathered rock or rock. See Section 450 of the Standard Specifications.

7) Testing Piles with the PDA during driving, restriking or redriving may be required at End Bent No. 2. The Engineer will determine the need for PDA testing. For PDA testing, see Section 450 of the Standard Specifications and for pile driving criteria, see Pile Driving Criteria Provision.

8) Concrete is required to fill holes for pile excavation at End Bent No. 1.

9) If necessary, predrill pile locations at End Bent No. 2 for pile No's. 1, 2, and 3. Install piles at End Bent No. 2 to elevation 1985 ft with equipment that will result in a maximum predrilling diameter of 12". For predrilling piles, see Section 450 of the Standard Specifications.

FOUNDATION RECOMMENDATION COMMENTS

1) A Delmag D19-32 pile hammer was utilized as a common hammer type to determine potential pile driving stresses. This hammer should provide sufficient energy to drive the piles to the required driving resistance at End Bent No. 2. The actual hammer to be utilized will need to be submitted by the contractor and analyzed prior to construction.

2) 1.5: 1 (H:V) or flatter end slopes with rip rap slope protection are recommended as shown on the preliminary general drawing.

3) PDA will not be used to monitor driving stresses at End Bent No. 1.

4) The sub-regional approach fill detail should be used at both end bents.

5) No waiting period is required at either end bent prior to construction.

PILE PAY ITEMS

(Revised 8/15/12)

WBS ELEMENT 45360.1.33 DATE Aug-14

TIP NO. BD-5114AG DESIGNED BY DMB

COUNTY Macon CHECKED BY MJW

STATION 14+14.77 -L-

DESCRIPTION Bridge No. 064 on SR 1328 over Watauga Creek

NUMBER OF BENTS WITH PILES
NUMBER OF PILES PER BENT
NUMBER OF END BENTS WITH PILES 1
NUMBER OF PILES PER END BENT 5

Only required for "Predrilling for Piles" & "Pile Excavation" pay items

Bent # or End Bent #	PILE PAY ITEM QUANTITIES						
	Steel Pile Points (yes/no)	Pipe Pile Plates (yes/no/maybe)	Predrilling For Piles (per linear ft)	Pile Redrives (per each)	Pile Excavation (per linear ft)		PDA Testing (per each)
					In Soil	Not In Soil	
End Bent No. 1	No	No	0	0	40	25	
End Bent No. 2	Yes	No	55	0	0	0	
TOTALS			55	0	40	25	1

Notes:

Blanks or "no" represent quantity of zero.

If steel pile points are required, calculate quantity of "Steel Pile Points" as equal to the number of steel piles.

If pipe pile plates are or may be required, calculate the quantity of "Pipe Pile Plates" as equal to the number of pipe piles.

Show quantity of "PDA Testing" on the plans as total only.

If quantity of "PDA Testing" is 3 or less, reference "Pile Driving Criteria" provision in PDA notes on plans and include "Pile Driving Criteria" provision in the contract.

STATE OF NORTH CAROLINA DEPARTMENT OF TRANSPORTATION DIVISION OF HIGHWAYS HIGHWAY BUILDING 1589 MAIL SERVICE CENTER RALEIGH, NORTH CAROLINA 27699-1589	SUBJECT: Bridge 550064 - SR 1328 over Watauga Creek		WBS Element No. 45360.1.33
	PREPARED BY:	DMB	COUNTY: Macon
	DATE:	Aug-14	TIP No. BD-5114AG
	CHECKED BY:	MJW	**Bridge Structure No. 550064**
	DATE:	Aug-14	

END BENTS SUMMARY

END BENT NO. 1

Pile Type: HP 12X53 Steel Piles	
Bottom of Cap Elevation: 1,997.6 ft.	Provided by Vaughn & Melton
Approx. Top of WR/CR Elevation: 1,989.2 ft (Lt), 1,992.6 ft (Rt)	By inspection of EB1-A and EB1-B
Pile Tip Elevation: 1,984.2ft. (Lt), 1,987.6 ft. (Rt)	Pile Excavation Required with Minimum 5' of Penetration into WR/CR
Anticipated Pile Length: 15 ft. ± (Lt), 11 ft. ± (Rt)	BOC Elevation - Pile Tip Elevation + 1 foot Embed into Cap
Average Pile Length: 15 ft. ± (Lt), 15 ft. ± (Rt)	Anticipated pile length rounded up to the nearest 5 feet
Pile Excavation In Soil: 40 ft.	
Pile Excavation Not In Soil: 25 ft.	Minimum 5' Penetration into WR/CR
Max Factored Load: 85 Tons/Pile	NCDOT Standard Loads, rounded up to the nearest 5 tons
Required Ultimate Resistance: 190 Tons/Pile	AASHTO Resistance Factor = 0.45
Required Driving Resistance: 145 Tons/Pile	Driving Resistance Factor = 0.6 for WEAP Analysis without PDA's.

END BENT NO. 2

Pile Type: HP 12X53 Steel Piles	
Bottom of Cap Elevation: 1,998.6 ft.	Provided by Vaughn & Melton
Approx. Top of WR/CR Elevation: 1,982.9 ft (Lt), 1,983.7 ft (Rt)	By inspection of EB2-A and EB2-B
Anticipated Pile Length: 17 ft. ±	BOC Elevation - Pile Tip Elevation + 1 foot Embed into Cap
Average Pile Length: 20 ft. ±	Anticipated pile length rounded up to the nearest 5 feet
Max Factored Load: 85 Tons/Pile	NCDOT Standard Loads, rounded up to the nearest 5 tons
Required Ultimate Resistance: 190 Tons/Pile	AASHTO Resistance Factor = 0.45
Required Driving Resistance: 145 Tons/Pile	Driving Resistance Factor = 0.6 for WEAP Analysis with limited PDA's.

NOTES ON PLANS

1) See Notes on Sheet 2

COMMENTS

1) A Delmag D19-32 pile hammer was utilized as a common hammer type to determine potential pile driving stresses. This hammer should provide sufficient energy to drive the piles to the required driving resistance at End Bent No. 2. The actual hammer to be utilized will need to be submitted by the contractor and analyzed prior to construction.

2) 1.5: 1 (H:V) or flatter end slopes with rip rap slope protection are recommended as shown on the preliminary general drawing.

3) PDA will not be used to monitor driving stresses at End Bent No. 1.

4) The sub-regional approach fill detail should be used at both end bents.

5) No waiting period is required at either end bent prior to construction.

APPENDIX B

STRUCTURE SUBSURFACE INVESTIGATION

STATE	STATE PROJECT REFERENCE NO.	SHEET NO.	TOTAL SHEETS
N.C.	BD-5114AG	1	13

STATE OF NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
GEOTECHNICAL ENGINEERING UNIT

STRUCTURE SUBSURFACE INVESTIGATION

PROJ. REFERENCE NO. 45360.1.33 F.A. PROJ. N/A

COUNTY Macon

PROJECT DESCRIPTION Bridge No. 550064 on SR 1328 (Jim Berry Road) over Watauga Creek

CONTENTS

SHEET	DESCRIPTION
1	TITLE SHEET
2, 2A	LEGEND
3	SITE PLAN
4	BORING LOCATION PLAN
5-12	BORE LOG REPORTS, CORE LOG REPORTS, AND ROCK CORE PHOTOS

PERSONNEL

C. Boyce

J. McKay

M. Brewer, E.I.

INVESTIGATED BY F&R, Inc.

CHECKED BY M. Walko, P.E.

SUBMITTED BY F&R, Inc.

DATE August 2014

CAUTION NOTICE

THE SUBSURFACE INFORMATION AND THE SUBSURFACE INVESTIGATION ON WHICH IT IS BASED WERE MADE FOR THE PURPOSE OF STUDY, PLANNING, AND DESIGN, AND NOT FOR CONSTRUCTION OR PAY PURPOSES. THE VARIOUS FIELD BORING LOGS, ROCK CORES, AND SOIL TEST DATA AVAILABLE MAY BE REVIEWED OR INSPECTED IN RALEIGH BY CONTACTING THE N. C. DEPARTMENT OF TRANSPORTATION, GEOTECHNICAL ENGINEERING UNIT AT (919) 707-6850. NEITHER THE SUBSURFACE PLANS AND REPORTS, NOR THE FIELD BORING LOGS, ROCK CORES, OR SOIL TEST DATA ARE PART OF THE CONTRACT.

GENERAL SOIL AND ROCK STRATA DESCRIPTIONS AND INDICATED BOUNDARIES ARE BASED ON A GEOTECHNICAL INTERPRETATION OF ALL AVAILABLE SUBSURFACE DATA AND MAY NOT NECESSARILY REFLECT THE ACTUAL SUBSURFACE CONDITIONS BETWEEN BORINGS OR BETWEEN SAMPLED STRATA WITHIN THE BOREHOLE. THE LABORATORY SAMPLE DATA AND THE IN SITU (IN-PLACE) TEST DATA CAN BE RELIED ON ONLY TO THE DEGREE OF RELIABILITY INHERENT IN THE STANDARD TEST METHOD. THE OBSERVED WATER LEVELS OR SOIL MOISTURE CONDITIONS INDICATED IN THE SUBSURFACE INVESTIGATIONS ARE AS RECORDED AT THE TIME OF THE INVESTIGATION. THESE WATER LEVELS OR SOIL MOISTURE CONDITIONS MAY VARY CONSIDERABLY WITH TIME ACCORDING TO CLIMATIC CONDITIONS INCLUDING TEMPERATURES, PRECIPITATION, AND WIND, AS WELL AS OTHER NON-CLIMATIC FACTORS.

THE BIDDER OR CONTRACTOR IS CAUTIONED THAT DETAILS SHOWN ON THE SUBSURFACE PLANS ARE PRELIMINARY ONLY AND IN MANY CASES THE FINAL DESIGN DETAILS ARE DIFFERENT. FOR BIDDING AND CONSTRUCTION PURPOSES, REFER TO THE CONSTRUCTION PLANS AND DOCUMENTS FOR FINAL DESIGN INFORMATION ON THIS PROJECT. THE DEPARTMENT DOES NOT WARRANT OR GUARANTEE THE SUFFICIENCY OR ACCURACY OF THE INVESTIGATION MADE, NOR THE INTERPRETATIONS MADE, OR OPINION OF THE DEPARTMENT AS TO THE TYPE OF MATERIALS AND CONDITIONS TO BE ENCOUNTERED. THE BIDDER OR CONTRACTOR IS CAUTIONED TO MAKE SUCH INDEPENDENT SUBSURFACE INVESTIGATIONS AS HE DEEMS NECESSARY TO SATISFY HIMSELF AS TO CONDITIONS TO BE ENCOUNTERED ON THIS PROJECT. THE CONTRACTOR SHALL HAVE NO CLAIM FOR ADDITIONAL COMPENSATION OR FOR AN EXTENSION OF TIME FOR ANY REASON RESULTING FROM THE ACTUAL CONDITIONS ENCOUNTERED AT THE SITE DIFFERING FROM THOSE INDICATED IN THE SUBSURFACE INFORMATION.

NOTE - THE INFORMATION CONTAINED HEREIN IS NOT IMPLIED OR GUARANTEED BY THE N. C. DEPARTMENT OF TRANSPORTATION AS BEING ACCURATE NOR IT IS CONSIDERED TO BE PART OF THE PLANS, SPECIFICATIONS, OR CONTRACT FOR THE PROJECT.

NOTE - BY HAVING REQUESTED THIS INFORMATION THE CONTRACTOR SPECIFICALLY WAIVES ANY CLAIMS FOR INCREASED COMPENSATION OR EXTENSION OF TIME BASED ON DIFFERENCES BETWEEN THE CONDITIONS INDICATED HEREIN AND THE ACTUAL CONDITIONS AT THE PROJECT SITE.

NORTH CAROLINA PROFESSIONAL SEAL 026917 ENGINEER MICHAEL J. WALKO

Michael J. Walko 8/29/14

DRAWN BY: M. Brewer, E.I.

PROJECT REFERENCE NO.	SHEET NO.
BD-5114AG	2

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
GEOTECHNICAL ENGINEERING UNIT
SOIL AND ROCK LEGEND, TERMS, SYMBOLS, AND ABBREVIATIONS

SOIL DESCRIPTION

SOIL IS CONSIDERED TO BE THE UNCONSOLIDATED, SEMI-CONSOLIDATED, OR WEATHERED EARTH MATERIALS THAT CAN BE PENETRATED WITH A CONTINUOUS FLIGHT POWER AUGER, AND YIELD LESS THAN 100 BLOWS PER FOOT ACCORDING TO STANDARD PENETRATION TEST (AASHTO T206, ASTM D-1586). SOIL CLASSIFICATION IS BASED ON THE AASHTO SYSTEM. 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, MOIST WITH INTERBEDDED FINE SAND LAYERS, HIGHLY PLASTIC, A-7-6

SOIL LEGEND AND AASHTO CLASSIFICATION

GENERAL CLASS.	GRANULAR MATERIALS (≤ 35% PASSING #200)							SILT-CLAY MATERIALS (> 35% PASSING #200)				ORGANIC MATERIALS		
GROUP CLASS.	A-1		A-3	A-2				A-4	A-5	A-6	A-7	A-1, A-2 A-3	A-4, A-5 A-6, A-7	
	A-1-a	A-1-b		A-2-4	A-2-5	A-2-6	A-2-7				A-7-5 A-7-6			
SYMBOL														
% PASSING # 10	50 MX											GRANULAR SOILS	SILT-CLAY SOILS	MUCK, PEAT
# 40	30 MX	50 MX	51 MN											
# 200	15 MX	25 MX	10 MX	35 MX	35 MX	35 MX	35 MX	36 MN	36 MN	36 MN	36 MN			
LIQUID LIMIT / PLASTIC INDEX	6 MX		NP	40 MX / 10 MX	41 MN / 10 MX	40 MX / 11 MN	41 MN / 11 MN	40 MX / 10 MX	41 MN / 10 MX	40 MX / 11 MN	41 MN / 11 MN	SOILS WITH LITTLE OR MODERATE AMOUNTS OF ORGANIC MATTER		HIGHLY ORGANIC SOILS
GROUP INDEX	0		0	0		4 MX		8 MX	12 MX	16 MX	No MX			
USUAL TYPES OF MAJOR MATERIALS	STONE FRAGS. GRAVEL, AND SAND		FINE SAND	SILTY OR CLAYEY GRAVEL AND SAND				SILTY SOILS		CLAYEY SOILS				
GEN. RATING AS A SUBGRADE	EXCELLENT TO GOOD							FAIR TO POOR				FAIR TO POOR	POOR	UNSUITABLE

PI OF A-7-5 SUBGROUP IS ≤ LL - 30 ; PI OF A-7-6 SUBGROUP IS > LL - 30

CONSISTENCY OR DENSENESS

PRIMARY SOIL TYPE	COMPACTNESS OR CONSISTENCY	RANGE OF STANDARD PENETRATION RESISTENCE (N-VALUE)	RANGE OF UNCONFINED COMPRESSIVE STRENGTH (TONS/FT^2)
GENERALLY GRANULAR MATERIAL (NON-COHESIVE)	VERY LOOSE LOOSE MEDIUM DENSE DENSE VERY DENSE	<4 4 TO 10 10 TO 30 30 TO 50 >50	N/A
GENERALLY SILT-CLAY MATERIAL (COHESIVE)	VERY SOFT SOFT MEDIUM STIFF STIFF VERY STIFF HARD	<2 2 TO 4 4 TO 8 8 TO 15 15 TO 30 >30	<0.25 0.25 TO 0.50 0.5 TO 1.0 1 TO 2 2 TO 4 >4

TEXTURE OR GRAIN SIZE

U.S. STD. SIEVE SIZE	4	10	40	60	200	270
OPENING (MM)	4.76	2.00	0.42	0.25	0.075	0.053

BOULDER (BLDR.)	COBBLE (COB.)	GRAVEL (GR.)	COARSE SAND (CSE. SD.)	FINE SAND (F SD.)	SILT (SL.)	CLAY (CL.)

GRAIN SIZE MM: 305 | 75 | 2.0 | 0.25 | 0.05 | 0.005
GRAIN SIZE IN.: 12 | 3

SOIL MOISTURE - CORRELATION OF TERMS

SOIL MOISTURE SCALE (ATTERBERG LIMITS)	FIELD MOISTURE DESCRIPTION	GUIDE FOR FIELD MOISTURE DESCRIPTION
	- SATURATED - (SAT.)	USUALLY LIQUID; VERY WET, USUALLY FROM BELOW THE GROUND WATER TABLE
LL — LIQUID LIMIT PLASTIC RANGE (PI) PL — PLASTIC LIMIT	- WET - (W)	SEMISOLID; REQUIRES DRYING TO ATTAIN OPTIMUM MOISTURE
OM — OPTIMUM MOISTURE SL — SHRINKAGE LIMIT	- MOIST - (M)	SOLID; AT OR NEAR OPTIMUM MOISTURE
	- DRY - (D)	REQUIRES ADDITIONAL WATER TO ATTAIN OPTIMUM MOISTURE

PLASTICITY

	PLASTICITY INDEX (PI)	DRY STRENGTH
NONPLASTIC	0-5	VERY LOW
LOW PLASTICITY	6-15	SLIGHT
MED. PLASTICITY	16-25	MEDIUM
HIGH PLASTICITY	26 OR MORE	HIGH

COLOR

DESCRIPTIONS MAY INCLUDE COLOR OR COLOR COMBINATIONS (TAN, RED, YELLOW-BROWN, BLUE-GRAY). MODIFIERS SUCH AS LIGHT, DARK, STREAKED, ETC. ARE USED TO DESCRIBE APPEARANCE.

GRADATION

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 IS DESIGNATED BY THE TERMS ANGULAR, SUBANGULAR, SUBROUNDED, OR ROUNDED.

MINERALOGICAL COMPOSITION

MINERAL NAMES SUCH AS QUARTZ, FELDSPAR, MICA, TALC, KAOLIN, ETC. ARE USED IN DESCRIPTIONS WHENEVER THEY ARE CONSIDERED OF SIGNIFICANCE.

COMPRESSIBILITY

SLIGHTLY COMPRESSIBLE	LIQUID LIMIT LESS THAN 31
MODERATELY COMPRESSIBLE	LIQUID LIMIT EQUAL TO 31-50
HIGHLY COMPRESSIBLE	LIQUID LIMIT GREATER THAN 50

PERCENTAGE OF MATERIAL

ORGANIC MATERIAL	GRANULAR SOILS	SILT - CLAY SOILS
TRACE OF ORGANIC MATTER	2 - 3%	3 - 5%
LITTLE ORGANIC MATTER	3 - 5%	5 - 12%
MODERATELY ORGANIC	5 - 10%	12 - 20%
HIGHLY ORGANIC	>10%	>20%

OTHER MATERIAL	
TRACE	1 - 10%
LITTLE	10 - 20%
SOME	20 - 35%
HIGHLY	35% AND ABOVE

GROUND WATER

- WATER LEVEL IN BORE HOLE IMMEDIATELY AFTER DRILLING
- STATIC WATER LEVEL AFTER 24 HOURS
- PW PERCHED WATER, SATURATED ZONE, OR WATER BEARING STRATA
- SPRING OR SEEP

MISCELLANEOUS SYMBOLS

- ROADWAY EMBANKMENT (RE) WITH SOIL DESCRIPTION
- SOIL SYMBOL
- ARTIFICIAL FILL (AF) OTHER THAN ROADWAY EMBANKMENT
- INFERRED SOIL BOUNDARY
- INFERRED ROCK LINE
- ALLUVIAL SOIL BOUNDARY
- 25/025 DIP & DIP DIRECTION OF ROCK STRUCTURES
- SPT DPT DMT VST PMT TEST BORING
- AUGER BORING
- CORE BORING
- MW MONITORING WELL
- PIEZOMETER INSTALLATION
- SLOPE INDICATOR INSTALLATION
- CONE PENETROMETER TEST
- SOUNDING ROD
- TEST BORING W/ CORE
- SPT N-VALUE
- REF SPT REFUSAL

ABBREVIATIONS

AR - AUGER REFUSAL
BT - BORING TERMINATED
CL. - CLAY
CPT - CONE PENETRATION TEST
CSE. - COARSE
CT - CORING TERMINATED
DMT - DILATOMETER TEST
DPT - DYNAMIC PENETRATION TEST
e - VOID RATIO
EMBANK. - EMBANKMENT
F - FINE
FOSS. - FOSSILIFEROUS
FRAC. - FRACTURED, FRACTURES
FRAGS. - FRAGMENTS
HI. - HIGHLY
MED. - MEDIUM
MICA. - MICACEOUS
MOD. - MODERATELY
NP - NON PLASTIC
ORG. - ORGANIC
PMT - PRESSUREMETER TEST
SAP. - SAPROLITIC
SDY. - SANDY
SL. - SILT, SILTY
SLI. - SLIGHTLY
TCR - TRICONE REFUSAL
w - MOISTURE CONTENT
V - VERY
WEA. - WEATHERED
γ - UNIT WEIGHT
γ_d - DRY UNIT WEIGHT

SAMPLE ABBREVIATIONS
S - BULK
SS - SPLIT SPOON
ST - SHELBY TUBE
RS - ROCK
RT - RECOMPACTED TRIAXIAL
CBR - CALIFORNIA BEARING RATIO

EQUIPMENT USED ON SUBJECT PROJECT

DRILL UNITS:
- [ ] MOBILE B-___
- [ ] BK-51
- [X] CME-550X
- [ ] CME-75
- [ ] PORTABLE HOIST
- [ ] _____
- [ ] _____

ADVANCING TOOLS:
- [ ] CLAY BITS
- [ ] 6" CONTINUOUS FLIGHT AUGER
- [X] 8" HOLLOW AUGERS
- [ ] HARD FACED FINGER BITS
- [ ] TUNG.-CARBIDE INSERTS
- [ ] CASING [ ] W/ ADVANCER
- [X] TRICONE 2-15/16 " STEEL TEETH
- [ ] TRICONE _____ " TUNG.-CARB.
- [X] CORE BIT
- [ ] _____

HAMMER TYPE:
- [X] AUTOMATIC
- [ ] MANUAL

CORE SIZE:
- [ ] -B_____
- [X] -N 02
- [ ] -H_____

HAND TOOLS:
- [ ] POST HOLE DIGGER
- [ ] HAND AUGER
- [ ] SOUNDING ROD
- [ ] VANE SHEAR TEST
- [ ] _____

REVISED 09/23/09

PROJECT REFERENCE NO.	SHEET NO.
BD-5114AG	2A

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
GEOTECHNICAL ENGINEERING UNIT
SOIL AND ROCK LEGEND, TERMS, SYMBOLS, AND ABBREVIATIONS

ROCK DESCRIPTION

HARD ROCK IS NON-COASTAL PLAIN MATERIAL THAT IF 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:

WEATHERED ROCK (WR)	NON-COASTAL PLAIN MATERIAL THAT WOULD YIELD SPT N VALUES > 100 BLOWS PER FOOT IF TESTED.
CRYSTALLINE ROCK (CR)	FINE TO COARSE GRAIN IGNEOUS AND METAMORPHIC ROCK THAT WOULD YIELD SPT REFUSAL IF TESTED. ROCK TYPE INCLUDES GRANITE, GNEISS, GABBRO, SCHIST, ETC.
NON-CRYSTALLINE ROCK (NCR)	FINE TO COARSE GRAIN METAMORPHIC AND NON-COASTAL PLAIN SEDIMENTARY ROCK THAT WOULD YEILD SPT REFUSAL IF TESTED. ROCK TYPE INCLUDES PHYLLITE, SLATE, SANDSTONE, ETC.
COASTAL PLAIN SEDIMENTARY ROCK (CP)	COASTAL PLAIN SEDIMENTS CEMENTED INTO ROCK, BUT MAY NOT YIELD SPT REFUSAL. ROCK TYPE INCLUDES LIMESTONE, SANDSTONE, CEMENTED SHELL BEDS, ETC.

WEATHERING

FRESH	ROCK FRESH, CRYSTALS BRIGHT, FEW JOINTS MAY SHOW SLIGHT STAINING. ROCK RINGS UNDER HAMMER IF CRYSTALLINE.
VERY SLIGHT (V SLI.)	ROCK GENERALLY FRESH, JOINTS STAINED, SOME JOINTS MAY SHOW THIN CLAY COATINGS IF OPEN, CRYSTALS ON A BROKEN SPECIMEN FACE SHINE BRIGHTLY. ROCK RINGS UNDER HAMMER BLOWS IF OF A CRYSTALLINE NATURE.
SLIGHT (SLI.)	ROCK GENERALLY FRESH, JOINTS STAINED AND DISCOLORATION EXTENDS INTO ROCK UP TO 1 INCH. OPEN JOINTS MAY CONTAIN CLAY. IN GRANITOID ROCKS SOME OCCASIONAL FELDSPAR CRYSTALS ARE DULL AND DISCOLORED. CRYSTALLINE ROCKS RING UNDER HAMMER BLOWS.
MODERATE (MOD.)	SIGNIFICANT PORTIONS OF ROCK SHOW DISCOLORATION AND WEATHERING EFFECTS. IN GRANITOID ROCKS, MOST FELDSPARS ARE DULL AND DISCOLORED, SOME SHOW CLAY. ROCK HAS DULL SOUND UNDER HAMMER BLOWS AND SHOWS SIGNIFICANT LOSS OF STRENGTH AS COMPARED WITH FRESH ROCK.
MODERATELY SEVERE (MOD. SEV.)	ALL ROCK EXCEPT QUARTZ DISCOLORED OR STAINED. IN GRANITOID ROCKS, ALL FELDSPARS DULL AND DISCOLORED AND A MAJORITY SHOW KAOLINIZATION. ROCK SHOWS SEVERE LOSS OF STRENGTH AND CAN BE EXCAVATED WITH A GEOLOGIST'S PICK. ROCK GIVES "CLUNK" SOUND WHEN STRUCK. *IF TESTED, WOULD YIELD SPT REFUSAL*
SEVERE (SEV.)	ALL ROCK EXCEPT QUARTZ DISCOLORED OR STAINED. ROCK FABRIC CLEAR AND EVIDENT BUT REDUCED IN STRENGTH TO STRONG SOIL. IN GRANITOID ROCKS ALL FELDSPARS ARE KAOLINIZED TO SOME EXTENT. SOME FRAGMENTS OF STRONG ROCK USUALLY REMAIN. *IF TESTED, YIELDS SPT N VALUES > 100 BPF*
VERY SEVERE (V SEV.)	ALL ROCK EXCEPT QUARTZ DISCOLORED OR STAINED. ROCK FABRIC ELEMENTS ARE DISCERNIBLE BUT THE MASS IS EFFECTIVELY REDUCED TO SOIL STATUS, WITH ONLY FRAGMENTS OF STRONG ROCK REMAINING. SAPROLITE IS AN EXAMPLE OF ROCK WEATHERED TO A DEGREE SUCH THAT ONLY MINOR VESTIGES OF THE ORIGINAL ROCK FABRIC REMAIN. *IF TESTED, YIELDS SPT N VALUES < 100 BPF*
COMPLETE	ROCK REDUCED TO SOIL. ROCK FABRIC NOT DISCERNIBLE, OR DISCERNIBLE ONLY IN SMALL AND SCATTERED CONCENTRATIONS. QUARTZ MAY BE PRESENT AS DIKES OR STRINGERS. SAPROLITE IS ALSO AN EXAMPLE.

ROCK HARDNESS

VERY HARD	CANNOT BE SCRATCHED BY KNIFE OR SHARP PICK. BREAKING OF HAND SPECIMENS REQUIRES SEVERAL HARD BLOWS OF THE GEOLOGIST'S PICK.
HARD	CAN BE SCRATCHED BY KNIFE OR PICK ONLY WITH DIFFICULTY. HARD HAMMER BLOWS REQUIRED TO DETACH HAND SPECIMEN.
MODERATELY HARD	CAN BE SCRATCHED BY KNIFE OR PICK. GOUGES OR GROOVES TO 0.25 INCHES DEEP CAN BE EXCAVATED BY HARD BLOW OF A GEOLOGIST'S PICK. HAND SPECIMENS CAN BE DETACHED BY MODERATE BLOWS.
MEDIUM HARD	CAN BE GROOVED OR GOUGED 0.05 INCHES DEEP BY FIRM PRESSURE OF KNIFE OR PICK POINT. CAN BE EXCAVATED IN SMALL CHIPS TO PEICES 1 INCH MAXIMUM SIZE BY HARD BLOWS OF THE POINT OF A GEOLOGIST'S PICK.
SOFT	CAN BE GROVED OR GOUGED READILY BY KNIFE OR PICK. CAN BE EXCAVATED IN FRAGMENTS FROM CHIPS TO SEVERAL INCHES IN SIZE BY MODERATE BLOWS OF A PICK POINT. SMALL, THIN PIECES CAN BE BROKEN BY FINGER PRESSURE.
VERY SOFT	CAN BE CARVED WITH KNIFE. CAN BE EXCAVATED READILY WITH POINT OF PICK. PIECES 1 INCH OR MORE IN THICKNESS CAN BE BROKEN BY FINGER PRESSURE. CAN BE SCRATCHED READILY BY FINGERNAIL.

FRACTURE SPACING

TERM	SPACING
VERY WIDE	MORE THAN 10 FEET
WIDE	3 TO 10 FEET
MODERATELY CLOSE	1 TO 3 FEET
CLOSE	0.16 TO 1 FEET
VERY CLOSE	LESS THAN 0.16 FEET

BEDDING

TERM	THICKNESS
VERY THICKLY BEDDED	> 4 FEET
THICKLY BEDDED	1.5 - 4 FEET
THINLY BEDDED	0.16 - 1.5 FEET
VERY THINLY BEDDED	0.03 - 0.16 FEET
THICKLY LAMINATED	0.008 - 0.03 FEET
THINLY LAMINATED	< 0.008 FEET

INDURATION

FOR SEDIMENTARY ROCKS, INDURATION IS THE HARDENING OF THE MATERIAL BY CEMENTING, HEAT, PRESSURE, ETC.

FRIABLE	RUBBING WITH FINGER FREES NUMEROUS GRAINS; GENTLE BLOW BY HAMMER DISINTEGRATES SAMPLE.
MODERATELY INDURATED	GRAINS CAN BE SEPARATED FROM SAMPLE WITH STEEL PROBE; BREAKS EASILY WHEN HIT WITH HAMMER.
INDURATED	GRAINS ARE DIFFICULT TO SEPARATE WITH STEEL PROBE; DIFFICULT TO BREAK WITH HAMMER.
EXTREMELY INDURATED	SHARP HAMMER BLOWS REQUIRED TO BREAK SAMPLE; SAMPLE BREAKS ACROSS GRAINS.

TERMS AND DEFINITIONS

ALLUVIUM (ALLUV.) - SOILS THAT HAVE BEEN TRANSPORTED BY WATER.

AQUIFER - 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 IT IS ENCOUNTERED, BUT WHICH DOES NOT NECESSARILY RISE TO OR ABOVE THE GROUND SURFACE.

CALCAREOUS (CALC.) - SOILS THAT 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 (FP) - 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 (RES.) SOIL - SOIL FORMED IN PLACE BY THE WEATHERING OF ROCK.

ROCK QUALITY DESIGNATION (RQD) - 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 THAT 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, THAT 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 (N OR BPF) 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 PENETRATION EQUAL TO OR LESS THAN 0.1 FOOT PER 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 (SRQD) - 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.

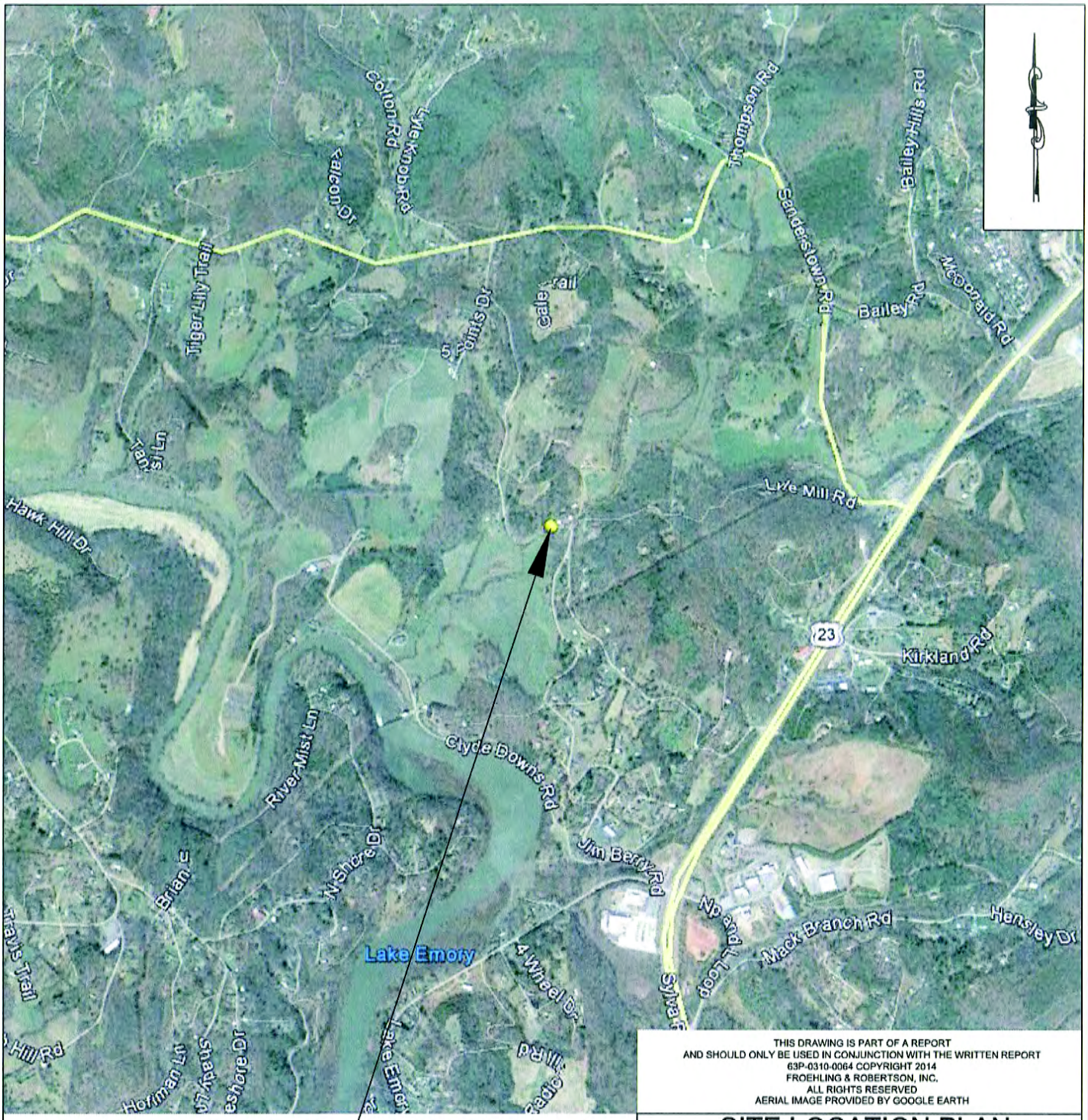
TOPSOIL (TS.) - SURFACE SOILS USUALLY CONTAINING ORGANIC MATTER.

BENCH MARK: Survey information provided by Vaughn & Melton, Inc.

ELEVATION: FT.

NOTES:

REVISED 09/23/09



SITE

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SITE LOCATION PLAN

Bridge No. 550064 on
SR 1328 (Jim Berry Road)
over Watauga Creek
Franklin, North Carolina

Scale: N.T.S.	DR. DMB	CHK. MJW	REV.

Prepared For:
NCDOT TIP No.: BD-5114AG

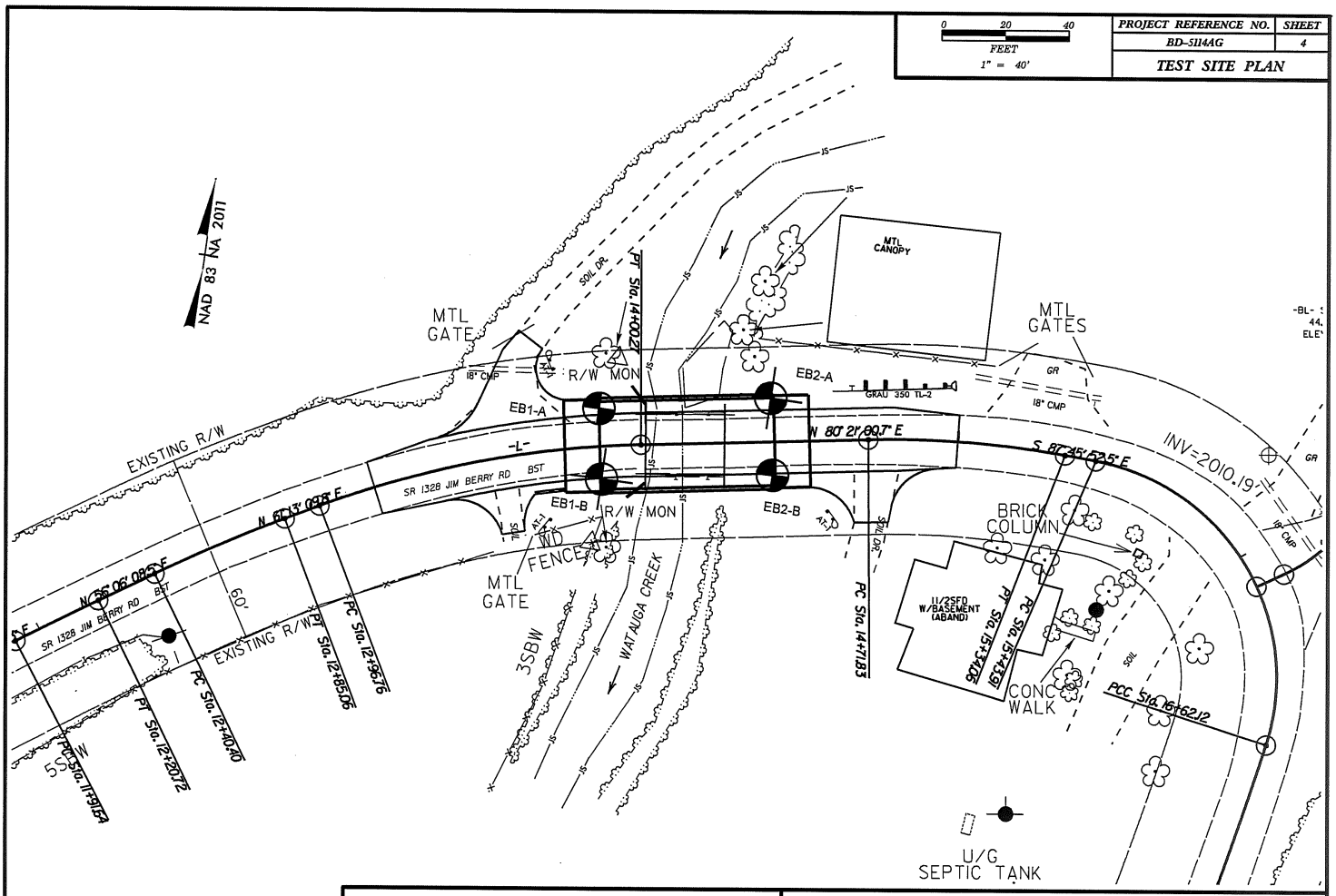
Froehling & Robertson, Inc.
2505 Hutchison-McDonald Road
Charlotte, North Carolina

Proj.: 63P-0310-0064	Date: August 2014	Sheet No. 3

PROJECT REFERENCE NO.	SHEET
BD-5114AG	4

TEST SITE PLAN

0 20 40
FEET
1" = 40'



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TEST SITE PLAN

WBS NO.: 45360.1.33	PROJECT ID: N/A	F&R PROJECT NO.: 63P-0310-0064
TIP NO.: BD-5114AG	F.A. PROJECT NO.: N/A	COUNTY: Macon
PROJECT DESCRIPTION: Bridge No. 550064 on SR 1328 (Jim Berry Road) over Watauga Creek		
DRAWN BY: M. Brewer, E.I.	CHECKED BY: M. Walko, P.E.	
DATE: August 2014	SCALE: 1"=40'	

NCDOT GEOTECHNICAL ENGINEERING UNIT
BORELOG REPORT

WBS 45360.1.33	**TIP** BD-5114AG	**COUNTY** Macon	**GEOLOGIST** M. Brewer
SITE DESCRIPTION Bridge No. 550064 on SR 1328 (Jim Berry Road) over Watauga Creek			**GROUND WTR (ft)**
BORING NO. EB1-A	**STATION** 13+88	**OFFSET** 12 ft LT	**ALIGNMENT** -L-	**0 HR.** 6.0
COLLAR ELEV. 2,001.2 ft	**TOTAL DEPTH** 12.0 ft	**NORTHING** 565,492	**EASTING** 696,590	**24 HR.** FIAD
DRILL RIG/HAMMER EFF./DATE F&R3763 CME-550X 75% 10/24/2013		**DRILL METHOD** H.S. Augers	**HAMMER TYPE** Automatic
DRILLER C. Boyce	**START DATE** 05/06/14	**COMP. DATE** 05/06/14	**SURFACE WATER DEPTH** N/A

ELEV (ft)	DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT (0 25 50 75 100)	SAMP. NO.	MOI	LOG	SOIL AND ROCK DESCRIPTION (ELEV. (ft) / DEPTH (ft))
2005										
	2,001.2	0.0								2,001.2 GROUND SURFACE 0.0
2000			2	2	3	5		M		2,000.7 Surficial Organic Laden Soils (0.5'). 0.5
	1,997.7	3.5								**ROADWAY EMBANKMENT** Brown-tan, silty fine SAND (A-2-4), with trace gravel and clay.
1995			1	1	1	2		M		1,994.2 7.0
	1,992.7	8.5	48	21	12	33		M		**RESIDUAL** Orange-brown, silty fine to coarse sandy GRAVEL (A-1-b).
1990	1,989.2	12.0	60/0.0			60/0.0				1,989.2 12.0

Boring Terminated with Standard Penetration Test Refusal at Elevation 1,989.2 ft ON CRYSTALLINE ROCK (BIOTITE GNEISS).

NCDOT GEOTECHNICAL ENGINEERING UNIT
BORELOG REPORT

WBS 45360.1.33	**TIP** BD-5114AG	**COUNTY** Macon	**GEOLOGIST** M. Brewer
SITE DESCRIPTION Bridge No. 550064 on SR 1328 (Jim Berry Road) over Watauga Creek			**GROUND WTR (ft)**
BORING NO. EB1-B	**STATION** 13+88	**OFFSET** 11 ft RT	**ALIGNMENT** -L-	**0 HR.** 6.0
COLLAR ELEV. 2,001.1 ft	**TOTAL DEPTH** 15.5 ft	**NORTHING** 565,470	**EASTING** 696,594	**24 HR.** FIAD
DRILL RIG/HAMMER EFF./DATE F&R3763 CME-550X 75% 10/24/2013		**DRILL METHOD** H.S. Augers	**HAMMER TYPE** Automatic
DRILLER C. Boyce	**START DATE** 05/06/14	**COMP. DATE** 05/06/14	**SURFACE WATER DEPTH** N/A

ELEV (ft)	DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT 0 25 50 75 100	SAMP. NO.	MOI	LOG	SOIL AND ROCK DESCRIPTION ELEV. (ft)	DEPTH (ft)
2005											
	2,001.1	0.0								2,001.1 GROUND SURFACE	0.0
2000			2	1	1	2		M		2,000.6 Surficial Organic Laden Soils (0.5').	0.5
	1,997.6	3.5	WOH	2	4	6		W		1,999.1 **ROADWAY EMBANKMENT** Brown-tan, silty fine SAND (A-2-4). Brown-tan, clayey fine sandy SILT (A-4), with trace gravel.	2.0
1995											
	1,992.6	8.5	61	39/0.1		100/0.6				1,992.6	8.5
1990	1,990.6	10.5	60/0.0			60/0.0				1,990.6 **WEATHERED ROCK** Gray-black-white, (BIOTITE GNEISS).	10.5
										CRYSTALLINE ROCK Gray-black-white, (BIOTITE GNEISS).	
										1,985.6	15.5

Boring Terminated at Elevation 1,985.6 ft IN CRYSTALLINE ROCK (BIOTITE GNEISS)

NCDOT GEOTECHNICAL ENGINEERING UNIT
CORE BORING REPORT

WBS 45360.1.33	**TIP** BD-5114AG	**COUNTY** Macon	**GEOLOGIST** M. Brewer
SITE DESCRIPTION Bridge No. 550064 on SR 1328 (Jim Berry Road) over Watauga Creek			**GROUND WTR (ft)**
BORING NO. EB1-B	**STATION** 13+88	**OFFSET** 11 ft RT	**ALIGNMENT** -L-	**0 HR.** 6.0
COLLAR ELEV. 2,001.1 ft	**TOTAL DEPTH** 15.5 ft	**NORTHING** 565,470	**EASTING** 696,594	**24 HR.** FIAD
DRILL RIG/HAMMER EFF./DATE F&R3763 CME-550X 75% 10/24/2013		**DRILL METHOD** H.S. Augers	**HAMMER TYPE** Automatic
DRILLER C. Boyce	**START DATE** 05/06/14	**COMP. DATE** 05/06/14	**SURFACE WATER DEPTH** N/A
CORE SIZE NQ2	**TOTAL RUN** 5.0 ft		

ELEV (ft)	RUN ELEV (ft)	DEPTH (ft)	RUN (ft)	DRILL RATE (Min/ft)	RUN REC. (ft) %	RUN RQD (ft) %	SAMP. NO.	STRATA REC. (ft) %	STRATA RQD (ft) %	LOG	DESCRIPTION AND REMARKS ELEV. (ft)	DEPTH (ft)
1990.6											Begin Coring @ 10.5 ft	
1990	1,990.6	10.5	5.0	N=60/0.0 2:33/1.0 2:22/1.0 2:18/1.0 2:26/1.0 2:31/1.0	(5.0) 100%	(4.9) 98%		(5.0) 100%	(4.9) 98%		1,990.6 **CRYSTALLINE ROCK** Fresh, hard to very hard, gray-black-white, (BIOTITE GNEISS), with close and moderately close fracture spacing.	10.5
	1,985.6	15.5									1,985.6	15.5
											Boring Terminated at Elevation 1,985.6 ft IN CRYSTALLINE ROCK (BIOTITE GNEISS)	

Bridge No. 550064 on SR 1328 (Jim Berry Road)

CORE PHOTOGRAPHS: EB1-B: Station 13+88, 11' RT

Begin Run 1
10.5 feet

End Run 1
15.5 feet

0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0

SCALE IN FEET

NCDOT GEOTECHNICAL ENGINEERING UNIT
BORELOG REPORT

WBS 45360.1.33	**TIP** BD-5114AG	**COUNTY** Macon	**GEOLOGIST** M. Brewer
SITE DESCRIPTION Bridge No. 550064 on SR 1328 (Jim Berry Road) over Watauga Creek			**GROUND WTR (ft)**
BORING NO. EB2-A	**STATION** 14+42	**OFFSET** 14 ft LT	**ALIGNMENT** -L-	**0 HR.** 8.0
COLLAR ELEV. 2,001.4 ft	**TOTAL DEPTH** 24.0 ft	**NORTHING** 565,503	**EASTING** 696,643	**24 HR.** FIAD
DRILL RIG/HAMMER EFF./DATE F&R3763 CME-550X 75% 10/24/2013		**DRILL METHOD** H.S. Augers	**HAMMER TYPE** Automatic
DRILLER C. Boyce	**START DATE** 05/06/14	**COMP. DATE** 05/06/14	**SURFACE WATER DEPTH** N/A

ELEV (ft)	DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT (0 25 50 75 100)	SAMP. NO.	MOI	LOG	SOIL AND ROCK DESCRIPTION (ELEV. (ft) / DEPTH (ft))
2005										
	2,001.4	0.0								2,001.4 — GROUND SURFACE — 0.0
2000			1	1	2	3		M		2,000.9 — Surficial Organic Laden Soils (0.5'). — 0.5
	1,997.9	3.5	WOH	1	1	2		W		1,999.4 — **ROADWAY EMBANKMENT** Brown, silty fine SAND (A-2-4), with trace wood fragments and clay. — 2.0
1995										Brown, fine sandy SILT (A-4), with trace clay and gravel.
	1,992.9	8.5	6	32	68/0.2	100/0.7		M		1,992.9 — 8.5
1990										**WEATHERED ROCK** Gray-black-white, (BIOTITE GNEISS).
	1,987.9	13.5	22	24	38	62				1,989.4 — 12.0
1985										**RESIDUAL** Brown-orange-gray, silty fine to coarse sandy GRAVEL (A-1-b).
	1,982.9	18.5								1,982.9 — 18.5
	1,982.4	19.0	60/0.0			60/0.0				**CRYSTALLINE ROCK** Gray-black-white, (BIOTITE GNEISS).
1980			60/0.0			60/0.0				
										1,977.4 — 24.0
										Boring Terminated at Elevation 1,977.4 ft IN CRYSTALLINE ROCK (BIOTITE GNEISS)

NCDOT GEOTECHNICAL ENGINEERING UNIT
CORE BORING REPORT

WBS 45360.1.33	**TIP** BD-5114AG	**COUNTY** Macon	**GEOLOGIST** M. Brewer
SITE DESCRIPTION Bridge No. 550064 on SR 1328 (Jim Berry Road) over Watauga Creek			**GROUND WTR (ft)**
BORING NO. EB2-A	**STATION** 14+42	**OFFSET** 14 ft LT	**ALIGNMENT** -L-	**0 HR.** 8.0
COLLAR ELEV. 2,001.4 ft	**TOTAL DEPTH** 24.0 ft	**NORTHING** 565,503	**EASTING** 696,643	**24 HR.** FIAD
DRILL RIG/HAMMER EFF./DATE F&R3763 CME-550X 75% 10/24/2013		**DRILL METHOD** H.S. Augers	**HAMMER TYPE** Automatic
DRILLER C. Boyce	**START DATE** 05/06/14	**COMP. DATE** 05/06/14	**SURFACE WATER DEPTH** N/A
CORE SIZE NQ2	**TOTAL RUN** 5.0 ft		

ELEV (ft)	RUN ELEV (ft)	DEPTH (ft)	RUN (ft)	DRILL RATE (Min/ft)	RUN REC. (ft) %	RUN RQD (ft) %	SAMP. NO.	STRATA REC. (ft) %	STRATA RQD (ft) %	LOG	DESCRIPTION AND REMARKS ELEV. (ft)	DEPTH (ft)
1982.4											Begin Coring @ 19.0 ft	
1980	1,982.4	19.0	5.0	N=60/0.0 2:11/1.0 2:18/1.0 1:42/1.0 2:51/1.0 2:41/1.0	(4.9) 98%	(2.6) 52%					**CRYSTALLINE ROCK** Slightly weathered to fresh, hard, gray-black-white, (BIOTITE GNEISS), with very close and close fracture spacing.	
	1,977.4	24.0									1,977.4	24.0
											Boring Terminated at Elevation 1,977.4 ft IN CRYSTALLINE ROCK (BIOTITE GNEISS)	

Bridge No. 550064 on SR 1328 (Jim Berry Road)

CORE PHOTOGRAPHS: EB2-A: Station 14+42, 14' LT

Begin Run 1
19.0 feet

End Run 1
24.0 feet

0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0

SCALE IN FEET

NCDOT GEOTECHNICAL ENGINEERING UNIT
BORELOG REPORT

WBS 45360.1.33	**TIP** BD-5114AG	**COUNTY** Macon	**GEOLOGIST** M. Brewer
SITE DESCRIPTION Bridge No. 550064 on SR 1328 (Jim Berry Road) over Watauga Creek			**GROUND WTR (ft)**
BORING NO. EB2-B	**STATION** 14+42	**OFFSET** 11 ft RT	**ALIGNMENT** -L-	**0 HR.** 8.0
COLLAR ELEV. 2,002.2 ft	**TOTAL DEPTH** 20.6 ft	**NORTHING** 565,479	**EASTING** 696,647	**24 HR.** FIAD
DRILL RIG/HAMMER EFF./DATE F&R3763 CME-550X 75% 10/24/2013		**DRILL METHOD** H.S. Augers	**HAMMER TYPE** Automatic
DRILLER C. Boyce	**START DATE** 05/06/14	**COMP. DATE** 05/06/14	**SURFACE WATER DEPTH** N/A

ELEV (ft)	DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT 0 25 50 75 100	SAMP. NO.	MOI	LOG	SOIL AND ROCK DESCRIPTION ELEV. (ft)	DEPTH (ft)
2005											
	2,002.2	0.0								2,002.2 GROUND SURFACE	0.0
			2	1	2	3		M		2,001.8 Surficial Organic Laden Soils (0.4).	0.4
2000										**ROADWAY EMBANKMENT** Brown, silty fine SAND (A-2-4), with trace mica and clay.	
	1,998.7	3.5	1	1	3	4		M			
1995										1,995.2	7.0
	1,993.7	8.5	4	20	36	56		W		**RESIDUAL** Gray-black-white-orange, silty fine to coarse sandy GRAVEL (A-1-b).	
1990										1,990.2	12.0
	1,988.7	13.5	8	11	14	25		Sat.		Brown, silty fine SAND (A-2-4), with little gravel.	
1985											
	1,983.7	18.5	15	85/0.4		100/0.9				1,983.7 **WEATHERED ROCK**	18.5
	1,981.6	20.6	60/0.0			60/0.0				1,981.6 Gray-black-white, (BIOTITE GNEISS).	20.6

Boring Terminated with Standard Penetration Test Refusal at Elevation 1,981.6 ft ON CRYSTALLINE ROCK (BIOTITE GNEISS)

NCDOT BORE SINGLE 63P-0310-0064-DIVISION 14 BRIDGE 550064.GPJ NC_DOT.GDT 8/5/14

APPENDIX C

SUPPORTING CALCULATIONS

END BENT 1 ANALYSIS

BRIDGE 550064
1@ 55'
30' OUT-TO-OUT
SKEW = 90°

End Bent Geometry and Loads

Bridge Width	CS Unit Length	Factored Pile Reaction (kips)	Factored Pile Reaction (tons)
27'	25'-0"	106	53
	30'-0"	118	59
	35'-0"	126	63
	40'-0"	132	66
	45'-0"	140	70
	50'-0"	154	77
	55'-0"	162	81
	60'-0"	170	85
	65'-0"	178	89
	70'-0"	184	92
30'	25'-0"	110	55
	30'-0"	122	61
	35'-0"	132	66
	40'-0"	140	70
	45'-0"	148	74
	50'-0"	162	81
	55'-0"	170	85
	60'-0"	180	90
	65'-0"	188	94
	70'-0"	194	97
33'	25'-0"	92	46
	30'-0"	102	51
	35'-0"	110	55
	40'-0"	118	59
	45'-0"	122	61
	50'-0"	134	67
	55'-0"	142	71
	60'-0"	148	74
	65'-0"	156	78
	70'-0"	162	81
36'	25'-0"	96	48
	30'-0"	108	54
	35'-0"	116	58
	40'-0"	122	61
	45'-0"	130	65
	50'-0"	142	71
	55'-0"	148	74
	60'-0"	156	78
	65'-0"	164	82
	70'-0"	170	85
39'	25'-0"	100	50
	30'-0"	112	56
	35'-0"	120	60
	40'-0"	126	63
	45'-0"	136	68
	50'-0"	146	73
	55'-0"	154	77
	60'-0"	162	81
	65'-0"	170	85
	70'-0"	176	88

USE 85 TON/PILE FOR END BENT ANALYSIS.

Bridge Width	Skew	Cap Length	No. of Vertical Piles	Pile Spacing
27'	60/120	38'-2"	5	8'-6"
	75/105	34'-3"	5	7'-6"
	90	33'-0"	5	7'-6"
30'	60/120	41'-8"	5	9'-6"
	75/105	37'-4"	5	8'-3"
	90	36'-0"	5	8'-3"
33'	60/120	45'-2"	7	7'-0"
	75/105	40'-6"	7	6'-0"
	90	39'-0"	7	6'-0"
36'	60/120	48'-7"	7	7'-6"
	75/105	43'-7"	7	6'-6"
	90	42'-0"	7	6'-6"
39'	60/120	52'-0"	7	8'-0"
	75/105	46'-8"	7	7'-0"
	90	45'-0"	7	7'-0"

5 PILES @ 8'3" SPACING

NCDOT GEOTECHNICAL ENGINEERING UNIT
BORELOG REPORT

WBS 45360.1.33	**TIP** BD-5114AG	**COUNTY** Macon	**GEOLOGIST** M. Brewer
SITE DESCRIPTION Bridge No. 550064 on SR 1328 (Jim Berry Road) over Watauga Creek			**GROUND WTR (ft)**
BORING NO. EB1-A	**STATION** 13+88	**OFFSET** 12 ft LT	**ALIGNMENT** -L-
COLLAR ELEV. 2,001.2 ft	**TOTAL DEPTH** 12.0 ft	**NORTHING** 565,492	**EASTING** 696,590
DRILL RIG/HAMMER EFF./DATE F&R3763 CME-550X 75% 10/24/2013		**DRILL METHOD** H.S. Augers	**HAMMER TYPE** Automatic
DRILLER C. Boyce	**START DATE** 05/06/14	**COMP. DATE** 05/06/14	**SURFACE WATER DEPTH** N/A

0 HR. 6.0
24 HR. FIAD

ELEV (ft)	DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT 0 25 50 75 100	SAMP. NO.	MOI	LOG	SOIL AND ROCK DESCRIPTION ELEV. (ft)	DEPTH (ft)
2005						BOC = 1,997.6'					
	2,001.2	0.0								2,001.2 GROUND SURFACE	0.0
2000			2	2	3	5		M		2,000.7 Surficial Organic Laden Soils (0.5').	0.5
	1,997.7	3.5				BOC				ROADWAY EMBANKMENT Brown-tan, silty fine SAND (A-2-4), with trace gravel and clay.	3.6'
1995			1	1	1	2		M			
	1,994.2	7.0								RESIDUAL Orange-brown, silty fine to coarse sandy GRAVEL (A-1-b).	
	1,992.7	8.5	48	21	12	33		M			
1990	1,989.2	12.0	60/0.0			60/0.0				1,989.2	12.0

Boring Terminated with Standard Penetration Test Refusal at Elevation 1,989.2 ft ON CRYSTALLINE ROCK (BIOTITE GNEISS).

EB-1(LT)

PILE EXCAVATION IS REQUIRED TO INSTALL THE PILES INTO CR.

MIN TIP EL = 1,984.2' AND HAVE AT LEAST 5' OF PENETRATION INTO CR.

L = BOC - TIP EL + 1.0' EMBED
= 1997.6 - 1984.2 + 1.0
= 14.4'

15' ANTICIPATED PILE LENGTH
15' AVERAGE PILE LENGTH

PILE EXCAVATION QTY:

IN SOIL = 8.4'/PILE × 2.5 = 21.0'

NOT IN SOIL = 5.0'/PILE × 2.5 = 12.5'

NCDOT BORE SINGLE 63P-0310-0064-DIVISION 14 BRIDGE 550064.GPJ NC_DOT.GDT 8/5/14

NCDOT GEOTECHNICAL ENGINEERING UNIT
BORELOG REPORT

WBS 45360.1.33	TIP BD-5114AG	COUNTY Macon	GEOLOGIST M. Brewer
SITE DESCRIPTION Bridge No. 550064 on SR 1328 (Jim Berry Road) over Watauga Creek			GROUND WTR (ft)
BORING NO. EB1-B	STATION 13+88	OFFSET 11 ft RT	ALIGNMENT -L-	0 HR. 6.0
COLLAR ELEV. 2,001.1 ft	TOTAL DEPTH 15.5 ft	NORTHING 565,470	EASTING 696,594	24 HR. FIAD
DRILL RIG/HAMMER EFF./DATE F&R3763 CME-550X 75% 10/24/2013		DRILL METHOD H.S. Augers	HAMMER TYPE Automatic
DRILLER C. Boyce	START DATE 05/06/14	COMP. DATE 05/06/14	SURFACE WATER DEPTH N/A

ELEV (ft)	DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT 0 25 50 75 100	SAMP. NO.	MOI	LOG	SOIL AND ROCK DESCRIPTION ELEV. (ft)	DEPTH (ft)
						BOC = 1997.6'					
2005											
	2,001.1	0.0								2,001.1 GROUND SURFACE	0.0
2000			2	1	1	2 BOC		M		2,000.6 Surficial Organic Laden Soils (0.5').	0.5
	1,997.6	3.5								1,999.1 ROADWAY EMBANKMENT Brown-tan, silty fine SAND (A-2-4).	2.0
1995			WOH	2	4	6		W		Brown-tan, clayey fine sandy SILT (A-4), with trace gravel.	3.5
	1,992.6	8.5								1,992.6	8.5
1990	1,990.6	10.5	61 / 60/0.0	39/0.1		100/0.6 / 60/0.0				1,990.6 WEATHERED ROCK Gray-black-white, (BIOTITE GNEISS).	10.5
										CRYSTALLINE ROCK Gray-black-white, (BIOTITE GNEISS).	
										1,985.6	15.5

Boring Terminated at Elevation 1,985.6 ft IN CRYSTALLINE ROCK (BIOTITE GNEISS)

EB1 (RT)
PILE EXCAVATION IS REQUIRED TO INSTALL THE PILES INTO WR/CR.

MIN TIP EL = 1987.6
AND HAVE AT LEAST 5' OF PENETRATION INTO WR/CR.

L = BOC - TIP EL + 1.0' EMBED
= 1997.6 - 1987.6 + 1.0'
= 11' ANTICIPATED PILE LENGTH
15' AVERAGE PILE LENGTH

PILE EXCAVATION QTY:
IN SOIL = 6.0'/PILE X 2.5 = 15.0'
NOT IN SOIL = 4.0'/PILE X 2.5 = 10.0'

Σ IN SOIL = 21.0' + 15.0' = 36.0
SAY 40'

Σ NOT IN SOIL = 12.5' + 10.0' = 22.5'
SAY 25'

FOR EB-1

END BENT 2 ANALYSIS

NCDOT GEOTECHNICAL ENGINEERING UNIT
BORELOG REPORT

WBS 45360.1.33	**TIP** BD-5114AG	**COUNTY** Macon	**GEOLOGIST** M. Brewer
SITE DESCRIPTION Bridge No. 550064 on SR 1328 (Jim Berry Road) over Watauga Creek			**GROUND WTR (ft)**
BORING NO. EB2-A	**STATION** 14+42	**OFFSET** 14 ft LT	**ALIGNMENT** -L-
COLLAR ELEV. 2,001.4 ft	**TOTAL DEPTH** 24.0 ft	**NORTHING** 565,503	**EASTING** 696,643
0 HR. 8.0	**24 HR.** FIAD		
DRILL RIG/HAMMER EFF./DATE F&R3763 CME-550X 75% 10/24/2013	**DRILL METHOD** H.S. Augers	**HAMMER TYPE** Automatic	
DRILLER C. Boyce	**START DATE** 05/06/14	**COMP. DATE** 05/06/14	**SURFACE WATER DEPTH** N/A

ELEV (ft)	DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT (0 25 50 75 100)	SAMP. NO.	MOI	LOG	SOIL AND ROCK DESCRIPTION (ELEV. (ft) / DEPTH (ft))
2005						BOC ≈ 1998.6', PILE IS 2.8' BELOW EX. GRADE				1998.6'
	2,001.4	0.0								2,001.4 GROUND SURFACE 0.0
2000			1	1	2	3 (4)	BOC	M		2,000.9 Surficial Organic Laden Soils (0.5'). 0.5
	1,997.9	3.5	WOH	1	1	2 (3) N=3 γ=110 C=50 Ø=28°	①	W		1,999.4 ROADWAY EMBANKMENT Brown, silty fine SAND (A-2-4), with trace wood fragments and clay. 2.0
1995							5.7	▽		Brown, fine sandy SILT (A-4), with trace clay and gravel.
	1,992.9	8.5	6	32	68/0.2	N=83 γ=125 Ø=43° 100/0.7 IGNORE				1,992.9 8.5 8.5 WEATHERED ROCK Gray-black-white, (BIOTITE GNEISS).
1990										1,989.4 12.0
	1,987.9	13.5	22	24	38	62 (83)	②	M		RESIDUAL Brown-orange-gray, silty fine to coarse sandy GRAVEL (A-1-b).
1985										Predrill to 1985
	1,982.9	18.5					15.7			1,982.9 18.5 18.5
	1,982.4	19.0	60/0.0 60/0.0			60/0.0 60/0.0 N=100 γ=130 C=300K	③			CRYSTALLINE ROCK Gray-black-white, (BIOTITE GNEISS).
1980										1,977.4 24.0

Boring Terminated at Elevation 1,977.4 ft IN CRYSTALLINE ROCK (BIOTITE GNEISS)

USE EB2-A FOR ANALYSIS

SPT N-VALUES CORRECTED FOR HAMMER EFFICIENCY

Due to WR lens, predrilling Piles 1, 2, & 3 may be Rqd. If so, predrill to Elev 1985.

NCDOT BORE SINGLE 63P-0310-0064-DIVISION 14 BRIDGE 550064.GPJ NC_DOT.GDT 8/5/14

NCDOT GEOTECHNICAL ENGINEERING UNIT
BORELOG REPORT

WBS 45360.1.33	**TIP** BD-5114AG	**COUNTY** Macon	**GEOLOGIST** M. Brewer
SITE DESCRIPTION Bridge No. 550064 on SR 1328 (Jim Berry Road) over Watauga Creek			**GROUND WTR (ft)**
BORING NO. EB2-B	**STATION** 14+42	**OFFSET** 11 ft RT	**ALIGNMENT** -L-	**0 HR.** 8.0
COLLAR ELEV. 2,002.2 ft	**TOTAL DEPTH** 20.6 ft	**NORTHING** 565,479	**EASTING** 696,647	**24 HR.** FIAD
DRILL RIG/HAMMER EFF./DATE F&R3763 CME-550X 75% 10/24/2013		**DRILL METHOD** H.S. Augers	**HAMMER TYPE** Automatic
DRILLER C. Boyce	**START DATE** 05/06/14	**COMP. DATE** 05/06/14	**SURFACE WATER DEPTH** N/A

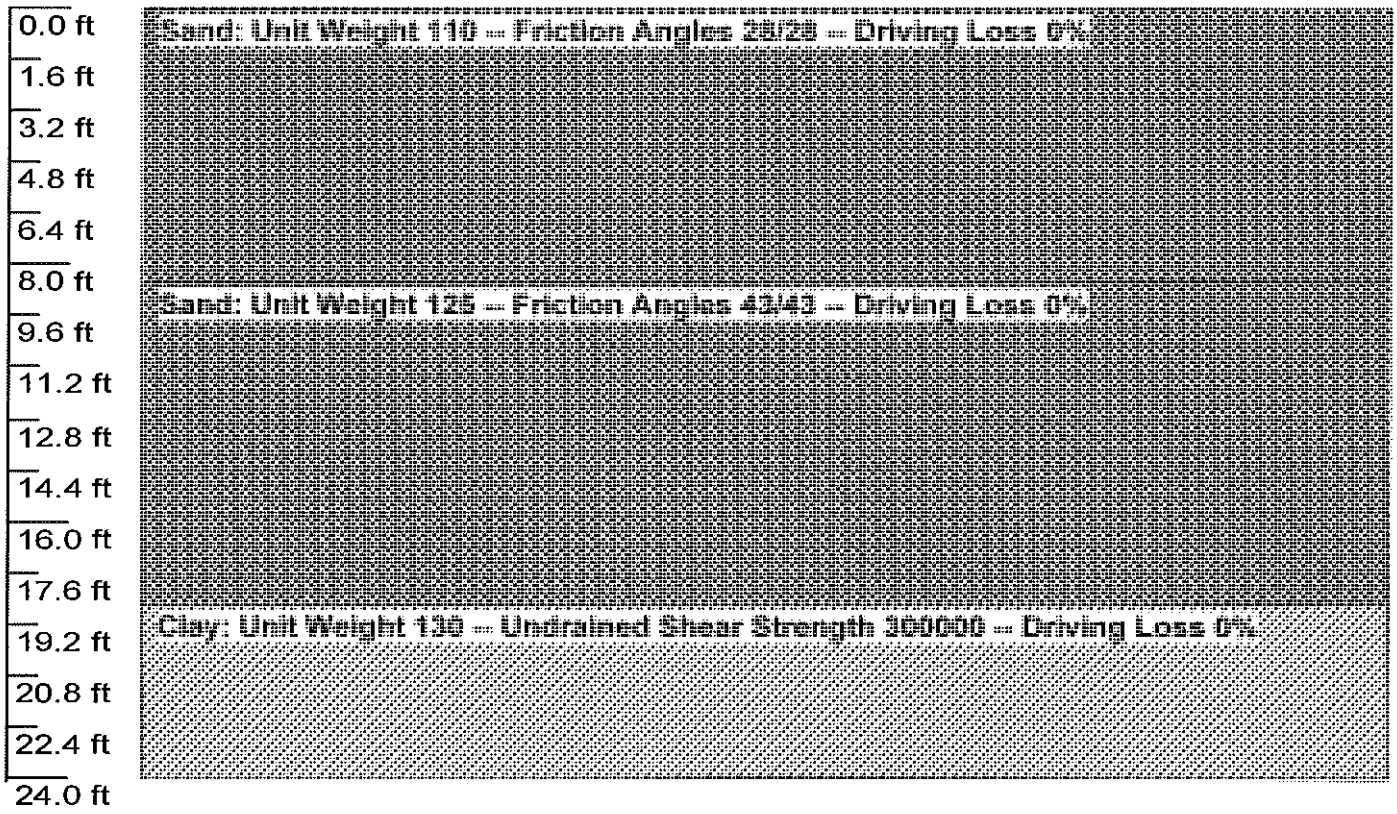
ELEV (ft)	DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT 0 25 50 75 100	SAMP. NO.	MOI	LOG	SOIL AND ROCK DESCRIPTION ELEV. (ft)	DEPTH (ft)
2005						BOC = 1998.6'				1998.6'	
	2,002.2	0.0								2,002.2 GROUND SURFACE	0.0
			2	1	2	3		M		2,001.8 Surficial Organic Laden Soils (0.4).	0.4
2000							BOC			ROADWAY EMBANKMENT Brown, silty fine SAND (A-2-4), with trace mica and clay.	
	1,998.7	3.5	1	1	3	4		M			
1995										1,995.2	7.0
	1,993.7	8.5	4	20	36	56		W		RESIDUAL Gray-black-white-orange, silty fine to coarse sandy GRAVEL (A-1-b).	
1990										1,990.2	12.0
	1,988.7	13.5	8	11	14	25		Sat.		Brown, silty fine SAND (A-2-4), with little gravel.	
1985											
	1,983.7	18.5	15	85/0.4		100/0.9				1,983.7	18.5
	1,981.6	20.6	60/0.0			60/0.0				1,981.6 WEATHERED ROCK Gray-black-white, (BIOTITE GNEISS).	20.6
										Boring Terminated with Standard Penetration Test Refusal at Elevation 1,981.6 ft ON CRYSTALLINE ROCK (BIOTITE GNEISS)	

BY INSPECTION, PILE WILL PENETRATE 1 FOOT INTO WR AND REFUSE.
TIP EL = 1982.7'
L = BOC - TIP EL + 1.0' EMBED
= 1998.6 - 1982.7 + 1.0
= 17.0
ANTICIPATED LENGTH: 17'
AVERAGE PILE LENGTH: 20'

NCDOT BORE SINGLE 63P-0310-0064-DIVISION 14 BRIDGE 550064.GPJ NC_DOT.GDT 8/5/14

Filename:

Soil Profile



DRIVEN 1.2

GENERAL PROJECT INFORMATION

Filename:
Project Name: Bridge 550064 Project Date: 08/05/2014
Project Client: Vaughn Melton
Computed By: M. Brewer
Project Manager: M. Walko

PILE INFORMATION

Pile Type: H Pile - HP12X53
Top of Pile: 2.80 ft
Perimeter Analysis: Box
Tip Analysis: Pile Area

ULTIMATE CONSIDERATIONS

Water Table Depth At Time Of:	- Drilling:	8.00 ft
	- Driving/Restrike	8.00 ft
	- Ultimate:	8.00 ft
Ultimate Considerations:	- Local Scour:	0.00 ft
	- Long Term Scour:	0.00 ft
	- Soft Soil:	0.00 ft

ULTIMATE PROFILE

Layer	Type	Thickness	Driving Loss	Unit Weight	Strength	Ultimate Curve
1	Cohesionless	8.50 ft	0.00%	110.00 pcf	28.1/28.1	Nordlund
2	Cohesionless	10.00 ft	0.00%	125.00 pcf	43.0/43.0	Nordlund
3	Cohesive	5.50 ft	0.00%	130.00 pcf	300000.00 psf	T-79 Steel

PILE WILL REFUSE ON
CRYSTALLINE ROCK

ULTIMATE - SUMMARY OF CAPACITIES

	Depth	Skin Friction	End Bearing	Total Capacity
	0.01 ft	0.00 Kips	0.00 Kips	0.00 Kips
BOC	2.79 ft	0.00 Kips	0.00 Kips	0.00 Kips
	2.80 ft	0.00 Kips	0.41 Kips	0.41 Kips
	7.99 ft	3.25 Kips	1.18 Kips	4.43 Kips
	8.01 ft	3.27 Kips	1.18 Kips	4.45 Kips
	8.49 ft	3.72 Kips	1.21 Kips	4.93 Kips
	8.51 ft	3.76 Kips	23.43 Kips	27.19 Kips
TOP OF	17.51 ft	35.78 Kips	38.03 Kips	73.81 Kips
CR	18.49 ft	40.19 Kips	39.62 Kips	79.80 Kips
	18.51 ft	40.27 Kips	290.62 Kips	330.89 Kips
	23.99 ft	61.97 Kips	290.62 Kips	352.59 Kips

STATIC ANALYSIS

FACTORED LOAD: 85 TONS / PILE

RESISTANC FACTOR : 0.45

$\frac{85 \text{ TON}}{0.45} = 188.9$ TON, ROUND TO NEAREST 5 TON

= 190 TON (380K) ULTIMATE RESISTANCE

BY INSPECTION, PILE WILL REFUSE ON CRYSTALLINE ROCK.

TIP EL = 1982.9'

L = BOC - TIPEL + 1.0' EMBED INTO CAP

L = 1998.6 - 1982.9 + 1.0

= 16.7

ANTICIPATED LENGTH: 17'

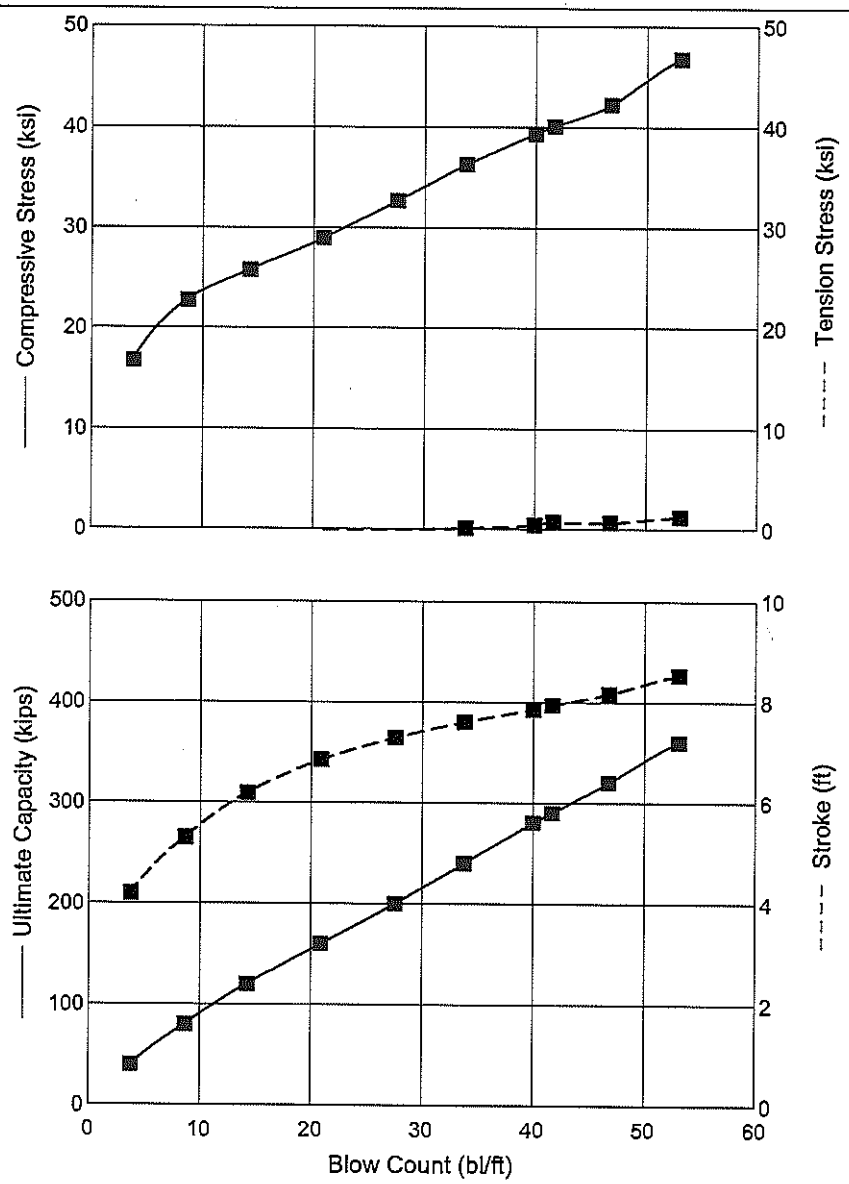
AVERAGE LENGTH: 20'

DRIVE PILES TO $\frac{85 \text{ TON}}{0.6} = 141.7$, SAY 145 TON (290K) DRIVING RESISTANCE

FOR WEAP: $\frac{40^K}{290^K} = 14\%$ SKIN FRICTION

Froehling & Robertson, Inc.
Macon Bridge 550064

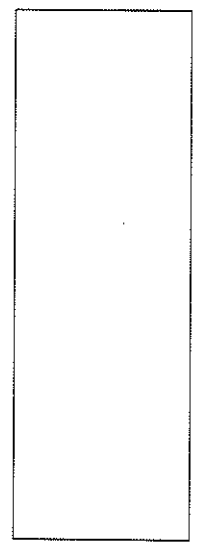
07-Aug-2014
GRLWEAP Version 2010



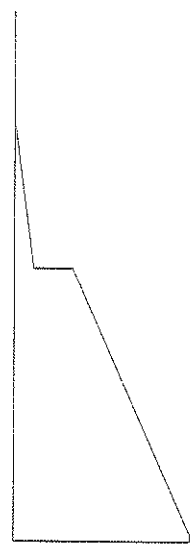
DELMAG. D 19-32

Ram Weight	4.00	kips
Efficiency	0.800	
Pressure	1500 (100%)	psi
Helmet Weight	1.90	kips
Hammer Cushion	60155	kips/in
COR of H.C.	0.800	
Skin Quake	0.100	in
Toe Quake	0.040	in ← Rock
Skin Damping	0.050	sec/ft
Toe Damping	0.150	sec/ft
Pile Length	20.00	ft
Pile Penetration	16.00	ft
Pile Top Area	15.60	in2

Pile Model



Skin Friction Distribution



Res. Shaft = 14 %
(Proportional)

Froehling & Robertson, Inc.
Macon Bridge 550064

07-Aug-2014
GRLWEAP Version 2010

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
40.0	16.74	0.00	3.8	4.19	21.78
80.0	22.77	0.00	8.7	5.30	18.60
120.0	25.76	0.00	14.3	6.18	17.19
160.0	28.99	0.00	20.9	6.85	16.33
200.0	32.73	0.00	27.6	7.29	15.87
240.0	36.31	0.12	33.8	7.61	15.73
280.0	39.38	0.46	40.0	7.86	15.74
290.0	40.09 <45ksi ✓	0.73	30 < 41.7 < 180 ✓	7.94	15.77
320.0	42.28	0.69	46.8	8.17	16.02
360.0	46.79	1.25	53.1	8.53	16.67

A DELMAG D 19-32 OR SIMILAR HAMMER SHOULD BE SUFFICIENT TO DRIVE PILES AT END BENT NO. 2.

GRLWEAP - Version 2010
WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS

written by GRL Engineers, Inc. (formerly Goble Rausche Likins and Associates, Inc.) with cooperation from Pile Dynamics, Inc.
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ABOUT THE WAVE EQUATION ANALYSIS RESULTS

The GRLWEAP program simulates the behavior of a preformed pile driven by either an impact hammer or a vibratory hammer. The program is based on mathematical models, which describe motion and forces of hammer, driving system, pile and soil under the hammer action. Under certain conditions, the models only crudely approximate, often complex, dynamic situations.

A wave equation analysis generally relies on input data, which represents normal situations. In particular, the hammer data file supplied with the program assumes that the hammer is in good working order. All of the input data selected by the user may be the best available information at the time when the analysis is performed. However, input data and therefore results may significantly differ from actual field conditions.

Therefore, the program authors recommend prudent use of the GRLWEAP results. Soil response and hammer performance should be verified by static and/or dynamic testing and measurements. Estimates of bending or other local non-axial stresses and prestress effects must also be accounted for by the user.

The calculated capacity - blow count relationship, i.e. the bearing graph, should be used in conjunction with observed blow counts for the capacity assessment of a driven pile. Soil setup occurring after pile installation may produce bearing capacity values that differ substantially from those expected from a wave equation analysis due to soil setup or relaxation. This is particularly true for pile driven with vibratory hammers. The GRLWEAP user must estimate such effects and should also use proper care when applying blow counts from restrike because of the variability of hammer energy, soil resistance and blow count during early restriking.

Finally, the GRLWEAP capacities are ultimate values. They MUST be reduced by means of an appropriate factor of safety to yield a design or working load. The selection of a factor of safety should consider the quality of the construction control, the variability of the site conditions, uncertainties in the loads, the importance of building and other factors.

Input File: E:\GRLWEAP 2010\DATA\BRANCH 63\DIV 14 V&M LIBR 63P-0310\DIVISION 14 BRIDGE 550064 END BENT 2 D 19-32.GWW
Hammer File: C:\ProgramData\PDI\GRLWEAP\2010\Resource\HAMMER2003.GW
Hammer File Version: 2003 (3/21/2012)

Input File Contents

Macon Bridge 550064

OUT	OSG	HAM	STR	FUL	PEL	N	SPL	N-U	P-D	%SK	ISM	0	PHI	RSA	ITR	H-D	MXT	DEx
6	0	40	0	1	0	0	0	0	0	14	1	0	0	0	0	0	0	0.000

Pile g	Hammer g	Toe Area	Pile Size	Pile Type
32.185	32.185	141.900	12.040	H Pile

W Cp	A Cp	E Cp	T Cp	CoR	ROut	StCp
1.900	227.000	530.0	2.000	0.800	0.010	0.0

A Cu	E Cu	T Cu	CoR	ROut	StCu
0.000	0.0	0.000	0.000	0.000	0.0

LPle	APle	EPle	WPle	Peri	CI	CoR	ROut
20.000	15.60	30457.9	493.356	3.971	0	0.850	0.010

Manufac	Hmr Name	HmrType	No Seg-s
DELMAG	D 19-32	1	5

Ram Wt	Ram L	Ram Dia	MaxStrk	RtdStrk	Efficy
4.00	129.10	12.60	11.76	10.61	0.80

IB. Wt	IB. L	IB.Dia	IB CoR	IB RO
0.75	25.30	12.60	0.900	0.010

CompStrk	A Chamber	V Chamber	C Delay	C Duratn	Exp Coeff	VolCStart	Vol CEnd
15.50	124.70	157.70	0.002	0.002	1.250	0.00	0.00

P atm	P1	P2	P3	P4	P5
14.70	1500.00	1350.00	1215.00	1094.00	0.00

Stroke	Effic.	Pressure	R-Weight	T-Delay	Exp-Coeff	Eps-Str	Total-AW
10.6100	0.8000	1500.0000	0.0000	0.0000	0.0000	0.0100	0.0000

Qs	Qt	Js	Jt	Qx	Jx	Rati	Dept
0.100	0.040	0.050	0.150	0.000	0.000	0.000	0.000

Research Soil Model: Atoe, Plug, Gap, Q-fac

0.000	0.000	0.000	0.000

Research Soil Model: RD-skn: m, d, toe: m, d

0.000	0.000	0.000	0.000

Res. Distribution

Dpth	Rskn	Dpth	Dpth						
0.00	0.00	16.00	16.00	0.00	0.00	0.00	0.00	0.00	0.0
5.70	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5.70	0.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
15.70	0.89	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
15.70	0.89	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
16.00	0.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
16.00	0.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
20.00	1.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0

Rult

40.0	80.0	120.0	160.0	200.0	240.0	280.0	290.0	320.0	360.0

GRLWEAP: WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS
Version 2010
English Units

Macon Bridge 550064

Hammer Model: D 19-32 Made by: DELMAG

No.	Weight kips	Stiffn k/inch	CoR	C-Slk ft	Dampg k/ft/s
1	0.800				
2	0.800	140046.7	1.000	0.0100	
3	0.800	140046.7	1.000	0.0100	
4	0.800	140046.7	1.000	0.0100	
5	0.800	140046.7	1.000	0.0100	
Imp Block	0.753	70735.6	0.900	0.0100	
Helmet	1.900	60155.0	0.800	0.0098	5.8
Combined Pile Top		11878.6			

HAMMER OPTIONS:

Hammer File ID No.	40	Hammer Type	OE Diesel
Stroke Option	FxdP-VarS	Stroke Convergence Crit.	0.010
Fuel Pump Setting	Maximum		

HAMMER DATA:

Ram Weight	(kips)	4.00	Ram Length	(inch)	129.10
Maximum Stroke	(ft)	11.76			
Rated Stroke	(ft)	10.61	Efficiency		0.800
Maximum Pressure	(psi)	1500.00	Actual Pressure	(psi)	1500.00
Compression Exponent		1.350	Expansion Exponent		1.250
Ram Diameter	(inch)	12.60			
Combustion Delay	(s)	0.00200	Ignition Duration	(s)	0.00200

The Hammer Data Includes Estimated (NON-MEASURED) Quantities

HAMMER CUSHION			PILE CUSHION		
Cross Sect. Area	(in2)	227.00	Cross Sect. Area	(in2)	0.00
Elastic-Modulus	(ksi)	530.0	Elastic-Modulus	(ksi)	0.0
Thickness	(inch)	2.00	Thickness	(inch)	0.00
Coeff of Restitution		0.8	Coeff of Restitution		0.0
RoundOut	(ft)	0.0	RoundOut	(ft)	0.0
Stiffness	(kips/in)	60155.0	Stiffness	(kips/in)	0.0

Macon Bridge 550064 08/07/2014
Froehling & Robertson, Inc. GRLWEAP Version 2010

PILE PROFILE:

Toe Area	(in2)	141.900	Pile Type	H Pile
Pile Size	(inch)	12.040		

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	15.60	30458.	493.4	4.0	0	16911.	28.1
20.0	15.60	30458.	493.4	4.0	0	16911.	28.1

Wave Travel Time 2L/c (ms) 2.365

Pile and Soil Model — Total Capacity Rut (kips) 40.0

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.178	11879	0.010	0.000	0.85	0.0	0.050	0.100	3.33	4.0	15.6
2	0.178	11879	0.000	0.000	1.00	0.1	0.050	0.100	6.67	4.0	15.6
3	0.178	11879	0.000	0.000	1.00	0.3	0.050	0.100	10.00	4.0	15.6
4	0.178	11879	0.000	0.000	1.00	1.2	0.050	0.100	13.33	4.0	15.6
5	0.178	11879	0.000	0.000	1.00	1.8	0.050	0.100	16.67	4.0	15.6
6	0.178	11879	0.000	0.000	1.00	2.3	0.050	0.100	20.00	4.0	15.6
Toe						34.4	0.150	0.040			

1.069 kips total unreduced pile weight (g= 32.17 ft/s2)
1.069 kips total reduced pile weight (g= 32.19 ft/s2)

PILE, SOIL, ANALYSIS OPTIONS:

Uniform pile		Pile Segments: Automatic	
No. of Slacks/Splices	0	Pile Damping (%)	1
Pile Penetration (ft)	16.00	Pile Damping Fact.(k/ft/s)	0.562
% Shaft Resistance	14		
Soil Damping Option	Smith		
Max No Analysis Iterations	0	Time Increment/Critical	160
Output Time Interval	1	Analysis Time-Input (ms)	0

Output Level: Variable vs Time
Gravity Mass, Pile, Hammer: 32.170 32.185 32.185
Output Segment Generation: Automatic

Macon Bridge 550064 08/07/2014
Froehling & Robertson, Inc. GRLWEAP Version 2010

Rut= 40.0, Rtoe = 34.4 kips, Time Inc. =0.076 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	261.1	0.00	16.74	11.44	3.202	21.78
2	0.0	260.7	0.00	16.71	12.15	3.199	21.82
3	0.0	259.1	0.00	16.61	12.61	3.196	21.81
4	0.0	250.2	0.00	16.04	12.86	3.193	21.58
5	0.0	221.3	0.00	14.19	13.51	3.190	21.08
6	0.0	163.4	0.00	10.47	14.06	3.187	20.78

(Eq) Strokes Analyzed and Last Return (ft):
10.61 3.88 4.29 4.13 4.19 4.17

Max. Combustion Pressure 1500.0 psi

Rut= 80.0, Rtoe= 68.8 kips, Time Inc. =0.076 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	352.4	0.00	22.59	10.89	1.461	18.60
2	0.0	353.9	0.00	22.68	10.84	1.455	18.60
3	0.0	355.2	0.00	22.77	11.57	1.449	18.56
4	0.0	351.8	0.00	22.55	13.15	1.443	18.33
5	0.0	330.6	0.00	21.19	14.39	1.437	17.87
6	0.0	271.8	0.00	17.42	15.05	1.431	17.59

(Eq) Strokes Analyzed and Last Return (ft):
10.61 4.57 5.54 5.30 5.36

Max. Combustion Pressure 1500.0 psi

Rut= 120.0, Rtoe= 103.2 kips, Time Inc. =0.076 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	398.6	0.00	25.55	12.45	0.932	17.19
2	0.0	399.9	0.00	25.64	12.38	0.923	17.15
3	0.0	401.9	0.00	25.76	12.38	0.913	17.08
4	0.0	401.0	0.00	25.70	12.55	0.904	16.84
5	0.0	394.0	0.00	25.25	13.77	0.894	16.38
6	0.0	363.8	0.00	23.32	14.41	0.885	16.10

(Eq) Strokes Analyzed and Last Return (ft):
10.61 5.72 6.27 6.18 6.19

Max. Combustion Pressure 1500.0 psi

Macon Bridge 550064 08/07/2014
Froehling & Robertson, Inc. GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
40.0	3.8	4.19	4.17	0.00	1	0	16.74	1	2	21.8	57.8
80.0	8.7	5.30	5.36	0.00	1	0	22.77	3	2	18.6	51.0
120.0	14.3	6.18	6.19	0.00	1	0	25.76	3	2	17.2	47.4
160.0	20.9	6.85	6.83	0.00	1	0	28.99	5	3	16.3	45.1
200.0	27.6	7.29	7.29	0.00	1	0	32.73	5	3	15.9	43.7
240.0	33.8	7.61	7.61	-0.12	3	49	36.31	6	3	15.7	42.8
280.0	40.0	7.86	7.89	-0.46	4	30	39.38	6	3	15.7	42.1
290.0	41.7	7.94	7.97	-0.73	4	30	40.09	6	3	15.8	41.9
320.0	46.8	8.17	8.20	-0.69	4	35	42.28	6	3	16.0	41.3
360.0	53.1	8.53	8.48	-1.25	3	24	46.79	1	4	16.7	40.6

END SLOPE ANALYSIS

SINCE 1881

FROEHLING & ROBERTSON, INC.

Engineering • Environmental • Geotechnical

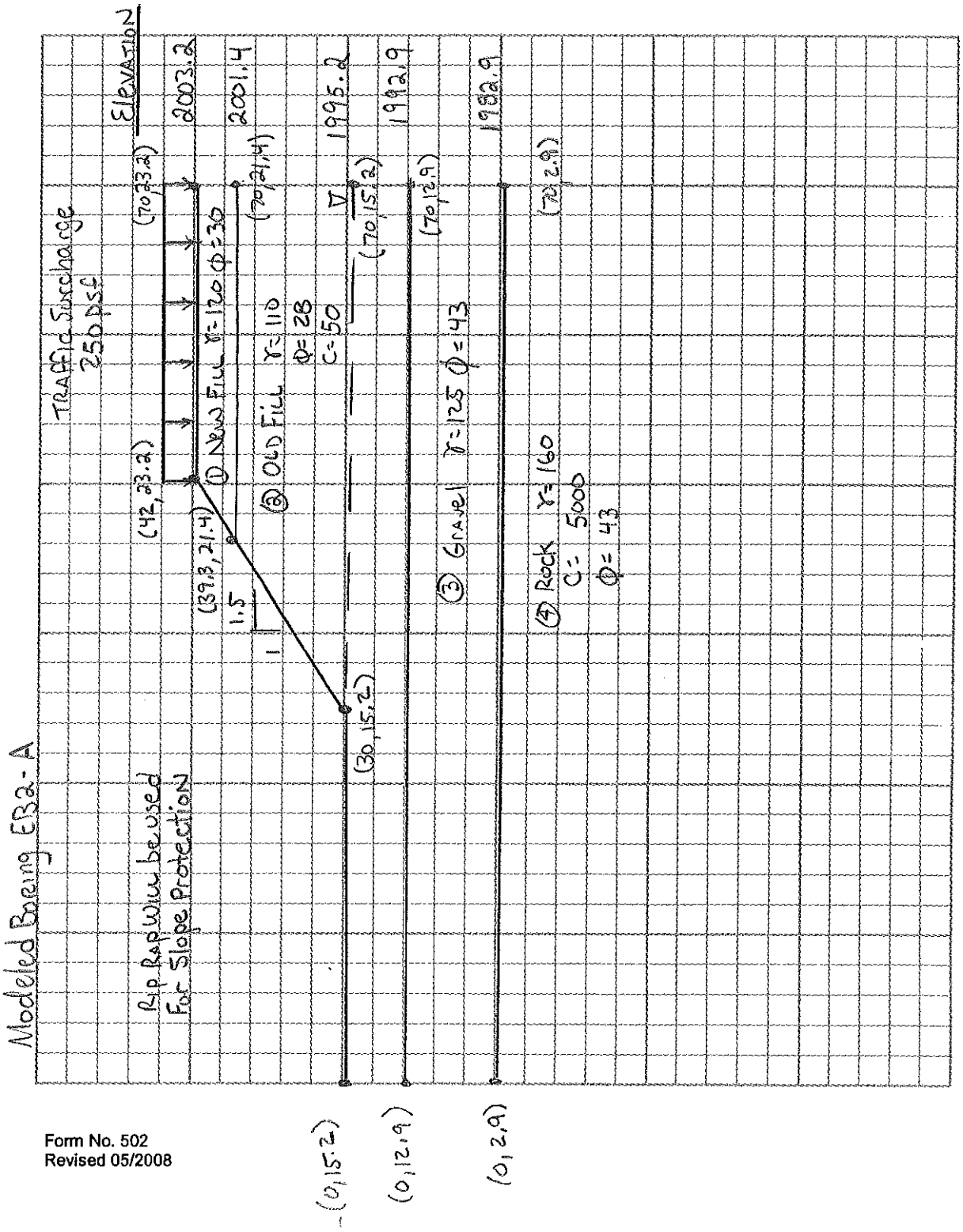
SHEET NO. 1 OF 1

JOB Bridge 550064 - EB 2

DATE Aug 2014

COMPUTATIONS FOR End Slope Stability

BY MJW CHKD



Form No. 502
Revised 05/2008

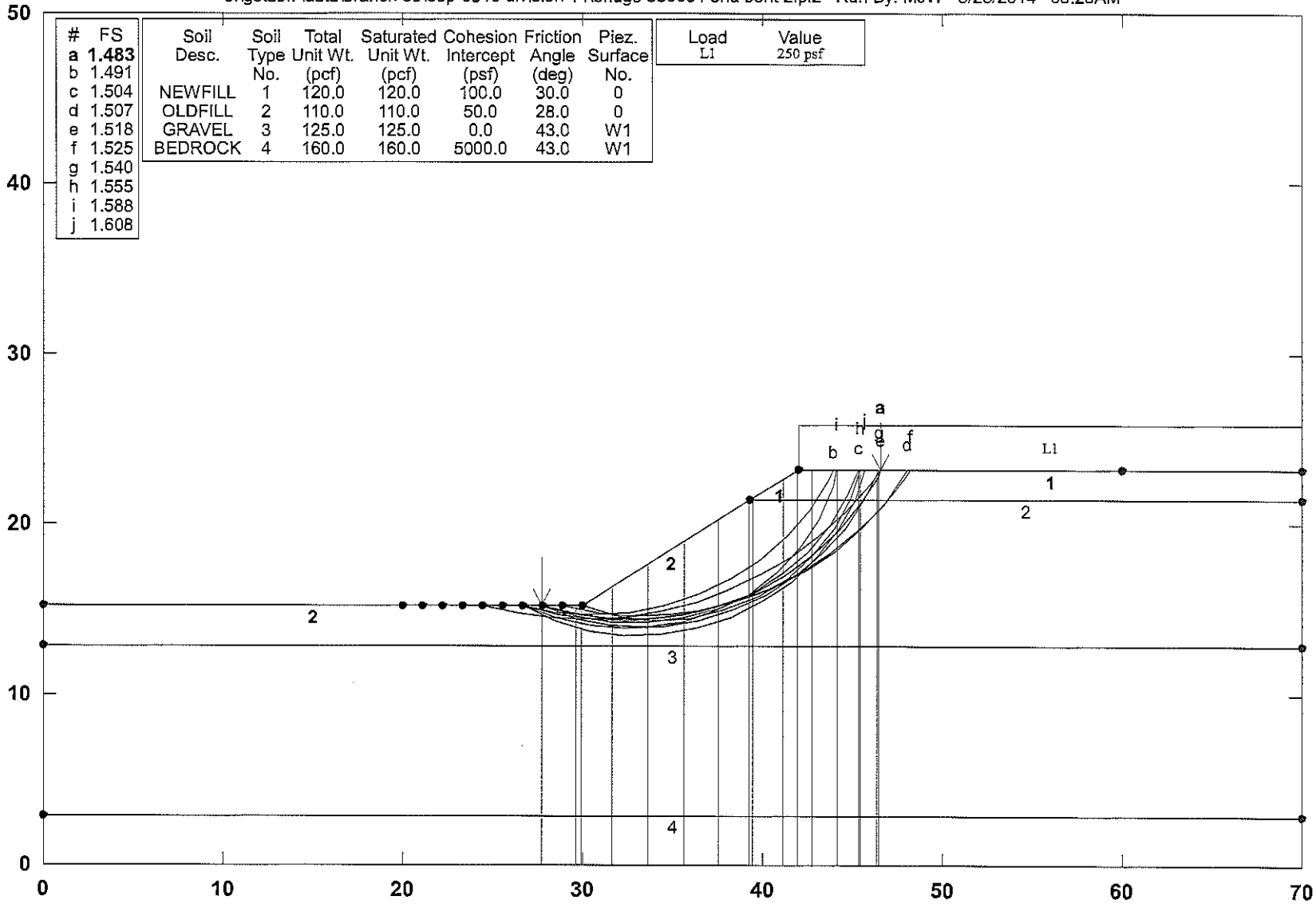
Bridge No. 550064 End Bent No. 2

e:\gstabl7\data\branch 63\63p-0310 division 14\bridge 550064 end bent 2.pl2 Run By: MJW 8/28/2014 08:28AM

#	FS
a	**1.483**
b	1.491
c	1.504
d	1.507
e	1.518
f	1.525
g	1.540
h	1.555
i	1.588
j	1.608

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
NEWFILL	1	120.0	120.0	100.0	30.0	0
OLDFILL	2	110.0	110.0	50.0	28.0	0
GRAVEL	3	125.0	125.0	0.0	43.0	W1
BEDROCK	4	160.0	160.0	5000.0	43.0	W1

Load	Value
L1	250 psf



GSTABL7 v.2 FSmin=1.483

Safety Factors Are Calculated By The Modified Bishop Method

GSTABL7

***** GSTABL7 *****

** GSTABL7 by Garry H. Gregory, P.E. **
** Original Version 1.0, January 1996; Current Version 2.003, June 2002 **
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SLOPE STABILITY ANALYSIS SYSTEM
Modified Bishop, Simplified Janbu, or GLE Method of Slices.
(Includes Spencer & Morgenstern-Price Type Analysis)
Including Pier/Pile, Reinforcement, Soil Nail, Tieback,
Nonlinear Undrained Shear Strength, Curved Phi Envelope,
Anisotropic Soil, Fiber-Reinforced Soil, Boundary Loads, Water
Surfaces, Pseudo-Static & Newmark Earthquake, and Applied Forces.

****

Analysis Run Date: 8/28/2014
Time of Run: 08:28AM
Run By: MJW
Input Data Filename: E:\GStabl7\Data\Branch 63\63P-0310 Division 14\bridge 550064 end bent 2.in
Output Filename: E:\GStabl7\Data\Branch 63\63P-0310 Division 14\bridge 550064 end bent 2.OUT
Unit System: English
Plotted Output Filename: E:\GStabl7\Data\Branch 63\63P-03ivision 14\bridge 550064 end bent 2.PLT
PROBLEM DESCRIPTION: Bridge No. 550064
End Bent No. 2

BOUNDARY COORDINATES
4 Top Boundaries
7 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	15.20	30.00	15.20	2
2	30.00	15.20	39.30	21.40	2
3	39.30	21.40	42.00	23.20	1
4	42.00	23.20	70.00	23.20	1
5	39.30	21.40	70.00	21.40	2
6	0.00	12.90	70.00	12.90	3
7	0.00	2.90	70.00	2.90	4

Default Y-Origin = 0.00(ft)
Default X-Plus Value = 0.00(ft)
Default Y-Plus Value = 0.00(ft)

ISOTROPIC SOIL PARAMETERS
4 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	120.0	120.0	100.0	30.0	0.00	0.0	0
2	110.0	110.0	50.0	28.0	0.00	0.0	0
3	125.0	125.0	0.0	43.0	0.00	0.0	1
4	160.0	160.0	5000.0	43.0	0.00	0.0	1

BOUNDARY LOAD(S)
1 Load(s) Specified

Load No.	X-Left (ft)	X-Right (ft)	Intensity (psf)	Deflection (deg)
1	42.00	70.00	250.0	0.0

NOTE - Intensity Is Specified As A Uniformly Distributed
Force Acting On A Horizontally Projected Surface.
A Critical Failure Surface Searching Method, Using A Random
Technique For Generating Circular Surfaces, Has Been Specified.
100 Trial Surfaces Have Been Generated.
10 Surface(s) Initiate(s) From Each Of 10 Points Equally Spaced
Along The Ground Surface Between X = 20.00(ft)
and X = 30.00(ft)
Each Surface Terminates Between X = 42.00(ft)
and X = 60.00(ft)
Unless Further Limitations Were Imposed, The Minimum Elevation
At Which A Surface Extends Is Y = 0.00(ft)
2.00(ft) Line Segments Define Each Trial Failure Surface.

Following Are Displayed The Ten Most Critical Of The Trial
Failure Surfaces Evaluated. They Are
Ordered - Most Critical First.
* * Safety Factors Are Calculated By The Modified Bishop Method * *
Total Number of Trial Surfaces Evaluated = 100
Statistical Data On All Valid FS Values:
FS Max = 4.996 FS Min = 1.483 FS Ave = 2.862
Standard Deviation = 1.013 Coefficient of Variation = 35.39 %
Failure Surface Specified By 13 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	27.78	15.20
2	29.71	14.68
3	31.69	14.42
4	33.69	14.42
5	35.68	14.67
6	37.61	15.19
7	39.46	15.95
8	41.19	16.94
9	42.78	18.16
10	44.20	19.57
11	45.42	21.15
12	46.43	22.88
13	46.56	23.20

Circle Center At X = 32.71 ; Y = 29.71 ; and Radius = 15.32
Factor of Safety
*** 1.483 ***
Individual data on the 16 slices

Slice No.	Width (ft)	Weight (lbs)	Water Force Top (lbs)	Water Force Bot (lbs)	Tie Force Norm (lbs)	Tie Force Tan (lbs)	Earthquake Force Hor (lbs)	Earthquake Force Ver (lbs)	Surcharge Load (lbs)
1	1.9	55.1	0.0	0.0	0.	0.	0.0	0.0	0.0
2	0.3	17.2	0.0	0.0	0.	0.	0.0	0.0	0.0
3	1.7	229.6	0.0	0.0	0.	0.	0.0	0.0	0.0
4	2.0	567.2	0.0	0.0	0.	0.	0.0	0.0	0.0
5	2.0	824.2	0.0	0.0	0.	0.	0.0	0.0	0.0
6	1.9	998.7	0.0	0.0	0.	0.	0.0	0.0	0.0
7	1.7	986.5	0.0	0.0	0.	0.	0.0	0.0	0.0
8	0.2	95.9	0.0	0.0	0.	0.	0.0	0.0	0.0
9	1.7	1087.2	0.0	0.0	0.	0.	0.0	0.0	0.0
10	0.8	517.1	0.0	0.0	0.	0.	0.0	0.0	0.0
11	0.8	473.2	0.0	0.0	0.	0.	0.0	0.0	195.4
12	1.4	702.2	0.0	0.0	0.	0.	0.0	0.0	354.6
13	1.2	404.0	0.0	0.0	0.	0.	0.0	0.0	305.6
14	0.1	33.3	0.0	0.0	0.	0.	0.0	0.0	36.2
15	0.9	109.6	0.0	0.0	0.	0.	0.0	0.0	215.3
16	0.1	2.6	0.0	0.0	0.	0.	0.0	0.0	33.5

Failure Surface Specified By 12 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	26.67	15.20
2	28.63	14.80
3	30.62	14.67
4	32.62	14.81
5	34.58	15.22
6	36.46	15.89
7	38.24	16.80
8	39.88	17.95
9	41.35	19.31
10	42.62	20.85
11	43.67	22.55
12	43.96	23.20

Circle Center At X = 30.59 ; Y = 29.42 ; and Radius = 14.75
Factor of Safety
*** 1.491 ***
Failure Surface Specified By 12 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	27.78	15.20
2	29.68	14.58
3	31.65	14.26
4	33.65	14.24
5	35.63	14.52
6	37.55	15.09
7	39.36	15.94
8	41.02	17.06
9	42.49	18.42
10	43.74	19.97
11	44.75	21.71
12	45.33	23.20

Circle Center At X = 32.80 ; Y = 27.43 ; and Radius = 13.23

Factor of Safety

*** 1.504 ***

Failure Surface Specified By 13 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	28.89	15.20
2	30.85	14.80
3	32.84	14.63
4	34.84	14.70
5	36.82	15.00
6	38.75	15.53
7	40.60	16.29
8	42.35	17.25
9	43.98	18.41
10	45.46	19.76
11	46.77	21.27
12	47.90	22.92
13	48.04	23.20

Circle Center At X = 33.27 ; Y = 31.68 ; and Radius = 17.05

Factor of Safety

*** 1.507 ***

Failure Surface Specified By 14 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	24.44	15.20
2	26.39	14.74
3	28.37	14.48
4	30.37	14.42
5	32.37	14.56
6	34.34	14.90
7	36.27	15.43
8	38.14	16.15
9	39.92	17.05
10	41.61	18.12
11	43.18	19.36
12	44.62	20.75
13	45.92	22.27
14	46.56	23.20

Circle Center At X = 29.99 ; Y = 34.44 ; and Radius = 20.02

Factor of Safety

*** 1.518 ***

Failure Surface Specified By 14 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	26.67	15.20
2	28.61	14.72
3	30.59	14.45
4	32.59	14.38
5	34.58	14.53
6	36.55	14.89
7	38.47	15.45
8	40.32	16.21

9	42.08	17.16
10	43.73	18.29
11	45.25	19.59
12	46.63	21.04
13	47.84	22.63
14	48.19	23.20

Circle Center At X = 32.19 ; Y = 33.30 ; and Radius = 18.92

Factor of Safety

*** 1.525 ***

Failure Surface Specified By 13 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	26.67	15.20
2	28.54	14.50
3	30.49	14.06
4	32.48	13.88
5	34.48	13.98
6	36.45	14.35
7	38.35	14.98
8	40.14	15.85
9	41.80	16.97
10	43.30	18.30
11	44.60	19.81
12	45.69	21.49
13	46.49	23.20

Circle Center At X = 32.77 ; Y = 28.65 ; and Radius = 14.77

Factor of Safety

*** 1.540 ***

Failure Surface Specified By 11 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	30.00	15.20
2	31.91	14.61
3	33.90	14.37
4	35.89	14.47
5	37.84	14.92
6	39.68	15.71
7	41.36	16.80
8	42.82	18.16
9	44.02	19.76
10	44.93	21.55
11	45.43	23.20

Circle Center At X = 34.30 ; Y = 25.82 ; and Radius = 11.45

Factor of Safety

*** 1.555 ***

Failure Surface Specified By 12 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	27.78	15.20
2	29.64	14.46
3	31.59	14.05
4	33.59	14.00
5	35.57	14.29
6	37.47	14.92
7	39.23	15.88
8	40.79	17.12
9	42.12	18.62
10	43.16	20.33
11	43.88	22.19
12	44.09	23.20

Circle Center At X = 32.92 ; Y = 25.34 ; and Radius = 11.37

Factor of Safety

*** 1.588 ***

Failure Surface Specified By 13 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	26.67	15.20

```
         2          28.48        14.35
         3          30.39        13.78
         4          32.38        13.52
         5          34.38        13.56
         6          36.35        13.90
         7          38.24        14.55
         8          40.01        15.47
         9          41.62        16.66
        10          43.03        18.08
        11          44.21        19.69
        12          45.12        21.47
        13          45.70        23.20
    Circle Center At X =    33.11 ; Y =    26.53 ; and Radius =    13.03
           Factor of Safety
          ***    1.608   ***
              **** END OF GSTABL7 OUTPUT ****
```

SINCE

F&R®

1881

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