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July 7, 2023

Prime AE Group, Inc.
8415 Pulsar Place, Suite 300
Columbus, Ohio 43240

Attention: Ms. Angela Trautman, P.E.
Associate Director – Bridge Design

Reference: **Structure Foundation Exploration- Final Report**
BRO-68-44.12 Bridge Replacement
PID No. 110556
Brown County, Ohio
CTL Project No. 22050029COL

Dear Ms. Trautman,

CTL Engineering, Inc. has completed the Structure Foundation Exploration report for the above referenced project. A pdf copy of the Final Report is being submitted.

Thank you for the opportunity to work with you on this project. If you have any questions or need further information, please feel free to contact our office.

Respectfully Submitted

CTL ENGINEERING, INC.

Sastry Malladi, P.E.
Project Engineer

STRUCTURE FOUNDATION EXPLORATION
FINAL REPORT

BRO-68-44.12
PID NO. 110556
1328 DOVER ROAD
BROWN COUNTY, OHIO
CTL PROJECT NO. 22050029COL

PREPARED FOR:

PRIME AE GROUP, INC.
8415 PULSAR PLACE, SUITE 300
COLUMBUS, OHIO 43240

PREPARED BY:

CTL ENGINEERING, INC.
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July 7, 2023

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I. EXECUTIVE SUMMARY

The project involves constructing a replacement structure for BRO-68-44.12 over East Fork Little Miami River in Brown County, Ohio, and the realignment of existing curve for the roadway. The existing bridge is a 3-span structure supported on spread footings. It is understood that the proposed structure will be a single span, concrete I- Beam bridge with a composite reinforced deck on new semi-integral reinforced concrete abutments with drilled shafts.

Within the project limits, the roadway profile will be slightly raised (1.0 to 2.0 feet) and the existing roadway will be widened. The proposed roadway width will be 40.0 feet (12.0-foot lanes + 8.0-foot shoulders). Side hill cuts and embankment fills are planned within the project limits to accommodate the proposed shoulder/ditch. Fill /cut slopes are planned at a maximum slope rate of 2 horizontal to 1 vertical.

A total of five (5) test borings were performed for this project. The borings were extended to depths ranging from 7.0 to 46.1 feet below existing grade. The borings generally exhibited layers of gravel and/or stone fragments with sand and silt (A-2-4), sandy silt (A-4a), silt and clay (A-6a), silty clay (A-6b) or clay (A-7-6). Bedrock was encountered in 4 out of 5 borings at depths ranging from 2.5 to 25.0 feet below grade. The bedrock was identified as shale, siltstone, claystone or interbedded shale and limestone.

The proposed abutments for the replacement structure may be supported onto drilled shafts socketed into the underlying bedrock. Please refer to the *Analyses and Recommendations* section of this report for additional information.

The proposed cut and fill slopes are considered acceptable.

The new pavement near the proposed bridge approach areas may designed using a CBR value of 7.0. Please refer to the *Analyses and Recommendations* section for additional information.

II. INTRODUCTION

The project involves constructing a replacement structure for BRO-68-44.12 over East Fork Little Miami River in Brown County, Ohio, and the realignment of existing curve for the roadway. The existing bridge is a 3-span structure supported on spread footings. It is understood that the proposed structure will be a single span concrete I- Beam bridge with composite reinforced deck on new semi-integral reinforced concrete abutments with drilled shafts.

Within the project limits, the roadway profile will be slightly raised (1.0 to 2.0 feet) and the existing roadway will be widened. The proposed roadway width will be 40.0 feet (12.0-foot lanes + 8.0-foot shoulders). Side hill cuts and embankment fills are planned within the project limits to accommodate the proposed shoulder/ditch. Fill /cut slopes are planned at a maximum slope rate of 2 horizontal to 1 vertical.

According to the plan/profile sheets provided to us, the project begins at Sta. 142+25 and ends at Sta. 148+75. This is a Final Structure Foundation Exploration Report.

The Geotechnical profile- Roadway & Structure sheets are appended in Appendix A of this report.
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III. GEOLOGY AND OBSERVATIONS OF THE PROJECT

According to the Ohio Department of Natural Resources (ODNR), Physiographic Regions of Ohio Map, the site is located within the Illinoian Till physiographic region of Ohio. According to the Bedrock Geologic Map of Ohio (2006), the underlying bedrock is mapped as Ordovician age interbedded shale and limestone of Waynesville and Arnheim Formations.

According to the ODNR website, no karst features have been mapped at the site. According to mapping from the ODNR Website, no underground mines have been mapped in the project area.

According to web-based mapping from *United States Department of Agriculture, Natural Resources Conservation Service,* the project area contains two primary soil types as shown below.

Table 1. Mapped Soil Survey Soils Types

Soil Series	Series Symbol	Drainage Characteristics	Parent Material
Genesee silt loam, 0 to 2 percent slopes	Ge	Well drained, negligible runoff class	Loamy Alluvium
Bonnell silt loam, 15 to 25 percent slopes	BoD2	Well drained, very high runoff class	Loess over till

Historic geotechnical records were searched for on the ODOT TIMS website. Historic geotechnical records were found from borings within the current project site. The information from these borings will be included on the Soil Profile – Structure Foundation Exploration sheets during future phases of this project.

An initial site visit was performed by CTL personnel on April 5, 2022. The existing structure is a three-span bridge. US 68, within the project limits is a bi-directional roadway having an asphalt surface. The area surrounding the bridge is primarily farmland with some residential properties. East Fork Little Miami River flows east to west flowing river below the structure. The stream bed is approximately 22 to 25 feet below the top of the existing bridge deck. No exposed bedrock was not observed from beneath the existing bridge or along the banks of East Fork Little Miami River.

No obvious signs of slope instability were noted along the hillside at the northern end of the site.

IV. EXPLORATION

A total of five (5) test borings, identified as B-001-0-22, B-002-0-22, B-003-0-22, B-004-0-22 and B-004-1-22 were performed for this project. The borings were drilled between June 14 and 22, 2022 and were extended to depths ranging from 7.0 to 46.1 feet below existing grade.

Information about the performed borings is provided in the Table 2 below:

Table 2. Boring Information

Boring ID	Boring Type	Boring Depth (feet)	Top of Augerable Rock (feet)	Rock Coring (feet)
B-001-1-22	A (roadway)	7.0	---	---
B-002-0-22	A/E1 (roadway/structure)	46.1	25.0	20.0
B-003-0-20	A/E1 (roadway/structure)	45.1	22.5	20.0
B-004-0-22*	A/B2 (roadway/sidehill cut)	5.8	2.5	---
B-004-1-22*	B2 (sidehill cut)	18.2	13.5	---

*Borings terminated at auger refusal depth on the underlying bedrock.

The test borings were performed with a track mounted drill rig utilizing hollow stem augers (HSA). Standard penetration tests were conducted using 140-pound hammers falling 30 inches to drive a 2-inch O.D. split barrel sampler for 18 inches. Rock coring was performed in the borings, using an NQ-size, double tube core barrel with a diamond bit. The energy transfer ratio associated with the automatic SPT hammer was 89.3 percent. The hammer was calibrated on August 05, 2022.

Soil samples obtained from the drilling operation were preserved in glass jars, visually classified in the field and laboratory, and tested for natural moisture content.

Representative soil samples were subjected to additional laboratory testing including grain size distribution, Atterberg limits hand penetrometer testing and sulfate testing.

A representative Shelby Tube (ST) sample obtained from the boring B-004-1-22 was subjected to unconsolidated undrained (UU) triaxial test.

Rock from the coring operation was visually classified in the field and laboratory and the Rock Quality Designation (RQD) and percent core loss values were determined. Representative samples of the recovered rock were subjected to unconfined compressive strength testing.

Ground surface elevations and boring coordinates at the test boring locations were provided by personnel from Prime AE Group Inc.,

V. FINDINGS

Roadway & Sidehill Cut Borings

Borings B-001-0-22 (roadway boring) and B-004-0-22 (dual purpose, roadway/sidehill cut) were performed within the roadway, and exhibited 7 to 10 inches of asphalt over 2 to 5 inches of granular base near the surface. Boring B-004-1-22 (sidehill cut) was performed off the road, exhibited approximately 4 inches of topsoil near the surface.

Beneath the surface cover, boring B-001-0-22 encountered embankment fill material to its termination depth. The fill was described as silty clay (A-6b) and exhibited SPT N_{60} values ranging from 13 to 37 blows per foot (bpf), with natural moisture content values ranging from 8 to 16 percent.

Beneath the surface cover, borings B-004-0-22 and B-004-1-22 exhibited native cohesive soils described as silt and clay (A-6a), silty clay (A-6b) or clay (A-7-6) extending downwards to depths ranging from 2.5 to 13.5 feet below existing grade. The native soils exhibited SPT N_{60} values ranging from 15 to 48 bpf, with natural moisture content values ranging from 11 to 22 percent.

Below the soil overburden, borings B-004-0-22 and B-004-1-22 exhibited augerable bedrock. The augerable bedrock was augered and sampled using soil sampling techniques. The augerable bedrock was described as siltstone, claystone or shale. The augerable bedrock exhibited N_{60} values ranging from 95 bpf to 50 blows for 4 inches of penetration

Bridge Borings

Borings B-002-0-22 and B-003-0-22 encountered approximately 8 to 10 inches of asphalt over 2 to 4 inches of base course at the surface.

Below the surface cover, both borings exhibited embankment fill material to depths ranging from 5.5 to 8.0 feet below grade. The fill was classified as gravel and/or stone fragments with sand and silt (A-2-4), silt and clay (A-6a) or clay (A-7-6). The fill soils exhibited SPT N_{60} values ranging from 13 to 37 blows per foot (bpf), with natural moisture content values ranging from 6 to 19 percent.

Below the fill, borings B-002-0-22 and B-003-0-22 encountered cohesive native soils extending down to depths of 22.5 to 25.0 feet below grade. These soils were described as sandy silt (A-4a), silt and clay (A-6a), silty clay (A-6b) and clay (A-7-6). The native soils exhibited N_{60} values ranging from 7 to 48 bpf, with natural moisture content values ranging from 11 to 28 percent.

Below the soil overburden, borings B-002-0-22 and B-003-0-22 encountered augerable bedrock. The top of bedrock was encountered at depths ranging from 22.5 to 25.0 feet (elevations 904.3 to 908.9). The bedrock was identified as claystone or interbedded shale and limestone.

The upper few feet of bedrock was augerable. The augerable bedrock exhibited N_{60} values ranging from 39 bpf to 50 blows for less than 1 inch of penetration. The lower 20.0 feet of bedrock after refusal was encountered was cored and recovered using rock coring techniques. The recovered bedrock from the coring operations exhibited Rock Quality Designation (RQD) values ranging from 28 to 88 percent, and core recovery values ranging from 88 to 100 percent.

Groundwater and soil cave-in

During drilling, groundwater was encountered at depths of 20.0 feet in borings B-002-0-22 and B-003-0-22 (elevations 909.3 to 911.4). Groundwater at completion was not feasible to measure due to water use associated with the rock coring. Upon removing the augers, soil cave-in was measured at depths ranging from 3.7 to 21.3 feet below existing grade in the test borings.

VI. ANALYSES AND RECOMMENDATIONS

Based on the soil and rock data obtained from the field and laboratory testing, the following analyses and recommendations are provided for this project.

A. Stream Bed Material for Scour Analysis

The information provided in Table 3 below van be utilized while performing the scour computations.

Table 3: Scour Information

Boring Number	Sample	Elevation (ft)	D_{50} (mm)	τ_c (psf)	$D_{50, equiv}$ (mm)	Erosion Category (EC)
B-002-0-22 (Rear Abutment)	SS-5	921.3-919.8	0.0086	0.4039	19.3407	3.612
	SS-7	916.3-914.8	0.0104	0.1499	7.1768	3.255
	SS-8	914.8-913.3	0.0407	0.0870	4.1632	2.754
	SS-9	913.3-911.8	0.0245	0.0416	1.9915	3.168
B-003-0-22 (Forward Abutment)	SS-6	920.9-919.4	0.0083	0.4694	22.4755	3.670
	SS-7	918.4-916.9	0.0096	0.1636	7.8312	3.168
	SS-8	916.9-915.4	0.018	0.0604	2.8903	3.075
	SS-9	915.4-913.9	0.0608	0.1188	5.6886	2.975

B. Subgrade Considerations

According to the plans, no significant fill will be placed near the approach embankments. Therefore, no major settlement is expected near the approach areas.

According to the plans, the project begins at project begins at Sta. 142+25 and ends at Sta. 148+75. Full depth pavement replacement is planned within the project limits in the bridge approach areas. Therefore, a GB1 analysis was performed to determine the limits of any subgrade stabilization needed prior to performing the full depth pavement replacement. A GB1 analysis was performed utilizing subsurface data from borings B-001-0-22 B-002-0-22, B-003-0-22 and B-004-0-22, which were drilled within the roadway of U.S. 68. A copy of the GB1 spreadsheet is provided in Appendix D.

To estimate cut/fill depths of the GB1 spreadsheet, the pavement thickness for the proposed roadway (pavement+ Item 304 granular material) was assumed to be on the order of 1.3 feet.

The natural moisture content values of the near surface (subgrade) samples ranged from 6 to 19 percent, averaging 13 percent. The estimated optimum moisture content (OMC) values ranged from 0 to 21 percent, averaging 13 percent.

According to GB1, the near surface soils in borings B-001-0-22, B-002-0-22 and B-003-0-22 are suitable to support the proposed pavement, and provide adequate cover for the underlying materials. Bedrock is not anticipated below the proposed pavement subgrade in these areas.

Bedrock was encountered and should be anticipated below the proposed pavement subgrade in B-004-0-22. According to the ODOT Geotechnical Design Manual Section 610.5, any bedrock encountered within 24 inches of the bottom of proposed pavement should be removed in accordance to 204.05 and replaced with Item 204 embankment.

According to the CMS 204.05, the aggregate base can be included with the bedrock removal depth. Since a 6 inch aggregate base is planned, the depth of bedrock removal can be 18 inches below the 6 inch aggregate base.

For estimating purposes, the approximate limits of bedrock removal are presented in Table 4.

Table 4. Bedrock Removal

Approximate Station	Depth* of Bedrock Removal (inches)
147+00 to End Project	18

* Depth measured below the proposed 6-inch aggregate base.

The bedrock should also be removed at least 12 inches beyond the edge of the surface of pavement

Group Index values for the subgrade samples ranged from 0 to 16, averaging 8. This average Group Index value corresponds to an estimated California Bearing Ratio (CBR) value of 7. It is recommended that the pavement be designed using a CBR value of 7.

C. Global Stability Analyses

Side hill cuts and embankment fills are planned within the project limits to accommodate the proposed shoulder/ditch. Fill /cut slopes are planned at a maximum slope rate of 2 horizontal to 1 vertical

Global stability analyses were performed on both the areas of the cut slope (Station 148+00) and fill slope (Station 142+00). The stations used for each cross section were selected based on their estimated most critical geometry. For each location, a

long-term, effective stress and short-term total stress stability analyses was performed on both sides of the proposed embankments. The global stability analyses were performed using SLIDE computer software. This program is based on two-dimensional limit equilibrium methods in which the calculation of the factor of safety against instability of a slope is performed by the method of slices. The method used in these analyses was the Morgenstern-Price method for surfaces of a non-circular shape.

The soil parameters used in the analysis are based on the subsurface conditions encountered in the borings and estimated parameters for the embankment soils and published references.

Results of the stability analyses are submitted in graphical format in Appendix E of this report.

The graphs present the geometry of the proposed critical cut/fill sections, the modeled soil strata, their corresponding parameters and the most critical failure surface along with the minimum factor of safety. Factor of safety is defined as the ratio of forces resisting movement (generally the shear strength value along the assumed failure surface) to forces acting on the slope, generally gravity and applied vehicular loads. Results of the global stability analyses are summarized in Tables 5 and 6.

Table 5. Global Stability- Proposed Fill Slopes (Station 142+00)

Case		Computed Factor of Safety	Computed Equivalent Resistance Factor from the analyses	Target Resistance Factor
Western Slope	Effective Stress	1.7	0.59	0.75
	Total Stress	9.1	0.11	0.75
Eastern Slope	Effective Stress	2.1	0.48	0.75
	Total Stress	9.3	0.11	0.75

Table 6. Global Stability- Proposed Cut Slopes (Station 148+00)

Case		Computed Factor of Safety	Computed Equivalent Resistance Factor from the analyses	Target Resistance Factor
Western Slope	Effective Stress	3.2	0.31	0.75
	Total Stress	11.2	0.09	0.75
Eastern Slope	Effective Stress	2.6	0.39	0.75
	Total Stress	10.1	0.10	0.75

Based on the analyses, it is our opinion that the proposed cut and fill slopes are considered safe against overall (global) stability when constructed at a maximum slope rate of 2 horizontal to 1 vertical.

D. Foundation Support

It is understood that the replacement structure will be single span bridge. It is also understood that the new bridge will be constructed in the general vicinity the existing structure. Based upon the soil and rock data obtained from the field and laboratory testing, the proposed abutments for the replacement structure may be supported onto drilled shafts socketed into the underlying bedrock. The tip of the drilled shaft should be extended deep into the bedrock to exceed the anticipated scour during the life of the structure.

The drilled shaft tips should be extended to a minimum depth of 10 feet below the controlling scour elevation (ODOT BDM 305.4.1.1).

Drilled shaft bases may be proportioned using a nominal unit tip resistance value not exceeding those provided in Table 7.

Table 7: Nominal Unit Tip Resistance

Location	Boring	Elevation (feet)	Nominal Unit Tip Resistance, q_p (ksf)
Rear Abutment	B-002-0-22	At or below 902.9	756.7
Forward Abutment	B-003-0-22	At or below 904.9	777.6

According to AASHTO Table 10.5.5.2.4-1, a resistance factor of 0.5 should be used for Unit Tip Resistance for the Strength Limit State.

The socket tip should extend at least 1.5 times the socket diameter into the bedrock per ODOT BDM 305.4.2 (AASHTO LRFD 10.8.3.5.4c).

Additional capacity can be achieved along the shafts using side resistance. Side resistance within upper portion of the rock socket should be neglected as outlined in ODOT BDM section 305.4.2. The side resistance should also be neglected within the scour zone (ODOT BDM 305.4.1.1).

Table 8. Unfactored Unit Side Resistance

Location	Boring	Elevation (feet)	Unfactored Unit Side Resistance (ksf)
Rear Abutment	B-002-0-22	904.0 to 902.9	2.3
		Below 902.9	25.3
Forward Abutment	B-003-0-22	907.5 to 904.9	1.6
		Below 904.9	25.7

The resistance factors in Table 9 should be used for Shaft Side Resistance. The resistance factors were obtained from AASHTO Table 10.5.5.2.4-1.

Table 9. Resistance Factors for Shaft Side Resistance

Material Type	Resistance Factors	
	Compressive	Uplift
Rock	0.55	0.40

Drilled shaft design calculations and soil and rock parameters for lateral load analysis are provided in Appendix F.

E. General Construction and Earthwork

1. Site preparation, earthwork and installation of structures should be performed in accordance with the ODOT Construction and Material Specifications, and applicable Geotechnical Bulletins.

2. Embankment side slopes should be seeded and vegetation growth permitted to limit sloughing and slope failure.

3. Temporary excavations in excess of 4.0 feet in depth should be sloped or shored in accordance with OSHA regulations.

VII. CHANGED CONDITIONS

The evaluations, conclusions, and recommendations in this report are based on our interpretation of the field and laboratory data obtained during the exploration, our understanding of the project and our experience with similar sites and subsurface conditions using generally accepted geotechnical engineering practices. Although individual test borings are representative of the subsurface conditions at the boring locations on the dates drilled, they are not necessarily representative of the subsurface conditions between boring locations or subsurface conditions during other seasons of the year.

In the event that changes in the project are proposed, additional information becomes available, or if it is apparent that subsurface conditions are different from those provided in this report, CTL Engineering should be notified so that our recommendations can modified, if required.

VIII. TESTING AND OBSERVATION

During the design process, it is recommended that CTL Engineering work with the project designers to confirm that the geotechnical recommendations are properly incorporated into the final plans and specifications, and to assist with establishing criteria for the construction observation and testing.

CTL Engineering is not responsible for independent conclusions, opinions and recommendations made by others based on the data and recommendations provided in this report. It is recommended that CTL be retained to provide construction quality control services on this project. If CTL Engineering is not retained for these services, CTL shall assume no responsibility for compliance with the design concepts or recommendations provided.

IX. CLOSING

This report has been prepared for the exclusive use by the client for use only on this project. Our services have been performed in accordance with generally accepted Geotechnical Engineering principles and practices. No warranty is either expressed or implied.

CTL Engineering's assignment does not include, nor does this geotechnical report address the environmental aspects of this particular site.

Specific design and construction recommendations have been provided in this report. Therefore, the report should be used in its entirety.

Respectfully Submitted,

CTL ENGINEERING, INC.

Sastry Malladi, P.E
Project Engineer

Evan Holcombe, P.E.
Geotechnical Engineer

APPENDIX A
BORING LOCATION MAP

PROJECT DESCRIPTION

THE PROJECT INVOLVES CONSTRUCTING A REPLACEMENT STRUCTURE FOR BRO-68-44.12 OVER EAST FORK LITTLE MIAMI RIVER IN BROWN COUNTY, OHIO, ALONG WITH THE REALIGNMENT OF AN EXISTING CURVE FOR THE ROADWAY. THE PROPOSED STRUCTURE WILL BE AN I-BEAM BRIDGE WITH A COMPOSITE REINFORCED DECK ON NEW SEMI-INTEGRAL CONCRETE ABUTMENTS WITH DRILLED SHAFTS.

HISTORIC RECORDS

FOUR (4) HISTORIC BORINGS FROM THE BRO-123-1.02 STRUCTURE FOUNDATION INVESTIGATION REPORT, DATED OCTOBER 30, 1996, ARE PRESENTED ON THIS GEOTECHNICAL PROFILE SHEETS.

GEOLOGY

ACCORDING TO PHYSIOGRAPHIC MAPS (ODNR, 1998), THE PROJECT SITE LIES WITHIN THE ILLINOIAN TILL PHYSIOGRAPHIC REGION OF OHIO. ACCORDING TO BEDROCK GEOLOGIC MAP OF OHIO (2006), THE BEDROCK UNDERLYING THE SITE CONSISTS OF ORDOVICIAN AGE INTERBEDDED SHALE AND LIMESTONE OF WAYNESVILLE AND ARNHEIM FORMATIONS.

RECONNAISSANCE

A SITE VISIT WAS PERFORMED ON APRIL 5, 2022, BY PERSONNEL FROM CTL ENGINEERING, INC. THE EXISTING STRUCTURE IS A THREE-SPAN BRIDGE. THE AREA SURROUNDING THE BRIDGE IS PRIMARILY FARMLAND WITH SOME RESIDENTIAL PROPERTIES. EAST FORK LITTLE MIAMI RIVER FLOWS EAST TO WEST BELOW THE STRUCTURE. NO EXPOSED BEDROCK WAS OBSERVED FROM BENEATH THE EXISTING BRIDGE OR ALONG THE BANKS OF EAST FORK LITTLE MIAMI RIVER.

SUBSURFACE EXPLORATION

A SUBSURFACE EXPLORATION WAS CONDUCTED BY CTL ENGINEERING, INC. BETWEEN JUNE 14 AND JUNE 22, 2022. THE EXPLORATION CONSISTED OF DRILLING FIVE (5) BORINGS DESIGNATED AS B-001-0-22 THROUGH B-004-0-22 AND B-004-1-22 TO DEPTHS RANGING FROM 7.0 TO 46.1 FEET.

EXPLORATION FINDINGS

BORINGS B-001-0-22 THROUGH B-003-22 ENCOUNTERED FILL MATERIAL EXTENDING TO DEPTHS RANGING FROM 5.5 TO 8.0 FEET BELOW EXISTING GRADE CONSISTING OF GRAVEL AND/OR STONE FRAGMENTS WITH SAND AND SILT (A-2-4), SILT AND CLAY (A-6a) OR CLAY (A-7-6). BENEATH THE FILL AND FROM THE SURFACE COVER IN BORINGS B-004-0-22 AND B-004-1-22, NATIVE SOILS WERE ENCOUNTERED AND DESCRIBED AS SANDY SILT (A-4a), SILT AND CLAY (A-6a), SILTY CLAY (A-6b) OR CLAY (A-7-6).

BEDROCK WAS ENCOUTNERED IN BORINGS B-002-0-22 THROUGH B-004-0-22 AND B-004-1-22 AT DEPTHS RANGING FROM 2.5 FEET TO 25.0 FEET BELOW EXISTING GRADE. THE BEDROCK WAS DESCRIBED AS SILTSTONE, CLAYSTONE, SHALE OR INTERBEDDED SHALE AND LIMESTONE.

BORINGS B-002-0-22 AND B-003-0-22 ENCOUNTERED GROUNDWATER DURING DRILLING BETWEEN APPROXIMATE ELEVATIONS 909.3 FEET TO 911.4 FEET.

SPECIFICATIONS

THIS GEOTECHNICAL EXPLORATION WAS PERFORMED IN ACCORDANCE WITH THE STATE OF OHIO, DEPARTMENT OF TRANSPORTATION, OFFICE OF GEOTECHNICAL ENGINEERING, SPECIFICATIONS FOR GEOTECHNICAL EXPLORATIONS, DATED JANUARY 2022.

AVAILABLE INFORMATION

THE SOIL, BEDROCK, AND GROUNDWATER INFORMATION COLLECTED FOR THIS SUBSURFACE EXPLORATION THAT CAN BE CONVENIENTLY DISPLAYED ON THE SOIL PROFILE SHEETS HAS BEEN PRESENTED. GEOTECHNICAL REPORTS, IF PREPARED, ARE AVAILABLE FOR REVIEW ON THE OFFICE OF CONTRACT SALES WEBSITE.

LEGEND

	DESCRIPTION	ODOT CLASS	CLASSIFIED MECH./VISUAL	
	GRAVEL AND/OR STONE FRAGMENTS W/SAND AND SILT	A-2-4 (0)	1	1
	SANDY SILT	A-4a (4)	2	1
	SILT AND CLAY	A-6a (7)	7	2
	SILTY CLAY	A-6b (10)	5	6
	CLAY	A-7-6 (12)	6	2
		TOTAL	21	12
	PAVEMENT OR BASE = X = APPROXIMATE THICKNESS	VISUAL		
	SOD AND TOPSOIL = X = APPROXIMATE THICKNESS	VISUAL		
	CLAYSTONE	VISUAL		
	INTERBEDDED SHALE AND LIMESTONE	VISUAL		
	SHALE	VISUAL		
	SILTSTONE	VISUAL		

PROJECT BORING LOCATION - PLAN VIEW

HISTORIC BORING LOCATION - PLAN VIEW - BRO-123-1.02

DRIVE SAMPLE AND/OR ROCK CORE BORING PLOTTED TO VERTICAL SCALE ONLY. HORIZONTAL BAR INDICATES A CHANGE IN STRATIGRAPHY.

WC — INDICATES WATER CONTENT IN PERCENT.

N_{60} — INDICATES STANDARD PENETRATION RESISTANCE NORMALIZED TO 60% DRILL ROD ENERGY RATIO.

W — INDICATES FREE WATER ELEVATION.

X/D" — NUMBER OF BLOWS FOR STANDARD PENETRATION TEST (SPT):
X/D"= NUMBER OF BLOWS (UNCORRECTED) FOR D" OF PENETRATION AT REFUSAL.

X/Y/D" — NUMBER OF BLOWS FOR STANDARD PENETRATION TEST (SPT):
X= NUMBER OF BLOWS FOR 6 INCHES (UNCORRECTED).
Y/D"= NUMBER OF BLOWS (UNCORRECTED) FOR D" OF PENETRATION AT REFUSAL.

X/Y/Z — NUMBER OF BLOWS FOR STANDARD PENETRATION TEST
X= NUMBER OF BLOWS FOR 6 INCHES.
Y=NUMBER OF BLOWS FOR SECOND 6 INCHES.
Z=NUMBER OF BLOWS FOR THIRD 6 INCHES.

X/Y/Z/D" — NUMBER OF BLOWS FOR STANDARD PENETRATION TEST
X= NUMBER OF BLOWS FOR 6 INCHES.
Y=NUMBER OF BLOWS FOR SECOND 6 INCHES.
Z/D"=NUMBER OF BLOWS (UNCORRECTED) FOR D" OF PENETRATION AT REFUSAL.

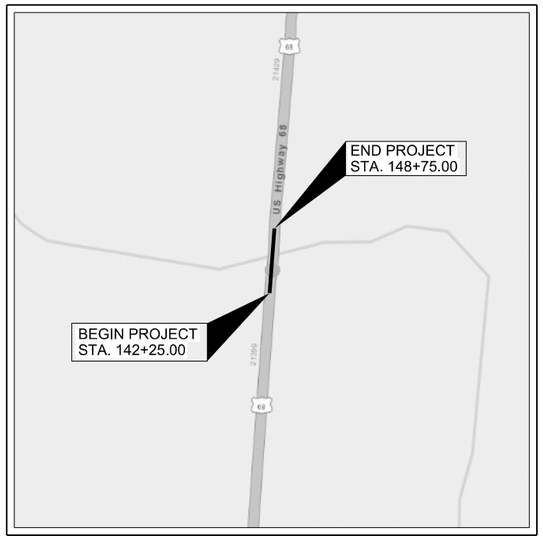
● — INDICATES A PLASTIC MATERIAL WITH MOISTURE CONTENT EQUAL TO OR GREATER THAN THE LIQUID LIMIT MINUS 3.

SS — INDICATES A SPLIT SPOON SAMPLE.

TR — INDICATES TOP OF ROCK.

ST — INDICATES A SHELBY TUBE SAMPLE.

	HISTORIC BORING DESCRIPTION	ODOT CLASS	CLASSIFIED MECH./VISUAL	
	GRAVEL AND/0R STONE FRAGMENT W/SAND, SILT & CLAY	A-2-6	0	2
	SANDY SILT	A-4a	4	5
	SILT AND CLAY	A-6a	2	5
	SILTY CLAY	A-6b	1	1
	CLAY	A-7-6	1	3
		TOTAL	8	16
	SHALE	VISUAL		
	LIMESTONE	VISUAL		



LOCATION MAP

SCALE : NOT TO SCALE

N

PARTICLE SIZE DEFINITIONS

12"	3"	2.0 mm	0.42 mm	0.074 mm	0.005 mm
BOULDERS	COBBLES	GRAVEL	COARSE SAND	FINE SAND	SILT	CLAY
		No. 10 SIEVE	No. 40 SIEVE	No. 200 SIEVE	

INDEX OF SHEETS					
LOCATION FROM STA. TO STA.	PLAN VIEW SHEET	PROFILE SHEET	CROSS-SECTION SHEET	CUT MAX.	FILL EMB. MAX.
COVER SHEET 1	1				
SUMMARY OF SOIL TEST DATA	2				
US - 68 137+00 151+00	3	3	-	-	-
BRIDGE 143+65 145+85	4	4	-	-	-
CROSS SECTION 142+00 AND 148+00	-	-	5	-	-
BORING LOGS 6 TO 8					
LAB TEST DATA 9 TO 11					

BEDROCK TEST SUMMARY				
BORING NO.	SAMPLE ELEVATION	SAMPLE DEPTH	QU (PSI)	LITHOLOGY
B-002-0-22	NQ2-1	26.3' - 26.7'	5,770	LIMESTONE
B-002-0-22	NQ2-3	39.3' - 39.6'	530	SHALE
B-003-0-22	NQ2-2	33.3' - 33.6'	1,650	SHALE
B-003-0-22	NQ2-4	40.3' - 40.7'	3,350	LIMESTONE

RECON. - SM 04/05/2022

DRILLING - CTL ENGINEERING, INC. 06/14/2022 - 06/22/2022

DRAWN - NKS 01/19/2023

REVIEWED - SM 01/19/2023

GEOTECHNICAL PROFILE - ROADWAY

DESIGN AGENCY
CTL ENGINEERING
2860 FISHER ROAD
COLUMBUS, OHIO 43204
PHONE: (614)276-8123
FAX: (614)276-6377

DESIGNER N.K.S

REVIEWER SM 01-19-23

PROJECT ID 110556

SUBSET 1 TOTAL 11

SHEET - TOTAL -

BRO-68-44.12

MODEL: Sheet PAPERSIZE: 17x11 (in.) DATE: 23-01-2023 TIME: 11:08:56 USER: hp
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SUMMARY OF SOIL TEST DATA
US - 68

EXPLORATION NO., STATION & OFFSET	FROM TO	SAMPLE ID	N_{60}	% REC	HP tsf	% GR	% CS	% FS	% SILT	% CLAY	LL	PL	PI	% WC	ODOT CLASS (GI)	ppm SO_4
B-001-0-22	01.00-02.50	SS-1	22	100	4.50	10	7	12	35	36	35	19	16	8	A-6b (10)	<100
STA. 142+00, 6' RT.	02.50-04.00	SS-2	37	67	2.75	18	6	9	29	38	38	19	16	16	A-6b (9)	-
LATITUDE = 39.225085	04.00-05.50	SS-3	15	44	2.75	SAME AS SS-2								12	A-6b (VISUAL)	-
LONGITUDE = -83.910738	05.50-07.00	SS-4	13	56	-	SAME AS SS-2								15	A-6b (VISUAL)	-
FOR STRUCTURE BORINGS B-002-0-22 AND B-003-0-22, SEE BORING LOGS ON SHEETS 6 AND 7 RESPECTIVELY.																
B-004-0-22	01.00-02.50	SS-1	28	100	4.50	10	6	19	35	30	27	16	11	11	A-6a (6)	400
STA. 148+33, 6' RT.	02.50-04.00	SS-2	138	89	-	SILTSTONE, GRAY, SEVERELY WEATHERED, VERY WEAK								9	ROCK (VISUAL)	-
LATITUDE = 39.226823	04.00-05.50	SS-3	95	100	-	SAME AS SS-2								11	ROCK (VISUAL)	-
LONGITUDE = -83.910560	05.50-05.83	SS-4	50/4"	100	-	CLAYSTONE, GRAY, SEVERELY WEATHERED, VERY WEAK								9	ROCK (VISUAL)	-
B-004-1-22	01.00-02.50	SS-1	15	78	4.50	1	4	14	42	39	40	22	18	19	A-6b (11)	-
STA. 148+40, 83' RT.	03.50-05.00	SS-2	27	100	4.50	SAME AS SS-1								13	A-6b (VISUAL)	-
LATITUDE = 39.226778	06.00-07.50	SS-3	48	100	4.50	3	7	12	24	54	55	27	28	22	A-7-6 (18)	-
LONGITUDE = -83.910281	08.00-09.00	ST-4	-	100	-	3	5	6	43	43	41	22	19	-	A-7-6 (12)	-
	11.00-12.50	SS-5	33	78	2.25	32	9	4	18	37	42	24	18	21	A-7-6 (7)	-
	13.50-15.00	SS-6	113	100	3.75	CLAYSTONE, GRAY, HIGHLY WEATHERED, VERY WEAK								12	ROCK (VISUAL)	-
	16.00-16.80	SS-7	20/50/4"	100	-	SHALE, GRAY, SEVERELY WEATHERED, VERY WEAK								9	ROCK (VISUAL)	-

SUMMARY OF SOIL TEST DATA
HISTORIC BORINGS US - 68

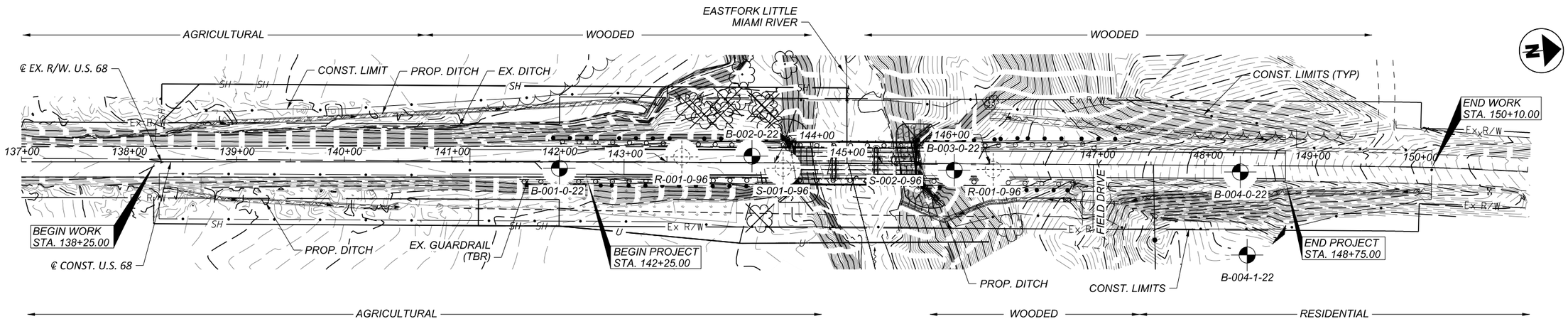
EXPLORATION NO., STATION & OFFSET	FROM TO	SAMPLE ID	N	% REC	% GR	% CS	% FS	% SILT	% CLAY	LL	PI	% WC	ODOT CLASS (GI)
R-001-0-96	01.15-02.65	SS-1	8	89	6	7	20	31	36	26	11	15	A-6a
STA. 143+13.7, 5' LT.	04.75-06.25	SS-2	5	89	SAME AS SS-1							22	A-6a
R-002-0-96	01.15-02.65	SS-1	16	100	9	11	19	28	33	-	-	12	A-6a
STA. 146+03.3, 5' RT.	04.75-06.25	SS-2	22	100	SAME AS SS-1							10	A-6a

FOR HISTORIC STRUCTURE BORINGS S-001-0-96 AND S-002-0-96, SEE BORING LOGS ON SHEET 8.

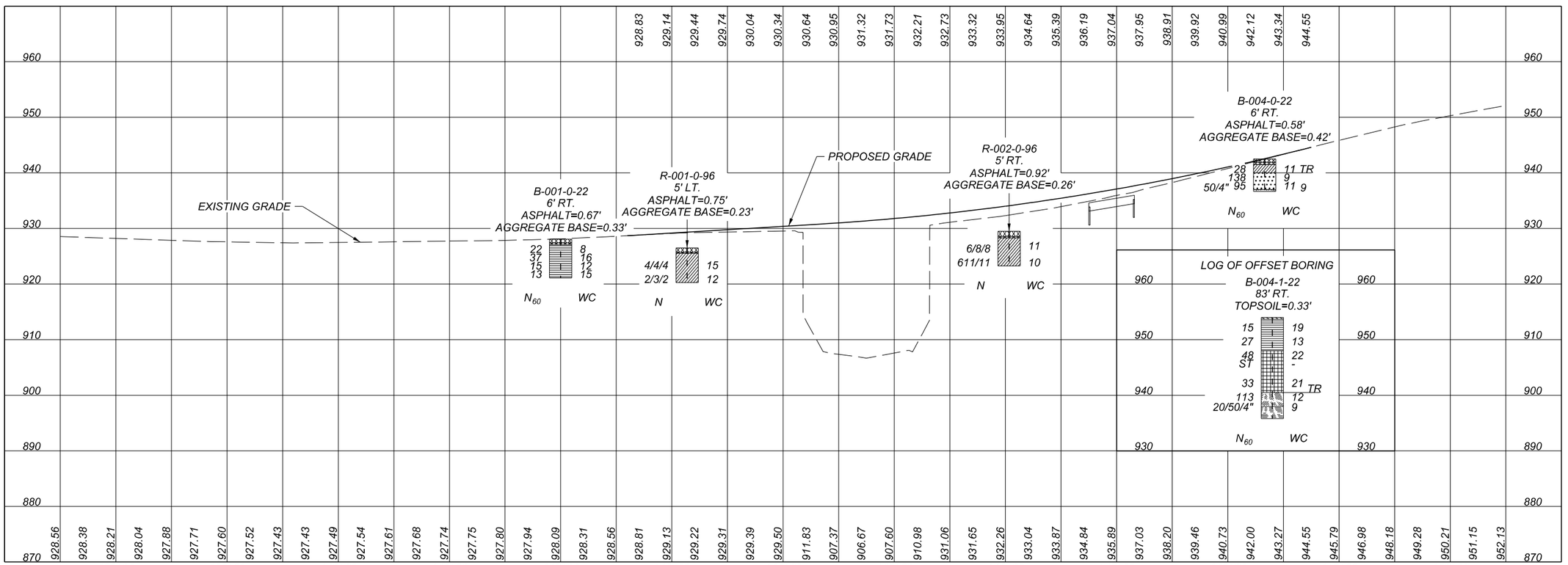
DESIGN AGENCY
CTL ENGINEERING
8800 LYRA DRIVE, 450
COLUMBUS, OHIO 43204
PHONE:(614)276-8123
FAX:(614)276-8377

DESIGNER N.K.S
REVIEWER SM 01-19-23
PROJECT ID 110556
SUBSET 2 TOTAL 11
SHEET P.0 TOTAL 0

GEOTECHNICAL PROFILE - ROADWAY
SUMMARY OF SOIL TEST DATA



NOTE : SEE SHEET 4 OF 11 FOR BORINGS B-002-0-22, B-003-0-22, S-001-0-96 AND S-002-0-96 SOIL PROFILES.



BRO-68-44.12

MODEL: Plan Drawing PAPERSIZE: 17x11(in) DATE: 20-01-2023 TIME: 16:01:53 USER: hp
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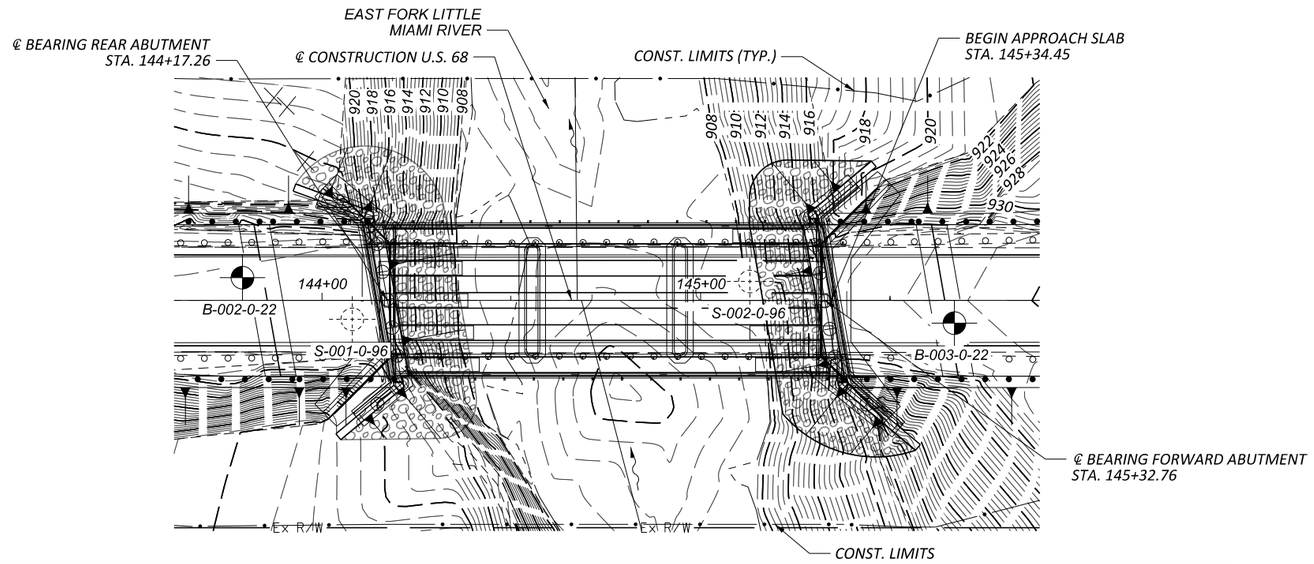
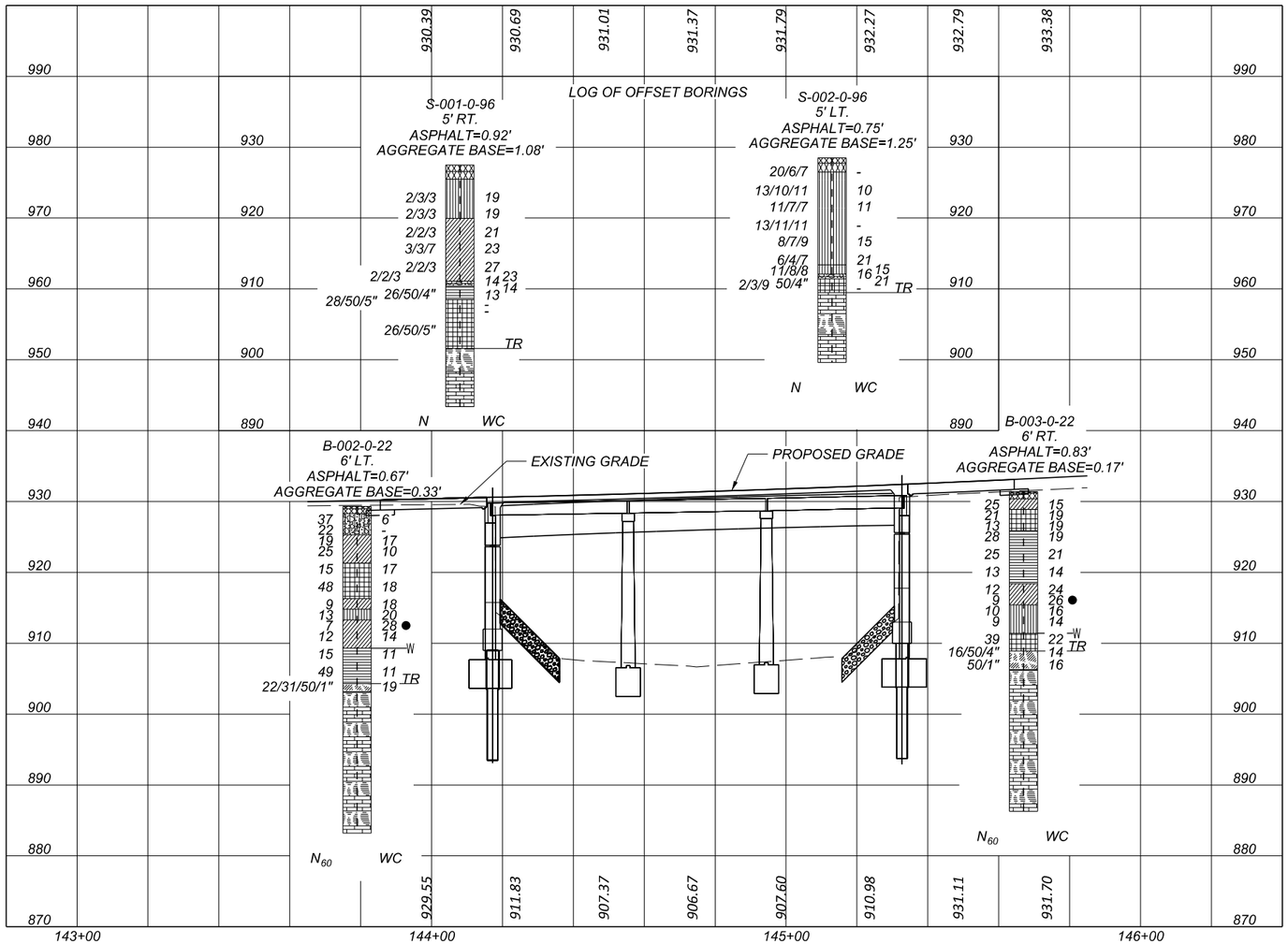
HORIZONTAL SCALE IN FEET
0 25 50 100

GEOTECHNICAL PROFILE - ROADWAY
STA. 137+00.00 TO STA. 151+00.00

DESIGN AGENCY
CTL ENGINEERING
2860 FISHER ROAD
COLUMBUS, OHIO 43204
PHONE: (614)276-8123
FAX: (614)276-6377

DESIGNER	N.K.S
REVIEWER	SM 01-19-23
PROJECT ID	110556
SUBSET	3
TOTAL	11
SHEET	P.0
TOTAL	0





HORIZONTAL SCALE IN FEET
0 10 20 40

GEOTECHNICAL PROFILE - ROADWAY
BRIDGE NO. - BRO-68-4412
U.S. 68 OVER EAST FORK LITTLE MIAMI RIVER

DESIGN AGENCY
GTL ENGINEERING
2860 FISHER ROAD
COLUMBUS, OHIO 43204
PHONE: (614)276-8123
FAX: (614)276-6377

DESIGNER	N.K.S
REVIEWER	SM 01-19-23
PROJECT ID	110556
SUBSET / TOTAL	4 / 11
SHEET / TOTAL	P.0 / 0

BRO-68-44.12

MODEL: PLAN ALT 4 PAPERSIZE: 17x11 (in.) DATE: 20-01-2023 TIME: 16:03:32 USER: hp
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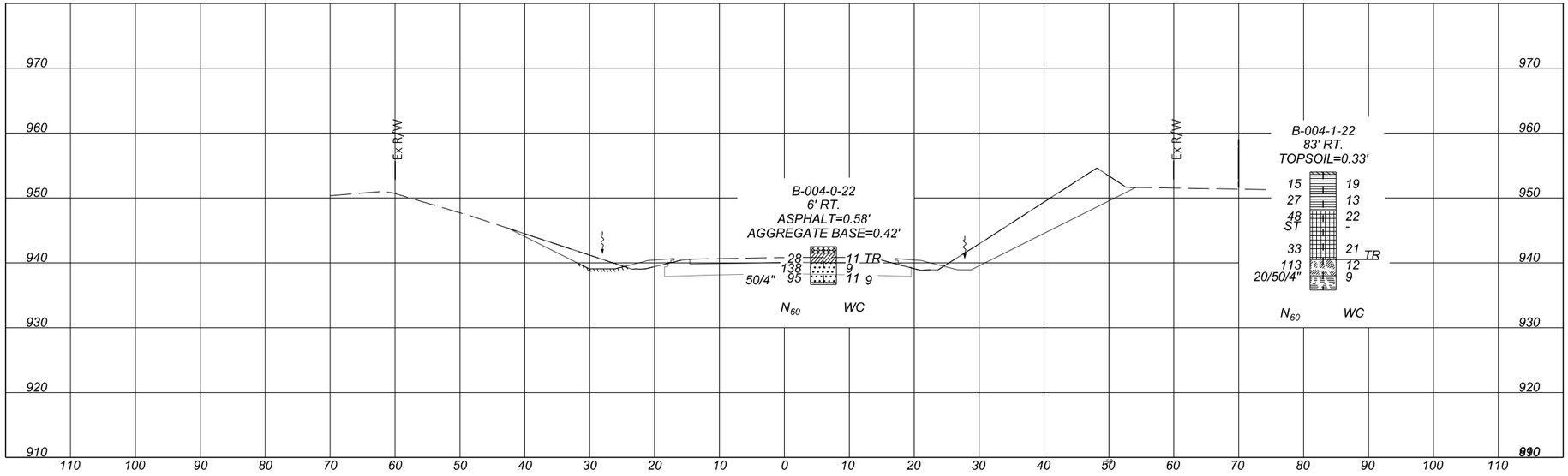
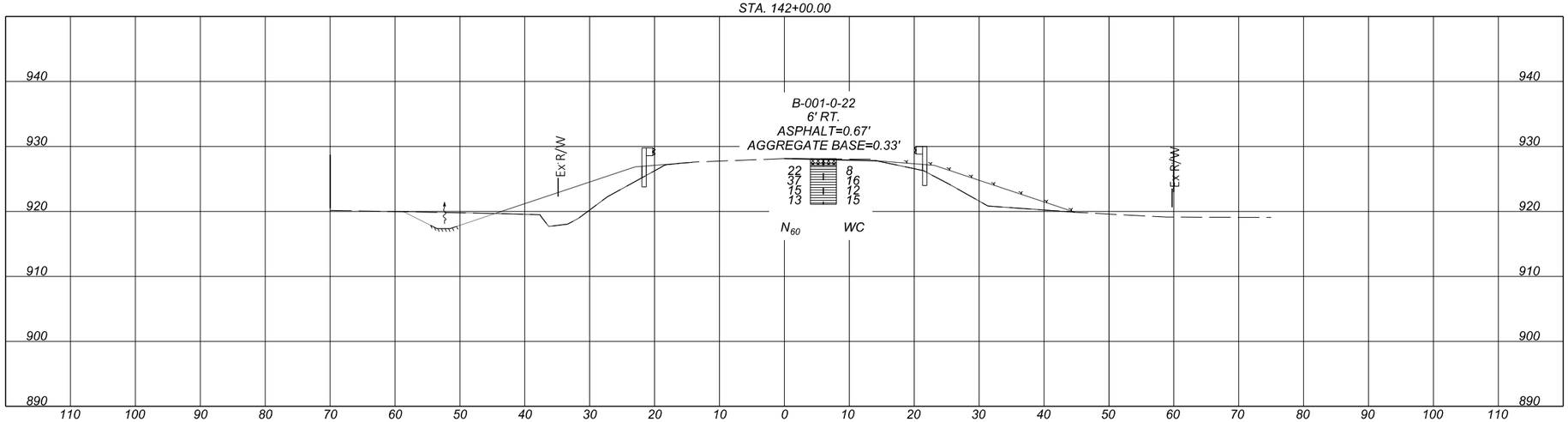
STA. 148+00.00



STA. 142+00.00



HORIZONTAL SCALE IN FEET
0 25 50 100

GEOTECHNICAL PROFILE - ROADWAY
CROSS SECTION STA. 142+00.00 AND STA. 148+00.00

DESIGN AGENCY

GTL ENGINEERING INC
2860 FISHER ROAD
COLUMBUS, OHIO 43204
PHONE: (614)276-8123
FAX: (614)276-6377

DESIGNER	N.K.S
REVIEWER	SM 01-19-23
PROJECT ID	110556
SUBSET / TOTAL	5 / 11
SHEET / TOTAL	P.0 / 0

BRO-68-44.12

MODEL: 142+00.00 Drawing Model PAPERSIZE: 17x11(in.) DATE: 20-01-2023 TIME: 16:05:18 USER: hp
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BRO-68-44.12

MODEL: Sheet PAPERSIZE: 11x17 (in.) DATE: 20-01-2023 TIME: 16:07:05 USER: hp
D:\Drop Box\CTL 2023\January\Dept 05\COL\Shahed\22050029COL_ODOT\Mod_20.01.23\110556ZL001.dgn

PROJECT: BRO-68-44.12	DRILLING FIRM / OPERATOR: CTL / TOM	DRILL RIG: CME 45 509	STATION / OFFSET: 143+79, 6' LT.	EXPLORATION ID B-002-0-22
TYPE: BRIDGE	SAMPLING FIRM / LOGGER: CTL / TOM	HAMMER: CME AUTOMATIC	ALIGNMENT: U.S. 68	
PID: 110556 SFN:	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 8-5-20	ELEVATION: 929.3 (MSL) EOB: 46.1 ft.	PAGE 1 OF 1
START: 6-15-22 END: 6-15-22	SAMPLING METHOD: SPT / NQ2	ENERGY RATIO (%): 89.3	LAT / LONG: 39.225641, -83.910727	

MATERIAL DESCRIPTION AND NOTES	ELEV. 929.3	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	SO4 ppm	BACK FILL
ASPHALT, (8")	929.0																		
AGGREGATE BASE, (4")	928.3																		
DENSE, BROWN, **GRAVEL AND STONE FRAGMENTS WITH SAND AND SILT**, LITTLE CLAY, (FILL), DAMP @2.5'; NO RECOVERY	925.3		8 11 14	37	100	SS-1	4.50	52	13	9	15	11	20	14	6	6	A-2-4 (0)	<100	
			8 7 8	22	0	SS-2	-	-	-	-	-	-	-	-	-	-	A-2-4 (V)	-	
VERY STIFF, BROWN, **SILT AND CLAY**, "AND" GRAVEL, TRACE SAND, (FILL), DAMP @5.5'; STIFF	921.3		8 7 6	19	67	SS-3	3.00	41	5	5	23	26	32	19	13	17	A-6a (4)	-	
			6 6 11	25	33	SS-4	1.50	-	-	-	-	-	-	-	-	10	A-6a (V)	-	
STIFF, BROWN, **CLAY**, SOME SILT, SOME GRAVEL, TRACE SAND, DAMP @10.5'; VERY STIFF	916.3		4 5 5	15	78	SS-5	1.75	26	4	5	23	42	41	23	18	17	A-7-6 (9)	-	
			3 17 15	48	67	SS-6	3.00	-	-	-	-	-	-	-	-	18	A-7-6 (V)	-	
STIFF, GRAY, **SILT AND CLAY**, LITTLE GRAVEL, LITTLE SAND, DAMP	914.8		3 3 3	9	100	SS-7	-	19	6	10	24	41	34	21	13	18	A-6a (7)	-	
STIFF, GRAY, **SANDY SILT**, LITTLE CLAY, TRACE GRAVEL, MOIST	913.3		4 4 5	13	100	SS-8	-	8	5	26	39	22	27	19	8	20	A-4a (5)	-	
MEDIUM STIFF, GRAY, **SILT AND CLAY**, SOME SAND, LITTLE GRAVEL, MOIST	909.3	W 909.3	2 2 3	7	67	SS-9	-	10	9	22	26	33	30	18	12	28	A-6a (6)	-	
			3 3 5	12	100	SS-10	-	-	-	-	-	-	-	-	-	14	A-6a (V)	-	
STIFF, BROWN AND BLACK, **SILTY CLAY**, SOME SAND, LITTLE GRAVEL, TRACE ORGANICS, MOIST @22.5'; HARD, CONTAINS CLAYSTONE FRAGMENTS	904.3	TR	3 5 5	15	67	SS-11	1.75	-	-	-	-	-	-	-	-	11	A-6b (V)	-	
			28 18 15	49	100	SS-12	4.50	-	-	-	-	-	-	-	-	11	A-6b (V)	-	
CLAYSTONE, GRAY, HIGHLY WEATHERED, VERY WEAK, (SOIL-LIKE).	903.2		22 31 50/1"	-	92	SS-13	4.00	-	-	-	-	-	-	-	-	19	Rock (V)	-	
INTERBEDDED SHALE (70%) AND LIMESTONE (30%), RQD 48%, REC. 95%; **SHALE**, GRAY, HIGHLY WEATHERED, VERY WEAK, FRIABLE, CALCAREOUS, ARGILLACEOUS, (RQD 41%, REC 68%); **LIMESTONE**, GRAY, SLIGHTLY WEATHERED, VERY STRONG, (RQD 7%, REC 27%).			46		88	NQ2-1											CORE		
			50		100	NQ2-2											CORE		
			28		97	NQ2-3											CORE		
	883.2	EOB	67		97	NQ2-4											CORE		

NOTES: CAVED AT 21.3'

ABANDONMENT METHODS, MATERIALS, QUANTITIES: AUGER CUTTINGS; BENTONITE POWDER

STANDARD ODOT LOG W/ SULFATES (11 X 17) - OH DOT.GDT - 17-1-23 14:54 - G:\2023\JANUARY\13\22050029COL\22050029COL_V1.GPJ

DESIGN AGENCY	DESIGNER	PROJECT ID	SUBSET / TOTAL	SHEET / TOTAL
ENGINEERING LLC 2060 KENNY ROAD COLUMBUS, OHIO 43204 PHONE: (614)276-8123 FAX: (614)276-4377	N.K.S	110556	6 / 11	- / -
	REVIEWER SM 01-19-23			

GEOTECHNICAL PROFILE - ROADWAY
BRIDGE NO. BRO-68-44.12 OVER EAST FORK LITTLE MIAMI RIVER
BORING LOG B-002-0-22

BRO-68-44.12

MODEL: Sheet PAPERSIZE: 11x17 (in.) DATE: 20-01-2023 TIME: 16:09:50 USER: hp
D:\Drop Box\CTL 2023\January\Dept 05\COL\Shahed\22050029COL_ODOT\Mod_20.01.23\110556ZL002.dgn

PROJECT: BRO-68-44.12	DRILLING FIRM / OPERATOR: CTL / TOM	DRILL RIG: CME 45 509	STATION / OFFSET: 145+67, 6' RT.
TYPE: BRIDGE	SAMPLING FIRM / LOGGER: CTL / TOM	HAMMER: CME AUTOMATIC	ALIGNMENT: U.S. 68
PID: 110556 SFN:	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 8-5-20	ELEVATION: 931.4 (MSL) EOB: 45.1 ft.
START: 6-15-22 END: 6-15-22	SAMPLING METHOD: SPT / NQ2	ENERGY RATIO (%): 89.3	LAT / LONG: 39.226007, -83.910656

EXPLORATION ID: B-003-0-22 — PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 931.4	DEPTHS
ASPHALT, 10"	931.2	
AGGREGATE BASE, 2"	930.4	
HARD, BROWN, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, (FILL), DAMP	928.9	
VERY STIFF, BROWN, **CLAY**, SOME SILT, LITTLE GRAVEL, TRACE SAND, (FILL), DAMP @4.0'; STIFF	925.9	
STIFF, BROWN, **SILTY CLAY**, SOME GRAVEL, LITTLE SAND, DAMP @8.0'; GRAY, MOIST @10.5'; MEDIUM STIFF, DAMP	918.4	
STIFF, GRAY, **SILT AND CLAY**, SOME SAND, TRACE GRAVEL, MOIST @14.5'; MEDIUM STIFF, WET	915.4	
STIFF, GRAY, **SANDY SILT**, SOME CLAY, LITTLE GRAVEL, DAMP @17.5'; VERY STIFF	911.4	W 911.4
HARD, GRAY, **CLAY**, SOME SILT, TRACE SAND, TRACE GRAVEL, DAMP	908.9	TR
CLAYSTONE, GRAY, HIGHLY WEATHERED, VERY WEAK, FRIABLE.	906.3	
INTERBEDDED SHALE (70%) AND LIMESTONE (30%), RQD 73%, REC. 97%; **SHALE**, GRAY, SLIGHTLY WEATHERED, VERY WEAK, FRIABLE, CALCAREOUS, (RQD 60%, REC 71%); **LIMESTONE**, GRAY, SLIGHTLY WEATHERED, VERY STRONG, (RQD 13%, REC 26%).	886.3	EOB (45)

SPT/RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)	SO4 ppm
7 7 10	25	67	SS-1	4.50	9	10	7	28	46	36	21	15	15	A-6a (10)	<100
12 7 7	21	78	SS-2	2.50	12	3	3	26	56	46	24	22	19	A-7-6 (14)	-
5 5 4	13	78	SS-3	1.75	-	-	-	-	-	-	-	-	19	A-7-6 (V)	-
9 9 10	28	56	SS-4	1.00	22	9	7	24	38	38	21	17	19	A-6b (8)	-
4 7 10	25	89	SS-5	1.75	-	-	-	-	-	-	-	-	21	A-6b (V)	-
4 4 5	13	100	SS-6	0.75	18	9	7	21	45	40	21	19	14	A-6b (10)	-
3 4 4	12	100	SS-7	1.75	3	3	18	37	39	32	20	12	24	A-6a (9)	-
3 3 3	9	100	SS-8	0.50	2	3	27	39	29	29	18	11	26	A-6a (7)	-
3 3 4	10	100	SS-9	1.25	11	9	28	25	27	27	17	10	16	A-4a (3)	-
3 3 3	9	67	SS-10	2.25	-	-	-	-	-	-	-	-	14	A-4a (V)	-
8 13 13	39	100	SS-11	4.50	9	5	3	24	59	45	25	20	22	A-7-6 (13)	-
16 50/4"	-	100	SS-12	4.50	-	-	-	-	-	-	-	-	14	Rock (V)	-
50/1"	-	100	SS-13	-	-	-	-	-	-	-	-	-	16	Rock (V)	-
52		97	NQ2-1											CORE	
72		97	NQ2-2											CORE	
88		95	NQ2-3											CORE	
80		100	NQ2-4											CORE	

NOTES: CAVED AT 20.2'

ABANDONMENT METHODS, MATERIALS, QUANTITIES: AUGER CUTTINGS; BENTONITE POWDER

STANDARD ODOT LOG W/ SULFATES (11 X 17) - OH DOT.GDT - 17-1-23 14:54 - G:\2023\JANUARY\13\22050029COL\22050029COL_V1.GPJ

DESIGN AGENCY: CTL ENGINEERING INC. 2860 FISHER ROAD COLUMBUS, OHIO 43204 PHONE: (614)276-8123 FAX: (614)276-6377

DESIGNER: N.K.S — REVIEWER: SM 01-19-23 — PROJECT ID: 110556 — SUBSET 7 TOTAL 11 — SHEET - TOTAL -

GEOTECHNICAL PROFILE - ROADWAY
BRIDGE NO. BRO-68-44.12 OVER EAST FORK LITTLE MIAMI RIVER
BORING LOG B-003-0-22

MODEL: Sheet PAPERSIZE: 11x17 (in.) DATE: 20-01-2023 TIME: 16:26:25 USER: hp
D:\Drop Box\CTL 2023\January\Dept 05\COL\Shahed\22050029COL_ODOT\Mod_20.01.23\110556ZL003.dgn

BORING LOG: S-001-0-96

STATION AND OFFSET: 1+638, 1.5M RT
SURFACE ELEVATION: 282.7 M
WATER ENCOUNTERED: N/A *

DATE STARTED: 10/2/96
DATE FINISHED: 10/2/96
SAMPLER TYPE: HSA/RC

ELEV.	SAMPLE NUMBER	BLOWS PER 15 cm	REC (%)	DEPTH	SOIL DESCRIPTION	WC	ATT LIMITS LL	ATT LIMITS PI	PHYSICAL CHARACTERISTIC % AGG	% CS	% FS	% SI	% CL	ODOT CLASS
					28 CM – ASPHALT 0.3M									
					33 CM – SAND AND GRAVEL BASE 0.6M									
				1	BROWN SILTY SAND, SOME CLAY, TRACE GRAVEL									
281.1	SS-1	2/3/3	100			19	25	10	3	7	30	30	30	A-4a
280.4	SS-2	2/3/3	100	2		19								VISUAL
					2.4M									
					BROWN CLAYEY SILT, LITTLE TO SOME SAND									
279.6	SS-3	2/2/3	100	3		21								VISUAL
278.9	SS-4	3/3/7	100	4		23								VISUAL
278.1	SS-5	2/2/3	100			27	29	12	0	1	16	52	31	A-6a
277.7	SS-6	2/2/3	100	5		23			0	1	26	43	30	VISUAL
					5.0M									
277.5	SS-7A				BROWNISH-GRAY SAND, SOME GRAVEL, SOME CLAY, TRACE SILT 5.2M	14			24	18	32	6	20	VISUAL
277.2	SS-7B	8/21/24	83			14								VISUAL
276.9	SS-8	26/50~4"	39	6	BROWNISH-GRAY SILTY CLAY, LITTLE SAND, LITTLE GRAVEL 5.8M	13	37	19	14	8	5	22	51	A-6b
276.5	SS-9	28/50~5"	56		GRAY INDURATED CLAY/HIGHLY WEATHERED SHALE									VISUAL
275.2	SS-10	26/50~5"	56	7	7.9M									VISUAL
	RC-1		33	8	SHALE / INDURATED CLAY (70%), GRAY, HIGHLY WEATHERED, SOFT; INTERBEDDED LIMESTONE (30%), GRAY, MODERATELY HARD, HIGHLY BROKEN, FOSSILIFEROUS -CORE LOSS = 67% -RQD = 0%									
273.8					8.9M									
	RC-2		33	9	LIMESTONE (75%); GRAY, MODERATELY HARD, HIGHLY BROKEN, FOSSILIFEROUS; INTERBEDDED SHALE / INDURATED CLAY (25%); GRAY, HIGHLY WEATHERED, SOFT -CORE LOSS = 67% -RQD = 0%									
272.3				10										

BOTTOM OF BORING = 10.4M

BORING LOG: S-002-0-96

STATION AND OFFSET: 1+670, 1.5M LT
SURFACE ELEVATION: 283.0 M
WATER ENCOUNTERED: N/A *

DATE STARTED: 10/2/96
DATE FINISHED: 10/2/96
SAMPLER TYPE: HSA/RC

ELEV.	SAMPLE NUMBER	BLOWS PER 15 cm	REC (%)	DEPTH	SOIL DESCRIPTION	WC	ATT LIMITS LL	ATT LIMITS PI	PHYSICAL CHARACTERISTIC % AGG	% CS	% FS	% SI	% CL	ODOT CLASS
					23 CM – ASPHALT 0.2M									
					38 CM – SAND AND GRAVEL BASE 0.6M									
282.2	SS-1	20/6/7	17	1	BROWN SILTY SAND, SOME CLAY, TRACE GRAVEL									VISUAL
281.4	SS-2	13/10/11	78			10	23	9	10	11	21	25	33	A-4a
280.7	SS-3	11/7/7	67	2		11	22	9	10	11	24	25	30	A-4a
279.9	SS-4	13/11/11	11	3										VISUAL
279.2	SS-5	8/7/9	89	4		15								VISUAL
278.4	SS-6	6/4/7	44		BROWN CLAYEY SAND, TRACE SILT, TRACE GRAVEL 4.6M	21			7	6	29	24	34	VISUAL
278.0	SS-7	11/8/8	67	5	BROWN SAND, SOME CLAY, LITTLE GRAVEL, TRACE SILT 5.0M	15	22	10	4	17	42	6	31	A-4a
277.8	SS-8A				BROWN CLAY, LITTLE SAND, LITTLE SILT, TRACE GRAVEL 5.2M	16			18	17	32	2	31	VISUAL
277.5	SS-8B	2/3/9	67		5.5M	21	47	29	7	7	11	10	65	A-7-6
277.2	SS-9	50~4"	22		GRAY LIMESTONE FRAGMENTS, LITTLE INDURATED CLAY 5.8M									VISUAL
	RC-1		39	6	LIMESTONE; GRAY, MODERATELY HARD, HIGHLY BROKEN, FOSSILIFEROUS -CORE LOSS = 61% -RQD = 0%									
276.3					6.7M									
	RC-2		44	7	SHALE / INDURATED CLAY (75%); GRAY, HIGHLY WEATHERED, SOFT; INTERBEDDED LIMESTONE (25%), GRAY, MODERATELY HARD, HIGHLY BROKEN, FOSSILIFEROUS -CORE LOSS = 56% -RQD = 0%									
275.4					7.6M									
	RC-3		63	8	LIMESTONE (55%); GRAY, MODERATELY HARD, HIGHLY BROKEN, FOSSILIFEROUS, INTERBEDDED SHALE / INDURATED CLAY (45%); GRAY, HIGHLY WEATHERED, SOFT -CORE LOSS = 37% -RQD = 0%									
274.2														

BOTTOM OF BORING = 8.8M

DESIGN AGENCY
ENGINEERING
2000 HENDERSON ROAD
COLUMBUS, OHIO 43204
PHONE: (614)276-8123
FAX: (614)276-8377

DESIGNER N.K.S
REVIEWER SM 01-19-23
PROJECT ID 110556
SUBSET 8 TOTAL 11
SHEET - TOTAL -

GEOTECHNICAL PROFILE - ROADWAY
BRIDGE NO. BRO-68-44.12 OVER EAST FORK LITTLE MIAMI RIVER
BORING LOGS S-001-0-96 AND S-002-0-96

B-002-0-22

Run #	Depth (ft)		Recovery (in)		RQD (in)	
NQ-1	26.1	31.1	53/60	88%	27.5/60	46%
NQ-2	31.1	36.1	60/60	100%	30/60	50%

B-002-0-22

Run #	Depth (ft)		Recovery (in)		RQD (in)	
NQ-3	36.1	41.1	58/60	97%	16.5/60	28%
NQ-4	41.1	46.1	58/60	97%	40/60	67%

DESIGNER N.K.S
REVIEWER SM 01-19-23
PROJECT ID 110556
SUBSET 9 TOTAL 11
SHEET - TOTAL -

ENGINEERING
COLUMBUS, OHIO 43204
PHONE: (614)276-8123
FAX: (614)276-6377

DESIGN AGENCY

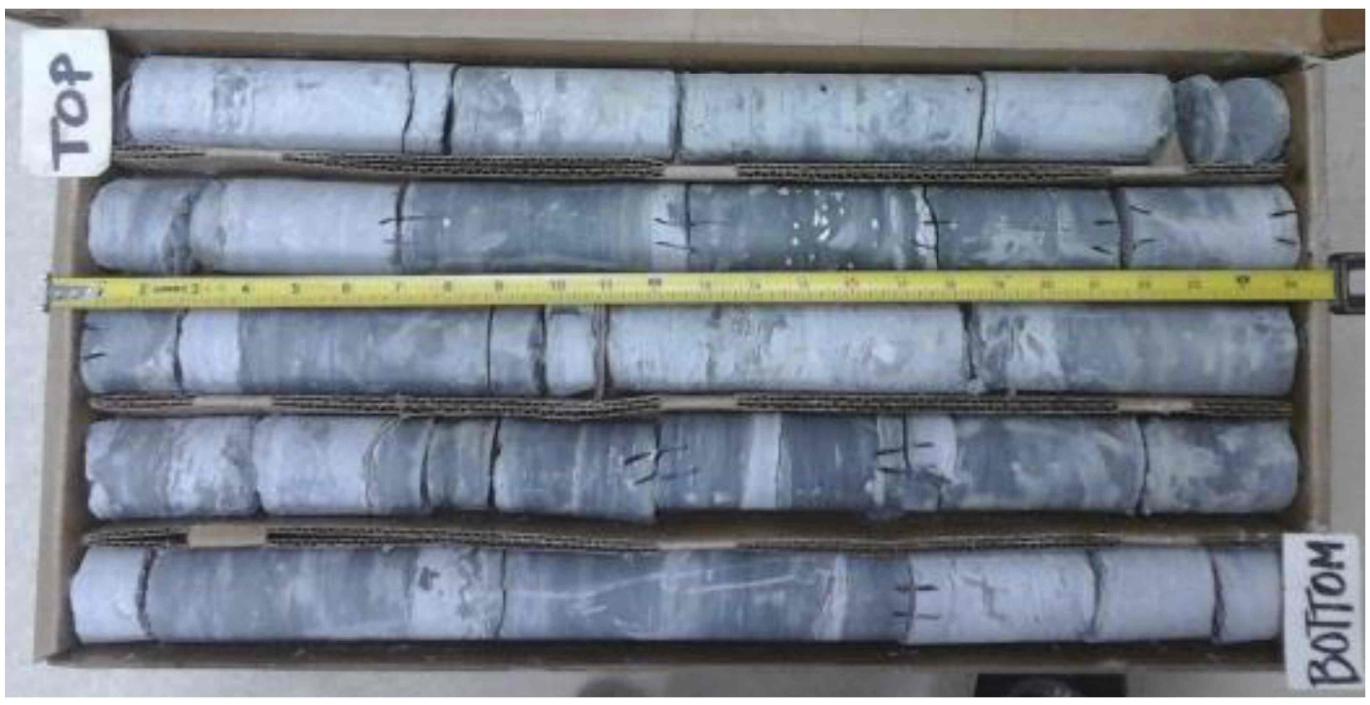
GEOTECHNICAL PROFILE - ROADWAY

ROCK CORE PHOTO FOR B-002-0-22

B-003-0-22

Run #	Depth (ft)		Recovery (in)		RQD (in)	
NQ-1	25.1	30.1	58/60	97%	31/60	52%
NQ-2	30.1	35.1	58/60	97%	43/60	72%

B-003-0-22



Run #	Depth (ft)		Recovery (in)		RQD (in)	
NQ-3	35.1	40.1	57/60	95%	53/60	88%
NQ-4	40.1	45.1	60/60	100%	48/60	80%

DESIGN AGENCY
GTL ENGINEERING
2200 FRANKLIN ROAD
COLUMBUS, OHIO 43204
PHONE: (614)276-8123
FAX: (614)276-8377

DESIGNER N.K.S
REVIEWER SM 01-19-23
PROJECT ID 110556
SUBSET 10 TOTAL 11
SHEET - TOTAL -

GEOTECHNICAL PROFILE - ROADWAY

ROCK CORE PHOTO FOR B-003-0-22

UNCONSOLIDATED UNDRAINED TRIAXIAL TEST ON COHESIVE SOILS
AASHTO 296 & ASTM D 2850

Avg. Sample Height (in.):	5.7877
Avg. Sample Diameter (in.):	2.8650
Height-to-diameter ratio:	2.02
Wet Density (pcf):	131.6
Dry Density (pcf):	112.2
Void Ratio:	0.474
Specific Gravity (assumed):	2.7
Saturation (%):	96.6
Moisture Content (%):	17.3
Cross Sectional Area (ft^2):	0.04
Volume (ft^3):	0.02
Confining Pressure (psf):	1008
Rate of Axial Strain (%/min):	0.2073
Compressive Strength (psf):	8361
Ultimate Deviator Stress (psf):	8361
Minor Principal Stress at Failure (psf):	1008
Major Principal Stress at Failure (psf):	9369
Failure Criterion:	Maximum Deviator Stress

POST SHEAR

CTL ENGINEERING, INC.
2860 Fisher Road Columbus, Ohio 43204

Client:	Prime AE Group Inc
Project:	BRO-68-44.12 Bridge Replacement
Location:	Brown County, Ohio
Project No.	22050029COL
County, Rt. & Sec.:	BRO-68-44.12
Station & Offset:	NA
Field No.:	NA
Sample ID:	B-004-1-22, ST-4, 8'-10'
Lab Code No.	NA
Date Set-up:	7/11/22
Date Sheared:	7/11/22
Reviewed by:	SM

Grading (ASTM D422)

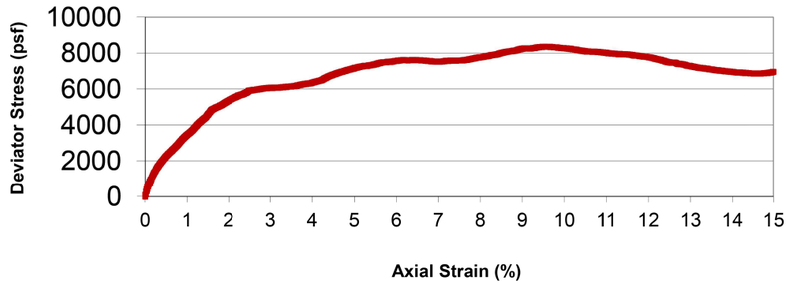
% Agg:	3
% Sand:	11
% Silt:	43
% Clay:	43

Atterberg Limits (ASTM D 4318)

L.L.:	41
P.L.:	22
P.I.:	19

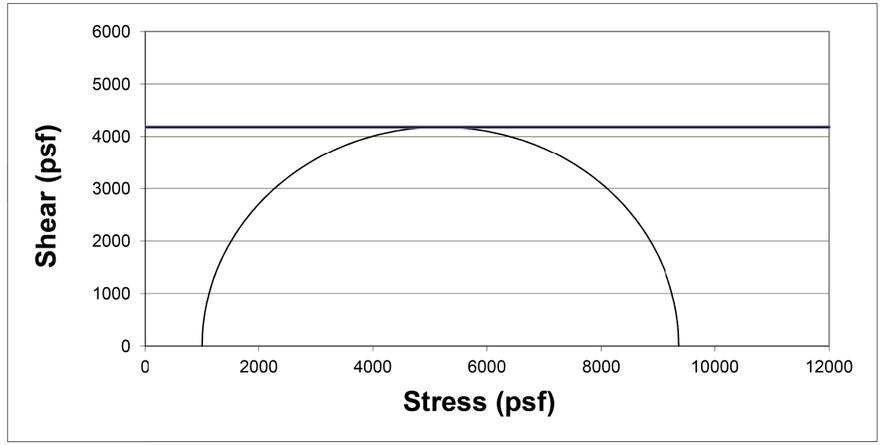
Visual Description: A-7-6(12)

Deviator Stress vs. Axial Strain



Mohr Circle Total Stress

CLIENT:	Prime AE Group Inc	Sample ID:	B-004-1-22, ST-4, 8'-10'
PROJECT:	BRO-68-44.12 Bridge Replacement	Confining Pressure (psf):	1008
LOCATION:	Brown County, Oh	Cohesion (psf):	4180
PROJECT #:	22050029COL		



GEOTECHNICAL PROFILE - ROADWAY
COMPRESSIVE STRENGTH TEST RESULT

DESIGN AGENCY
CTL ENGINEERING
2860 FISHER ROAD
COLUMBUS, OHIO 43204
PHONE: (614)276-8123
FAX: (614)276-6377

DESIGNER: N.K.S
REVIEWER: SM 01-19-23
PROJECT ID: 110556
SUBSET: 11 TOTAL: 11
SHEET: - TOTAL: -

BRO-68-44.12

APPENDIX B
TEST BORING RECORDS

PROJECT: BRO-68-44.12	DRILLING FIRM / OPERATOR: CTL / TOM	DRILL RIG: CME 45 509	STATION / OFFSET: 142+00, 6' RT.
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: CTL / TOM	HAMMER: CME AUTOMATIC	ALIGNMENT: U.S. 68
PID: 110556 SFN:	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: 8/5/20	ELEVATION: 928.1 (MSL) EOB: 7.0 ft.
START: 6/14/22 END: 6/14/22	SAMPLING METHOD: SPT	ENERGY RATIO (%): 89.3	LAT / LONG: 39.225085, -83.910738

EXPLORATION ID B-001-0-22

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	SO4 ppm	BACK FILL
ASPHALT, (8")	928.1																		
AGGREGATE BASE, (4")	927.4																		
HARD, BROWN, **SILTY CLAY**, LITTLE SAND, LITTLE GRAVEL, (FILL), DAMP	927.1	1	6 6 9	22	100	SS-1	4.50	10	7	12	35	36	35	19	16	8	A-6b (10)	<100	
@2.5'; VERY STIFF		2																	
		3	11 11 14	37	67	SS-2	2.75	18	6	9	29	38	35	19	16	16	A-6b (9)	-	
		4	10 4 6	15	44	SS-3	2.75	-	-	-	-	-	-	-	-	12	A-6b (V)	-	
@5.5'; STIFF		5																	
		6	5 4 5	13	56	SS-4	-	-	-	-	-	-	-	-	-	15	A-6b (V)	-	
	921.1	EOB 7																	

NOTES: CAVED AT 3.7'

ABANDONMENT METHODS, MATERIALS, QUANTITIES: AUGER CUTTINGS; BENTONITE POWDER

PROJECT: BRO-68-44.12	DRILLING FIRM / OPERATOR: CTL / TOM	DRILL RIG: CME 45 509	STATION / OFFSET: 143+79, 6' LT.	EXPLORATION ID B-002-0-22
TYPE: BRIDGE	SAMPLING FIRM / LOGGER: CTL / TOM	HAMMER: CME AUTOMATIC	ALIGNMENT: U.S. 68	
PID: 110556 SFN:	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 8/5/20	ELEVATION: 929.3 (MSL) EOB: 46.1 ft.	PAGE 1 OF 2
START: 6/15/22 END: 6/15/22	SAMPLING METHOD: SPT / NQ2	ENERGY RATIO (%): 89.3	LAT / LONG: 39.225641, -83.910727	

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	SO4 ppm	BACK FILL
ASPHALT, (8")	929.0																		
AGGREGATE BASE, (4")	928.3																		
DENSE, BROWN, **GRAVEL AND STONE FRAGMENTS WITH SAND AND SILT**, LITTLE CLAY, (FILL), DAMP @2.5'; NO RECOVERY	925.3		8 11 14	37	100	SS-1	4.50	52	13	9	15	11	20	14	6	6	A-2-4 (0)	<100	
			8 7 8	22	0	SS-2	-	-	-	-	-	-	-	-	-	-	A-2-4 (V)	-	
VERY STIFF, BROWN, **SILT AND CLAY**, "AND" GRAVEL, TRACE SAND, (FILL), DAMP @5.5'; STIFF	921.3		8 7 6	19	67	SS-3	3.00	41	5	5	23	26	32	19	13	17	A-6a (4)	-	
			6 6 11	25	33	SS-4	1.50	-	-	-	-	-	-	-	-	10	A-6a (V)	-	
STIFF, BROWN, **CLAY**, SOME SILT, SOME GRAVEL, TRACE SAND, DAMP @10.5'; VERY STIFF	916.3		4 5 5	15	78	SS-5	1.75	26	4	5	23	42	41	23	18	17	A-7-6 (9)	-	
			3 17 15	48	67	SS-6	3.00	-	-	-	-	-	-	-	-	18	A-7-6 (V)	-	
STIFF, GRAY, **SILT AND CLAY**, LITTLE GRAVEL, LITTLE SAND, DAMP	914.8		3 3 3	9	100	SS-7	-	19	6	10	24	41	34	21	13	18	A-6a (7)	-	
STIFF, GRAY, **SANDY SILT**, LITTLE CLAY, TRACE GRAVEL, MOIST	913.3		4 4 5	13	100	SS-8	-	8	5	26	39	22	27	19	8	20	A-4a (5)	-	
MEDIUM STIFF, GRAY, **SILT AND CLAY**, SOME SAND, LITTLE GRAVEL, MOIST	909.3	W 909.3	2 2 3	7	67	SS-9	-	10	9	22	26	33	30	18	12	28	A-6a (6)	-	
			3 3 5	12	100	SS-10	-	-	-	-	-	-	-	-	-	14	A-6a (V)	-	
STIFF, BROWN AND BLACK, **SILTY CLAY**, SOME SAND, LITTLE GRAVEL, TRACE ORGANICS, MOIST @22.5'; HARD, CONTAINS CLAYSTONE FRAGMENTS	904.3		3 5 5	15	67	SS-11	1.75	-	-	-	-	-	-	-	-	11	A-6b (V)	-	
			28 18 15	49	100	SS-12	4.50	-	-	-	-	-	-	-	-	11	A-6b (V)	-	
CLAYSTONE, GRAY, HIGHLY WEATHERED, VERY WEAK, (SOIL-LIKE).	903.2	TR	22 31 50/1"	-	92	SS-13	4.00	-	-	-	-	-	-	-	-	19	Rock (V)	-	
@26.3' TO 26.7'; Qu = 5,770 PSI			46		88	NQ2-1											CORE		

PID: 110556	SFN:	PROJECT: BRO-68-44.12	STATION / OFFSET: 143+79, 6' LT.	START: 6/15/22	END: 6/15/22	PG 2 OF 2	B-002-0-22

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	SO4 ppm	BACK FILL
INTERBEDDED SHALE (70%) AND LIMESTONE (30%), RQD 48%, REC. 95%; **SHALE**, GRAY, HIGHLY WEATHERED, VERY WEAK, FRIABLE, CALCAREOUS, ARGILLACEOUS, (RQD 41%, REC 68%); **LIMESTONE**, GRAY, SLIGHTLY WEATHERED, VERY STRONG, (RQD 7%, REC 27%). *(continued)*	899.3	31																	
		32																	
		33																	
		34	50		100	NQ2-2											CORE		
		35																	
		36																	
		37																	
		38																	
@39.3' TO 39.6'; Qu = 530 PSI		39	28		97	NQ2-3											CORE		
		40																	
		41																	
		42																	
		43																	
		44	67		97	NQ2-4											CORE		
		45																	
	883.2	EOB 46																	

NOTES: CAVED AT 21.3'

ABANDONMENT METHODS, MATERIALS, QUANTITIES: AUGER CUTTINGS; BENTONITE POWDER

PROJECT: BRO-68-44.12	DRILLING FIRM / OPERATOR: CTL / TOM	DRILL RIG: CME 45 509	STATION / OFFSET: 145+67, 6' RT.	EXPLORATION ID B-003-0-22
TYPE: BRIDGE	SAMPLING FIRM / LOGGER: CTL / TOM	HAMMER: CME AUTOMATIC	ALIGNMENT: U.S. 68	
PID: 110556 SFN:	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 8/5/20	ELEVATION: 931.4 (MSL) EOB: 45.1 ft.	PAGE 1 OF 2
START: 6/15/22 END: 6/15/22	SAMPLING METHOD: SPT / NQ2	ENERGY RATIO (%): 89.3	LAT / LONG: 39.226007, -83.910656	

MATERIAL DESCRIPTION AND NOTES	ELEV. 931.4	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	SO4 ppm	BACK FILL
ASPHALT, 10"	931.2																		
AGGREGATE BASE, 2"	930.4																		
HARD, BROWN, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, (FILL), DAMP	928.9		7 7 10	25	67	SS-1	4.50	9	10	7	28	46	36	21	15	15	A-6a (10)	<100	
VERY STIFF, BROWN, **CLAY**, SOME SILT, LITTLE GRAVEL, TRACE SAND, (FILL), DAMP			12 7 7	21	78	SS-2	2.50	12	3	3	26	56	46	24	22	19	A-7-6 (14)	-	
@4.0'; STIFF	925.9		5 5 4	13	78	SS-3	1.75	-	-	-	-	-	-	-	-	19	A-7-6 (V)	-	
STIFF, BROWN, **SILTY CLAY**, SOME GRAVEL, LITTLE SAND, DAMP			9 9 10	28	56	SS-4	1.00	22	9	7	24	38	38	21	17	19	A-6b (8)	-	
@8.0'; GRAY, MOIST			4 7 10	25	89	SS-5	1.75	-	-	-	-	-	-	-	-	21	A-6b (V)	-	
@10.5'; MEDIUM STIFF, DAMP	918.4		4 4 5	13	100	SS-6	0.75	18	9	7	21	45	40	21	19	14	A-6b (10)	-	
STIFF, GRAY, **SILT AND CLAY**, SOME SAND, TRACE GRAVEL, MOIST			3 4 4	12	100	SS-7	1.75	3	3	18	37	39	32	20	12	24	A-6a (9)	-	
@14.5'; MEDIUM STIFF, WET	915.4		3 3 3	9	100	SS-8	0.50	2	3	27	39	29	29	18	11	26	A-6a (7)	-	
STIFF, GRAY, **SANDY SILT**, SOME CLAY, LITTLE GRAVEL, DAMP			3 3 4	10	100	SS-9	1.25	11	9	28	25	27	27	17	10	16	A-4a (3)	-	
@17.5'; VERY STIFF	911.4	W 911.4	3 3 3	9	67	SS-10	2.25	-	-	-	-	-	-	-	-	14	A-4a (V)	-	
HARD, GRAY, **CLAY**, SOME SILT, TRACE SAND, TRACE GRAVEL, DAMP	908.9		8 13 13	39	100	SS-11	4.50	9	5	3	24	59	45	25	20	22	A-7-6 (13)	-	
CLAYSTONE, GRAY, HIGHLY WEATHERED, VERY WEAK, FRIABLE.	906.3	TR	16 50/4"	-	100	SS-12	4.50	-	-	-	-	-	-	-	-	14	Rock (V)	-	
INTERBEDDED SHALE (70%) AND LIMESTONE (30%), RQD 73%, REC. 97%; **SHALE**, GRAY, SLIGHTLY WEATHERED, VERY WEAK, FRIABLE, CALCAREOUS, (RQD 60%, REC 71%); **LIMESTONE**, GRAY, SLIGHTLY WEATHERED, VERY STRONG, (RQD 13%, REC 26%).			50/1"	-	100	SS-13	-	-	-	-	-	-	-	-	-	16	Rock (V)	-	
			52		97	NQ2-1											CORE		

PID: 110556	SFN:	PROJECT: BRO-68-44.12	STATION / OFFSET: 145+67, 6' RT.	START: 6/15/22	END: 6/15/22	PG 2 OF 2	B-003-0-22

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	SO4 ppm	BACK FILL
INTERBEDDED SHALE (70%) AND LIMESTONE (30%), RQD 73%, REC. 97%; **SHALE**, GRAY, SLIGHTLY WEATHERED, VERY WEAK, FRIABLE, CALCAREOUS, (RQD 60%, REC 71%); **LIMESTONE**, GRAY, SLIGHTLY WEATHERED, VERY STRONG, (RQD 13%, REC 26%). *(continued)* @33.3' TO 33.6'; Qu = 1,650 PSI	901.4	31 32 33 34 35	72		97	NQ2-2											CORE		
@40.3' TO 40.7'; Qu = 3,350 PSI		36 37 38 39 40	88		95	NQ2-3											CORE		
		41 42 43 44 45	80		100	NQ2-4											CORE		
	886.3	EOB																	

NOTES: CAVED AT 20.2'

ABANDONMENT METHODS, MATERIALS, QUANTITIES: AUGER CUTTINGS; BENTONITE POWDER

PROJECT: BRO-68-44.12	DRILLING FIRM / OPERATOR: CTL / TOM	DRILL RIG: CME 45 509	STATION / OFFSET: 148+33, 6' RT.
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: CTL / TOM	HAMMER: CME AUTOMATIC	ALIGNMENT: U.S. 68
PID: 110556 SFN:	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: 8/5/20	ELEVATION: 942.5 (MSL) EOB: 5.83 ft.
START: 6/14/22 END: 6/14/22	SAMPLING METHOD: SPT / ST	ENERGY RATIO (%): 89.3	LAT / LONG: 39.226823, -83.910560

EXPLORATION ID B-004-0-22

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	SO4 ppm	BACK FILL
	942.5																		
ASPHALT, 7"	941.9																		
AGGREGATE BASE, 5"	941.5																		
HARD, GRAY, **SILT AND CLAY**, SOME SAND, LITTLE GRAVEL, DAMP	940.0	1 2 TR	10 8 11	28	100	SS-1	4.50	10	6	19	35	30	27	16	11	11	A-6a (6)	400	
SILTSTONE, GRAY, SEVERLY WEATHERED, VERY WEAK, FRIABLE.		3	40 44 49	138	89	SS-2	-	-	-	-	-	-	-	-	-	9	Rock (V)	-	
@4.0'; CONTAINS LIMESTONE FRAGMENTS.	937.0	4 5	28 34 30	95	100	SS-3	-	-	-	-	-	-	-	-	-	11	Rock (V)	-	
CLAYSTONE, GRAY, SEVERLY WEATHERED, VERY WEAK, FRIABLE.	936.6	EOB	50/4"	-	100	SS-4	-	-	-	-	-	-	-	-	-	9	Rock (V)	-	

NOTES: CAVED AT 4.6'

ABANDONMENT METHODS, MATERIALS, QUANTITIES: AUGER CUTTINGS; BENTONITE POWDER

PROJECT: BRO-68-44.12	DRILLING FIRM / OPERATOR: CTL / TOM	DRILL RIG: CME 45 509	STATION / OFFSET: 148+40, 83' RT.	EXPLORATION ID B-004-1-22
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: CTL / TOM	HAMMER: CME AUTOMATIC	ALIGNMENT: U.S. 68	
PID: 110556 SFN:	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: 8/5/20	ELEVATION: 954.0 (MSL) EOB: 18.2 ft.	PAGE 1 OF 1
START: 6/22/22 END: 6/22/22	SAMPLING METHOD: SPT / ST	ENERGY RATIO (%): 89.3	LAT / LONG: 39.226778, -83.910281	

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	SO4 ppm	BACK FILL
TOPSOIL, 4"	954.0																		
HARD, BROWN, **SILTY CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP	953.7	1	3 4 6	15	78	SS-1	4.50	1	4	14	42	39	40	22	18	19	A-6b (11)	-	
		2																	
		3																	
		4	5 8 10	27	100	SS-2	4.50	-	-	-	-	-	-	-	-	13	A-6b (V)	-	
		5																	
	948.0	6																	
HARD, BROWN, **CLAY**, SOME SILT, LITTLE SAND, TRACE GRAVEL, DAMP		7	8 16 16	48	100	SS-3	4.50	3	7	12	24	54	55	27	28	22	A-7-6 (18)	-	
@8.0'-10.0'; UNDRAINED SHEAR STRENGTH = 4,180 PSF		8			100	ST-4	-	3	5	6	43	43	41	22	19	-	A-7-6 (12)	-	
		9																	
		10																	
@11.0'; VERY STIFF		11	6 8 14	33	78	SS-5	2.25	32	9	4	18	37	42	24	18	21	A-7-6 (7)	-	
	940.5	12																	
CLAYSTONE, GRAY, HIGHLY WEATHERED, VERY WEAK, FRIABLE, CONTAINS LIMESTONE FRAGMENTS.		13 TR	20 27 49	113	100	SS-6	3.75	-	-	-	-	-	-	-	-	12	Rock (V)	-	
	938.0	14																	
SHALE, GRAY, SEVERLY WEATHERED, VERY WEAK, FRIABLE, CONTAINS LIMESTONE FRAGMENTS.		15	20 50/4"	-	100	SS-7	-	-	-	-	-	-	-	-	-	9	Rock (V)	-	
	935.8	16																	
		17																	
		18 EOB																	

NOTES: CAVED AT 13.4'; BORING COORDINATES AND ELEVATION ESTIMATED FROM GOOGLE EARTH IMAGERY AND SHOULD BE CONSIDERED APPROXIMATE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: AUGER CUTTINGS; BENTONITE POWDER

APPENDIX C
LABORATORY TEST RESULTS

PROJECT NO:	22050029COL
DATE:	6/28/2022

UNIAXIAL COMPRESSIVE STRENGTH OF INTACT ROCK CORE - ASTM D 7012

Method C

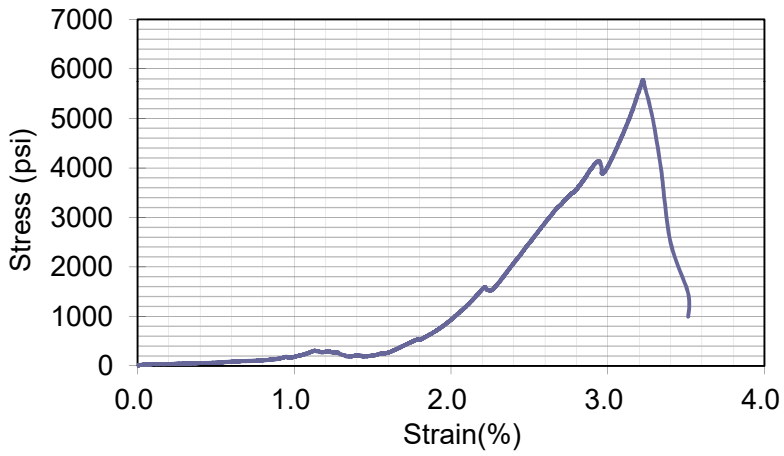
BORING NUMBER	B-002-0-22	TOP DEPTH(FT)	26.3	BOTTOM DEPTH(FT)	26.7
SAMPLE NUMBER	NQ-1	DISTRICT	9	PID NO.	110556
COUNTY	BRO	ROUTE	68	SECTION	44.12

FORMATION	Ordovician age, Waynesville and Arnheim Group
DESCRIPTION	Limestone, gray, slightly weathered, moderately strong
MOISTURE CONDITION	As Received

MEASUREMENT	LENGTH(INCHES)	DIAMETER(INCHES)
1	4.041	1.956
2	4.051	1.966
3	4.070	1.966
AVERAGE	4.054	1.963

LENGTH/DIAMETER	2.1
CORRECTION FACTOR	1
AREA(IN^2)	3.0
MASS (GRAMS)	546.1
UNIT WEIGHT(LBS/FT^3)	169.6

RATE OF LOADING (in/min)
0.08
COMPRESSIVE STRENGTH (PSI)
5,770
Equip. ID - 68897
NON-CONFORMANCES - None
TIME OF TEST (MINUTES)
1.8
LOADING DIRECTION
PERP. TO BEDDING
TECHNICIAN - MW
TEMPERATURE - Room



BEFORE TESTING

AFTER TESTING

PROJECT NO:	22050029COL
DATE:	6/28/2022

UNIAXIAL COMPRESSIVE STRENGTH OF INTACT ROCK CORE - ASTM D 7012

Method C

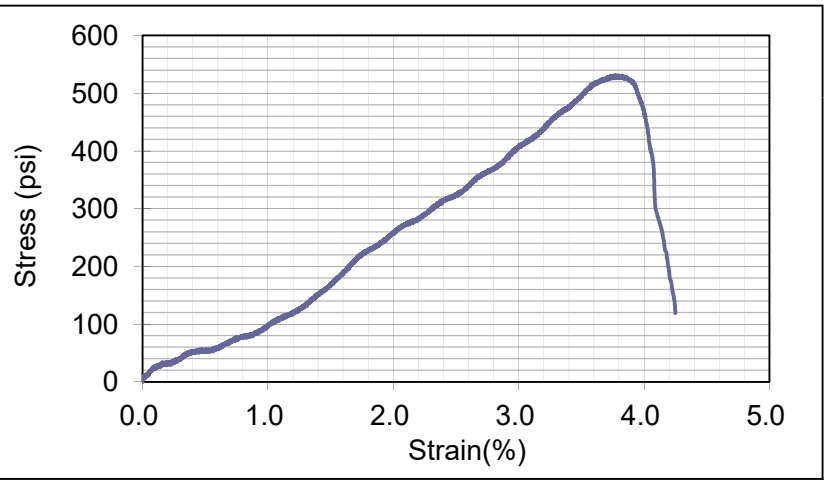
BORING NUMBER	B-002-0-22	TOP DEPTH(FT)	39.3	BOTTOM DEPTH(FT)	39.6
SAMPLE NUMBER	NQ-3	DISTRICT	9	PID NO.	110556
COUNTY	BRO	ROUTE	68	SECTION	44.12

FORMATION	Ordovician age, Waynesville and Arnheim Group
DESCRIPTION	Shale, gray, highly weathered, very weak
MOISTURE CONDITION	As Received

MEASUREMENT	LENGTH(INCHES)	DIAMETER(INCHES)
1	4.076	1.908
2	4.078	1.929
3	4.072	1.941
AVERAGE	4.075	1.926

LENGTH/DIAMETER	2.1
CORRECTION FACTOR	1
AREA(IN^2)	2.9
MASS (GRAMS)	488.7
UNIT WEIGHT(LBS/FT^3)	156.8

RATE OF LOADING (in/min)
0.10
COMPRESSIVE STRENGTH (PSI)
530
Equip. ID - 68897
NON-CONFORMANCES - None
TIME OF TEST (MINUTES)
1.67
LOADING DIRECTION
PERP. TO BEDDING
TECHNICIAN - MW
TEMPERATURE - Room



BEFORE TESTING

AFTER TESTING

PROJECT NO:	22050029COL
DATE:	6/28/2022

UNIAXIAL COMPRESSIVE STRENGTH OF INTACT ROCK CORE - ASTM D 7012

Method C

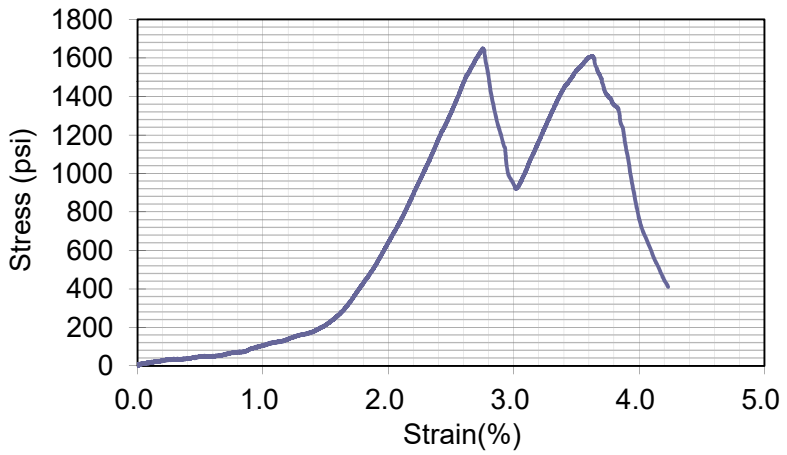
BORING NUMBER	B-003-0-22	TOP DEPTH(FT)	33.3	BOTTOM DEPTH(FT)	33.6
SAMPLE NUMBER	NQ-2	DISTRICT	9	PID NO.	110556
COUNTY	BRO	ROUTE	68	SECTION	44.12

FORMATION	Ordovician age, Waynesville and Arnheim Group
DESCRIPTION	Shale, gray, slightly weathered, slightly strong
MOISTURE CONDITION	As Received

MEASUREMENT	LENGTH(INCHES)	DIAMETER(INCHES)
1	4.089	1.957
2	4.084	1.956
3	4.081	1.957
AVERAGE	4.085	1.957

LENGTH/DIAMETER	2.1
CORRECTION FACTOR	1
AREA(IN^2)	3.0
MASS (GRAMS)	517.6
UNIT WEIGHT(LBS/FT^3)	160.5

RATE OF LOADING (in/min)
0.10
COMPRESSIVE STRENGTH (PSI)
1,650
Equip. ID - 68897
NON-CONFORMANCES - None
TIME OF TEST (MINUTES)
1.819
LOADING DIRECTION
PERP. TO BEDDING
TECHNICIAN - MW
TEMPERATURE - Room



BEFORE TESTING

AFTER TESTING

PROJECT NO:	22050029COL
DATE:	6/28/2022

UNIAXIAL COMPRESSIVE STRENGTH OF INTACT ROCK CORE - ASTM D 7012

Method C

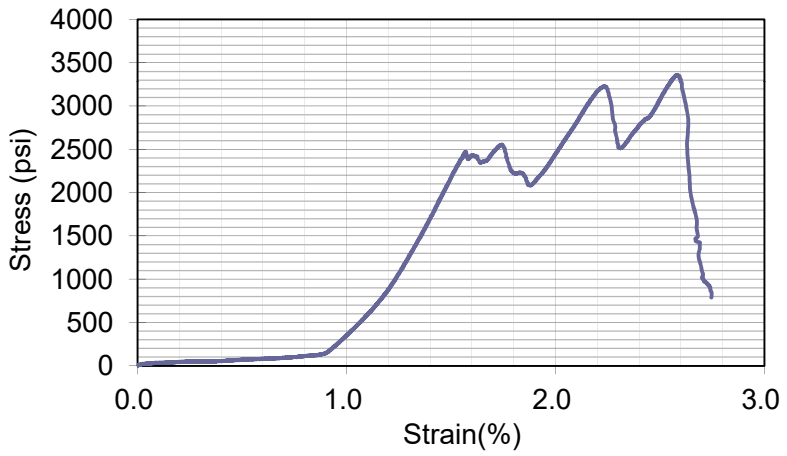
BORING NUMBER	B-003-0-22	TOP DEPTH(FT)	40.3	BOTTOM DEPTH(FT)	40.7
SAMPLE NUMBER	NQ-4	DISTRICT	9	PID NO.	110556
COUNTY	BRO	ROUTE	68	SECTION	44.12

FORMATION	Ordovician age, Waynesville and Arnheim Group
DESCRIPTION	Limestone, gray, slightly weathered, slightly strong
MOISTURE CONDITION	As Received

MEASUREMENT	LENGTH(INCHES)	DIAMETER(INCHES)
1	3.945	1.970
2	3.950	1.966
3	3.948	1.966
AVERAGE	3.948	1.967

LENGTH/DIAMETER	2.0
CORRECTION FACTOR	1
AREA(IN^2)	3.0
MASS (GRAMS)	529.3
UNIT WEIGHT(LBS/FT^3)	168

RATE OF LOADING (in/min)
0.10
COMPRESSIVE STRENGTH (PSI)
3,350
Equip. ID - 68897
NON-CONFORMANCES - None
TIME OF TEST (MINUTES)
1.04
LOADING DIRECTION
PERP. TO BEDDING
TECHNICIAN - MW
TEMPERATURE - Room



BEFORE TESTING

AFTER TESTING

UNCONSOLIDATED UNDRAINED TRIAXIAL TEST ON COHESIVE SOILS
AASHTO 296 & ASTM D 2850

CTL ENGINEERING, INC.
2860 Fisher Road Columbus, Ohio 43204

Avg. Sample Height (in.):	5.7877
Avg. Sample Diameter (in.):	2.8650
Height-to-diameter ratio:	2.02
Wet Density (pcf):	131.6
Dry Density (pcf):	112.2
Void Ratio:	0.474
Specific Gravity (assumed):	2.7
Saturation (%):	96.6
Moisture Content (%):	17.3
Cross Sectional Area (ft^2):	0.04
Volume (ft^3):	0.02
Confining Pressure (psf):	1008
Rate of Axial Strain (%/min):	0.2073
Compressive Strength (psf):	8361
Ultimate Deviator Stress (psf):	8361
Minor Principal Stress at Failure (psf):	1008
Major Principal Stress at Failure (psf):	9369
Failure Criterion:	Maximum Deviator Stress

POST SHEAR

Client:	Prime AE Group Inc
Project:	BRO-68-44.12 Bridge Replacement
Location:	Brown County, Ohio
Project No.	22050029COL
County, Rt. & Sec.:	BRO-68-44.12
Station & Offset:	NA
Field No.:	NA
Sample ID:	B-004-1-22, ST-4, 8'-10'
Lab Code No.	NA
Date Set-up:	7/11/22
Date Sheared:	7/11/22
Reviewed by:	SM

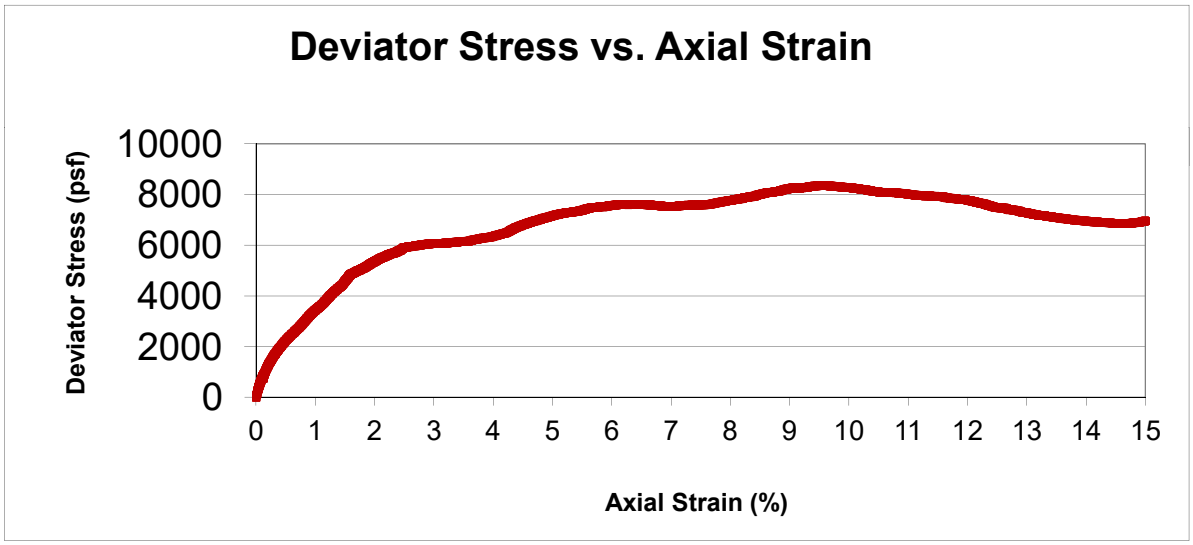
Grading (ASTM D422)

% Agg:	3
% Sand:	11
% Silt:	43
% Clay:	43

Atterberg Limits (ASTM D 4318)

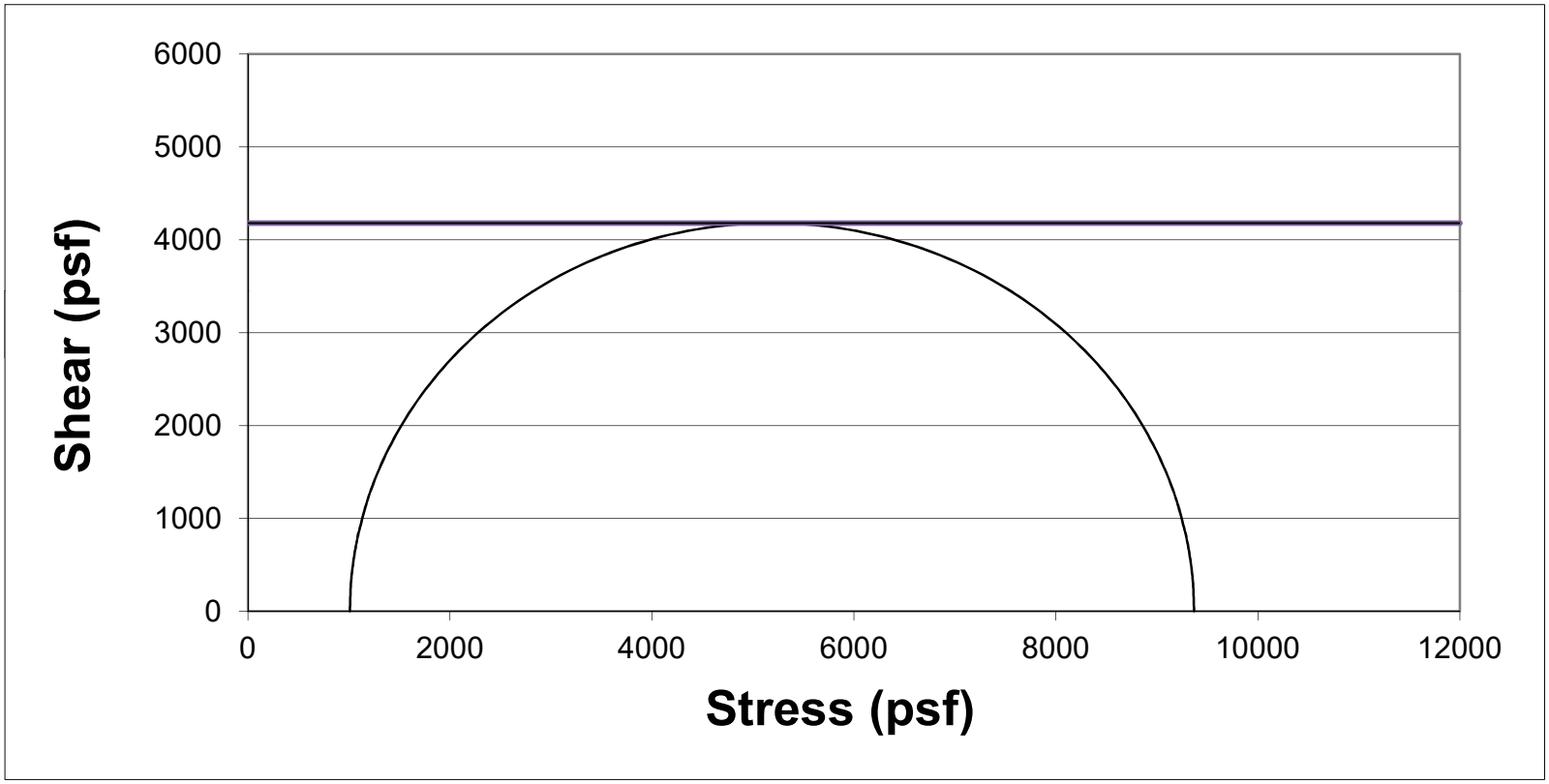
L.L.:	41
P.L.:	22
P.I.:	19

Visual Description: A-7-6(12)



Mohr Circle Total Stress

CLIENT:	Prime AE Group Inc	Sample ID:	B-004-1-22, ST-4, 8'-10'
PROJECT:	BRO-68-44.12 Bridge Replacement	Confining Pressure (psf):	1008
LOCATION:	Brown County, Oh	Cohesion (psf):	4180
PROJECT #:	22050029COL		



APPENDIX D
GB1 ANALYSIS

OHIO DEPARTMENT OF TRANSPORTATION

OFFICE OF GEOTECHNICAL ENGINEERING

PLAN SUBGRADES
Geotechnical Bulletin GB1

BRO-68-44.12
110556

Re-alignment of bridge and roadway along US-68 from Sta. 142+60 to 148+75

CTL Engineering Inc.

Prepared By: Evan Holcombe, P.E.
Date prepared: Thursday, January 12, 2023

CTL ENGINEERING INC.
2860 FISHER ROAD
COLUMBUS, OHIO
43204
614-276-8123
eholcombe@ctleng.com

NO. OF BORINGS: 4

#	Boring ID	Alignment	Station	Offset	Dir	Drill Rig	ER	Boring EL.	Proposed Subgrade EL	Cut Fill
1	B-001-0-22	US-68	142+00	6	Rt	CME 45 Track	89	928.1	926.8	1.3 C
2	B-002-0-22	US-68	143+79	6	Lt	CME 45 Track	89	929.3	928.6	0.7 C
3	B-003-0-22	US-68	145+67	6	Rt	CME 45 Track	89	931.4	931.8	0.4 F
4	B-004-0-22	US-68	148+33	6	Rt	CME 45 Track	89	942.5	941.2	1.3 C

OHIO DEPARTMENT OF TRANSPORTATION

Subgrade Analysis

V. 14.5 1/18/2019

#	Boring	Sample	Sample Depth		Subgrade Depth		Standard Penetration		HP (tsf)	Physical Characteristics						Moisture		Ohio DOT		Sulfate Content (ppm)	Problem		Excavate and Replace (Item 204)		Recommendation (Enter depth in inches)
			From	To	From	To	N_{60}	N_{60L}		LL	PL	PI	% Silt	% Clay	P200	M_C	M_{OPT}	Class	GI		Unsuitable	Unstable	Unsuitable	Unstable	
1	B	SS-1	1.0	2.5	-0.3	1.2	22		4.5	35	19	16	35	36	71	8	16	A-6b	10	99					
	001-0	SS-2	2.5	4.0	1.2	2.7	37		2.75	35	19	16	29	38	67	16	16	A-6b	9						
	22	SS-3	4.0	5.5	2.7	4.2	15		2.75							12	16	A-6b	16						
		SS-4	5.5	7.0	4.2	5.7	13	13								15	16	A-6b	16						
2	B	SS-1	1.0	2.5	0.3	1.8	37		4.5	20	14	6	15	11	26	6	10	A-2-4	0	99					
	002-0	SS-2	2.5	4.0	1.8	3.3	22										14	A-6a	10						
	22	SS-3	4.0	5.5	3.3	4.8	19		3	41	23	18	23	26	49	17	18	A-6a	6						
		SS-4	5.5	7.0	4.8	6.3	25	19	1.5							10	14	A-6a	10						
3	B	SS-1	1.0	2.5	1.4	2.9	25		4.5	36	21	15	28	46	74	15	16	A-6a	10	99					
	003-0	SS-2	2.5	4.0	2.9	4.4	21		2.5	46	24	22	26	56	82	19	21	A-7-6	14						
	22	SS-3	4.0	5.5	4.4	5.9	13		1.75							19	18	A-7-6	16						
		SS-4	5.5	7.0	5.9	7.4	28	13	1	38	21	17	24	38	62	19	16	A-6b							
4	B	SS-1	1.0	2.5	-0.3	1.2	28		4.5	27	16	11	35	30	65	11	14	A-6a	6	400					
	004-0	SS-2	2.5	4.0	1.2	2.7	138									9	0	Rock	0		Rock	Mc			
	22	SS-3	4.0	5.5	2.7	4.2	95									11	0	Rock	0						
		SS-4	5.5	5.8	4.2	4.6	225	28								9	0	Rock	0						

PID: 110556

County-Route-Section: BRO-68-44.12
No. of Borings: 4

Geotechnical Consultant: CTL Engineering Inc.
Prepared By: Evan Holcombe, P.E.
Date prepared: 1/12/2023

Chemical Stabilization Options		
320	Rubblize & Roll	Option
206	Cement Stabilization	Option
	Lime Stabilization	No
206	Depth	NA

Excavate and Replace Stabilization Options	
Global Geotextile Average(N60L):	0"
Average(HP):	0"
Global Geogrid Average(N60L):	0"
Average(HP):	0"

Design CBR	7

% Samples within 6 feet of subgrade			
$N_{60} \leq 5$	0%	HP ≤ 0.5	0%
$N_{60} < 12$	0%	0.5 < HP ≤ 1	6%
$12 \leq N_{60} < 15$	13%	1 < HP ≤ 2	13%
$N_{60} \geq 20$	75%	HP > 2	50%
M+	6%		
Rock	22%		
Unsuitable	19%		

Excavate and Replace at Surface	
Average	0"
Maximum	0"
Minimum	0"

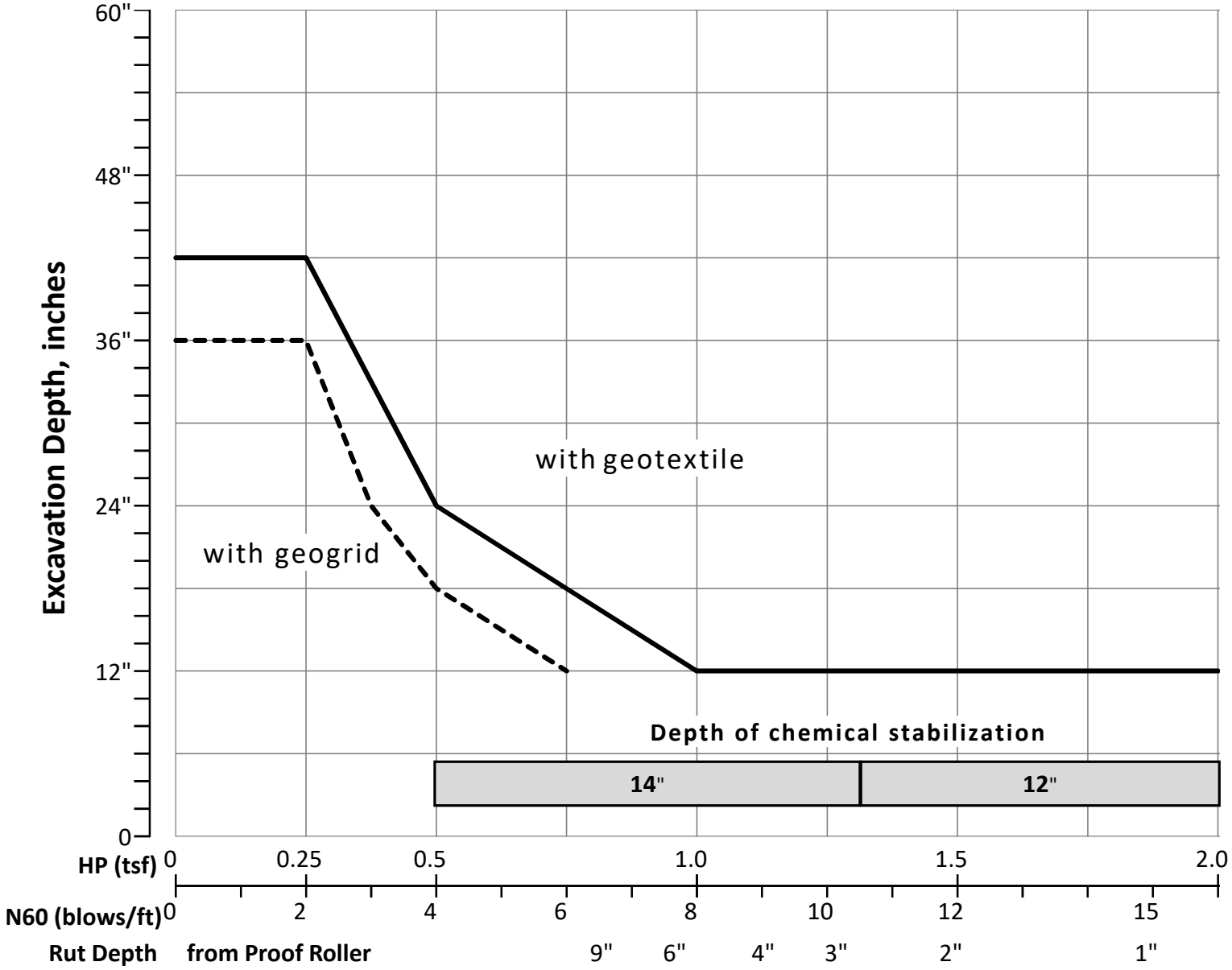
% Proposed Subgrade Surface	
Unstable & Unsuitable	22%
Unstable	11%
Unsuitable	11%

	N_{60}	N_{60L}	HP	LL	PL	PI	Silt	Clay	P 200	M_C	M_{OPT}	GI
Average	48	18	3.02	35	20	15	27	35	62	13	13	8
Maximum	225	28	4.50	46	24	22	35	56	82	19	21	16
Minimum	13	13	1.00	20	14	6	15	11	26	6	0	0

Classification Counts by Sample

ODOT Class	Rock	A-1-a	A-1-b	A-2-4	A-2-5	A-2-6	A-2-7	A-3	A-3a	A-4a	A-4b	A-5	A-6a	A-6b	A-7-5	A-7-6	A-8a	A-8b	Totals
Count	3	0	0	1	0	0	0	0	0	0	0	0	5	5	0	2	0	0	16
Percent	19%	0%	0%	6%	0%	0%	0%	0%	0%	0%	0%	0%	31%	31%	0%	13%	0%	0%	100%
% Rock|Granular|Cohesive	19%	6%									75%								100%
Surface Class Count	2	0	0	1	0	0	0	0	0	0	0	0	3	3	0	0	0	0	9
Surface Class Percent	22%	0%	0%	11%	0%	0%	0%	0%	0%	0%	0%	0%	33%	33%	0%	0%	0%	0%	100%

GB1 Figure B – Subgrade Stabilization



OVERRIDE TABLE

Calculated Average	New Values	Check to Override
3.02	0.50	☐ HP
18.25	6.00	☐ N60L

Average HP
Average N_{60L}

APPENDIX E
GLOBAL STABILITY ANALYSIS

Soil Parameters

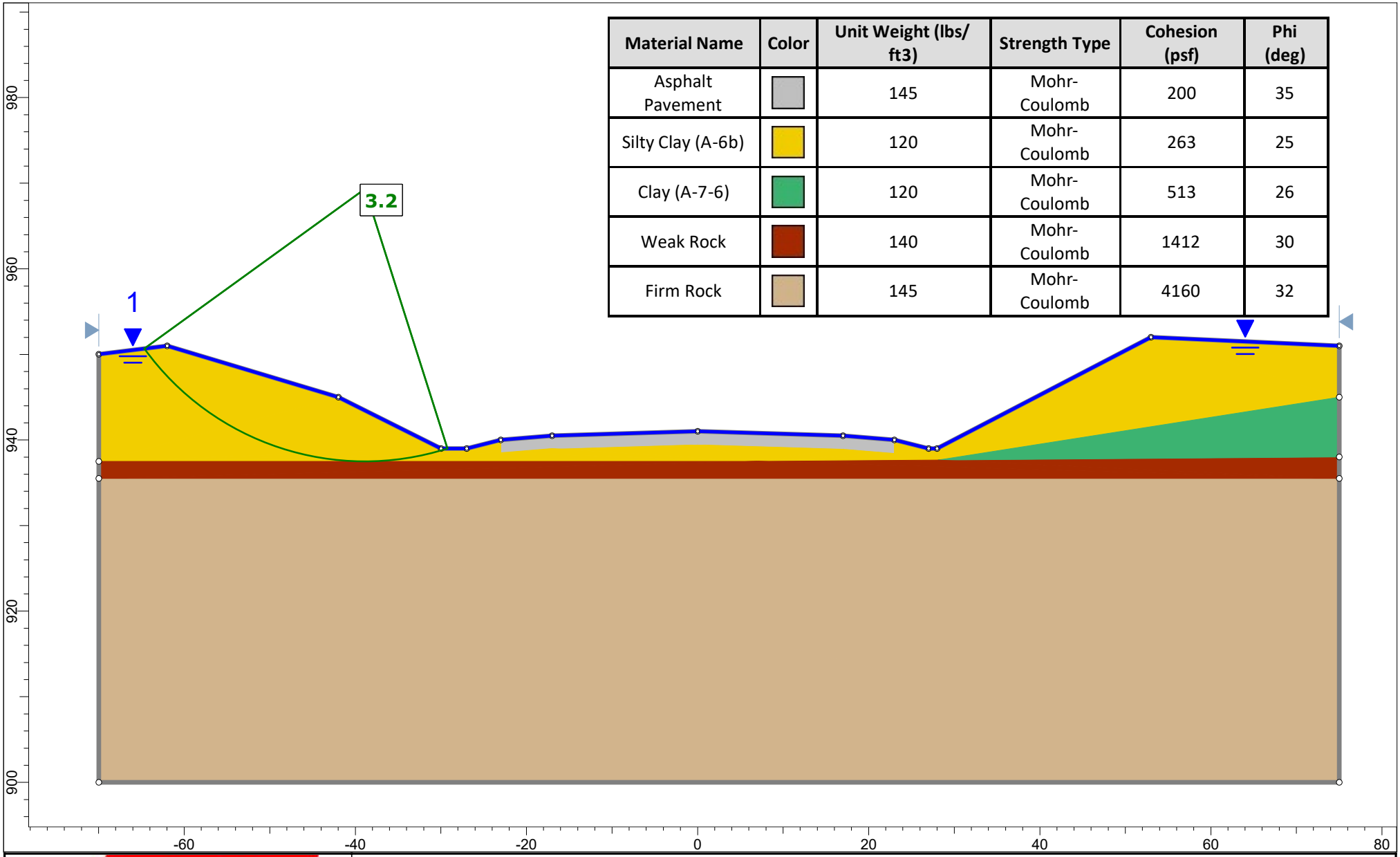
Project: BRO-68-44.12
Location: Stations 148+33, 143+40
Boring No.: B-004-0-22, B-004-1-22
Date: 7/27/2022

					Effective Stress		Total Stress		
Layer No.	Type	Total Weight (pcf)	N_{60} value (bpf)	Moisture Content (%)	Cohesion (psf)	Friction Angle (degrees)	Cohesion (psf)	Friction Angle (degrees)	Reference
1	Asphalt Pavement	145	NA	NA	200	35	200	35	5
2	A-6b (Native)	120	15 27	19 13					
	A-6b (Native)	120	21	16	263	25	2625	0	1,2,3,4
3	A-7-6 (Native)	120	48 33	22 21					
	A-7-6 (Native)	120	41	22	418	26	4180	0	1,2,3,4,7
4	Weak Rock	140	113	12					
	Weak Rock	140	113	NA	1412.5	30	14125	0	1,2,5
5	Firm Rock	145	100	NA					
	Firm Rock	145	100	NA	4160	32	4160	32	5,6

Reference Key

1 Total Stress Cohesion estimated as 12.5% of average N-Value - Bowles "Foundation Analysis and Design"
2 Total Stess Friction Angle estimated to be 0
3 Effective Stress Cohesion estimated to be 10 to 25 percent of Total Stress Cohesion
4 Effective Stress Friction Angle estimated based on soil type
5 ODOT GB7
6 Based on RMR value according to Bieniawski (1989).
7 UU Triaxial Laboratory Test Result (Boring B-004-1-22, 8.0'-10.0')

Material Name	Color	Unit Weight (lbs/ ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Asphalt Pavement		145	Mohr-Coulomb	200	35
Silty Clay (A-6b)		120	Mohr-Coulomb	263	25
Clay (A-7-6)		120	Mohr-Coulomb	513	26
Weak Rock		140	Mohr-Coulomb	1412	30
Firm Rock		145	Mohr-Coulomb	4160	32



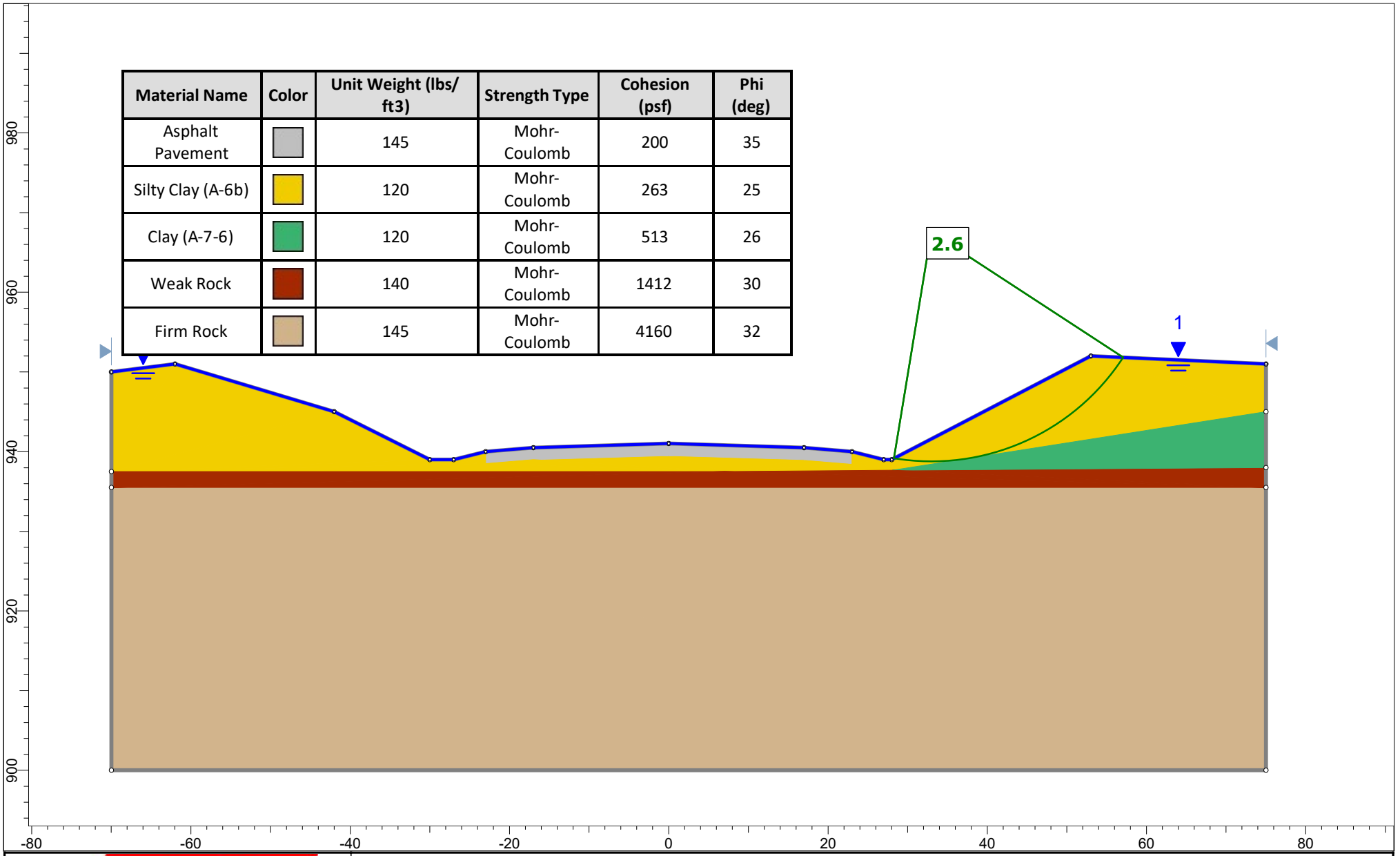
CTL ENGINEERING INC.

BRO-68-44.12 Cut Slope Section

Location	Station 148+00	Analysis Type	Long Term - Effective Stress
Drawn By	EH	Company	CTL Engineering Inc.
Date	7/22/2022, 8:23:00 AM	Station	148+00

SLIDEINTERPRET6.018

Material Name	Color	Unit Weight (lbs/ ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Asphalt Pavement		145	Mohr-Coulomb	200	35
Silty Clay (A-6b)		120	Mohr-Coulomb	263	25
Clay (A-7-6)		120	Mohr-Coulomb	513	26
Weak Rock		140	Mohr-Coulomb	1412	30
Firm Rock		145	Mohr-Coulomb	4160	32

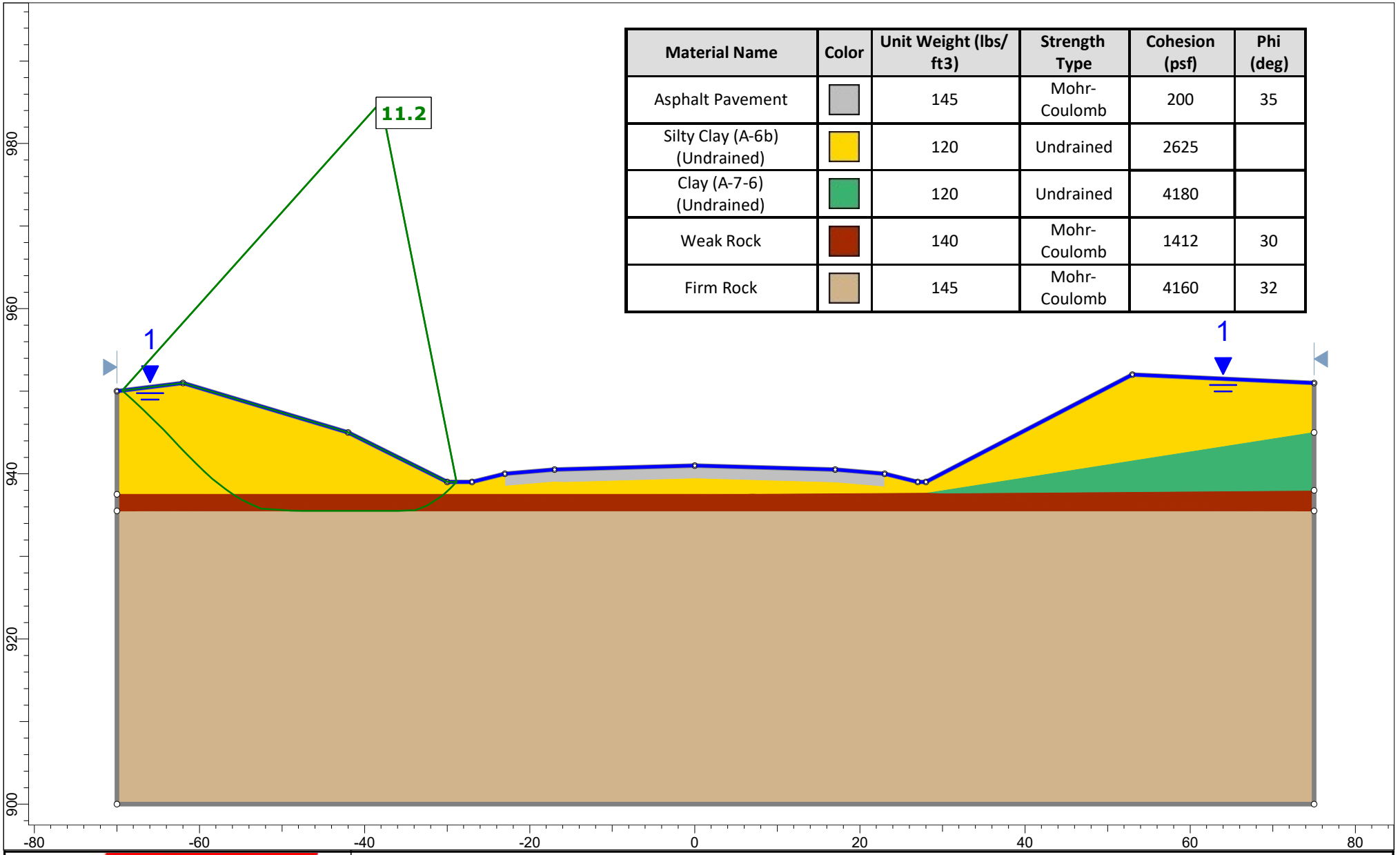


BRO-68-44.12 Cut Slope Section

Location	Station 148+00	Analysis Type	Long Term - Effective Stress
Drawn By	EH	Company	CTL Engineering Inc.
Date	7/22/2022, 8:23:00 AM	Station	148+00

SLIDEINTERPRET9.018

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Asphalt Pavement		145	Mohr-Coulomb	200	35
Silty Clay (A-6b) (Undrained)		120	Undrained	2625	
Clay (A-7-6) (Undrained)		120	Undrained	4180	
Weak Rock		140	Mohr-Coulomb	1412	30
Firm Rock		145	Mohr-Coulomb	4160	32



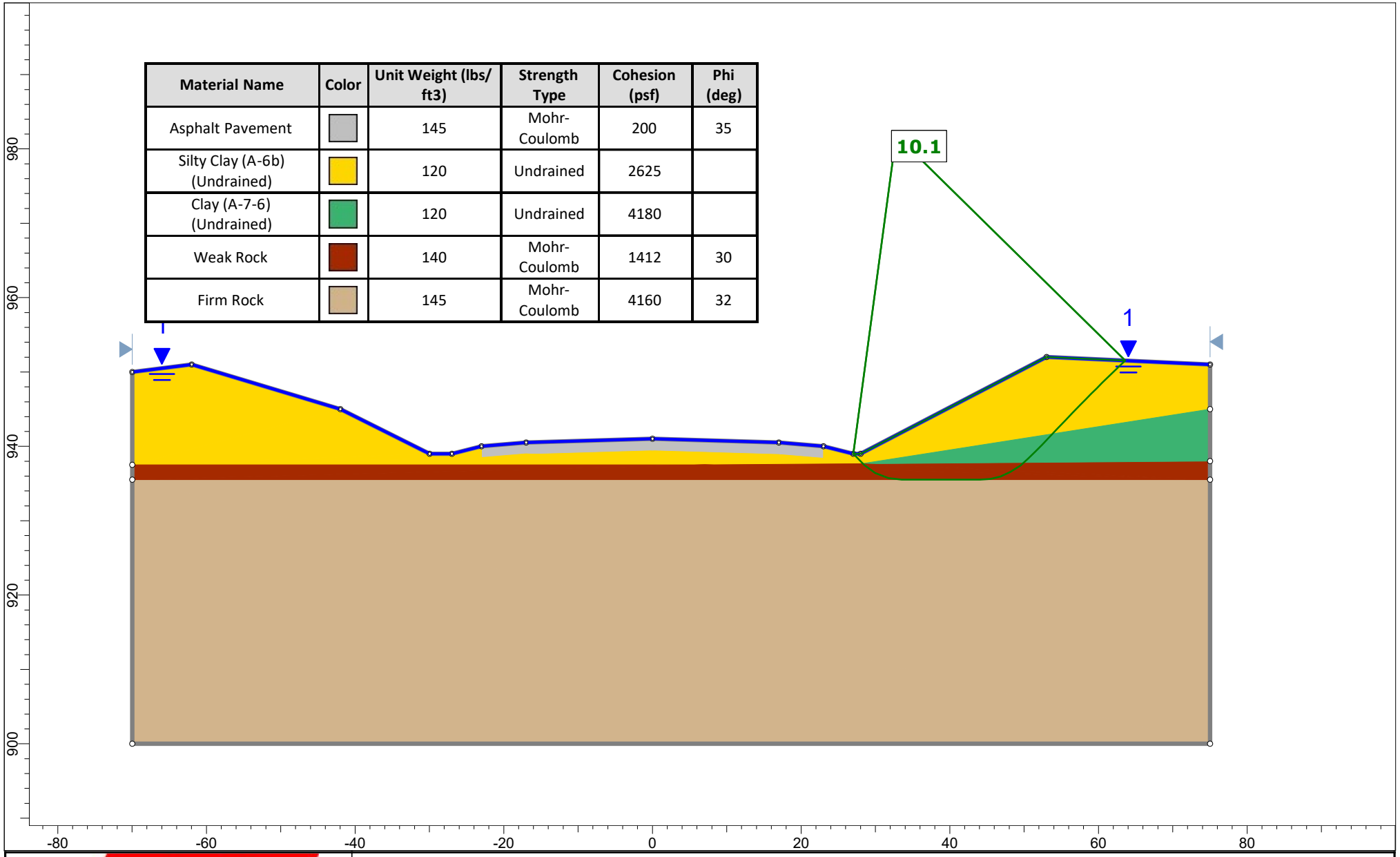
CTL ENGINEERING INC.

BRO-68-44.12 Fill Slope Section

Location	Station 142+00	*Analysis Type*	Short Term - Total Stress
Drawn By	EH	*Company*	CTL Engineering Inc.
Date	7/22/2022, 8:23:00 AM	*Station*	142+00

SLIDEINTERPRET8.dat

Material Name	Color	Unit Weight (lbs/ ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Asphalt Pavement		145	Mohr-Coulomb	200	35
Silty Clay (A-6b) (Undrained)		120	Undrained	2625	
Clay (A-7-6) (Undrained)		120	Undrained	4180	
Weak Rock		140	Mohr-Coulomb	1412	30
Firm Rock		145	Mohr-Coulomb	4160	32



CTL ENGINEERING INC

BRO-68-44.12 Fill Slope Section

Location	Station 142+00	Analysis Type	Short Term - Total Stress
Drawn By	EH	Company	CTL Engineering Inc.
Date	7/22/2022, 8:23:00 AM	Station	142+00

SLIDEINTERPRET8.dat

Soil Parameters

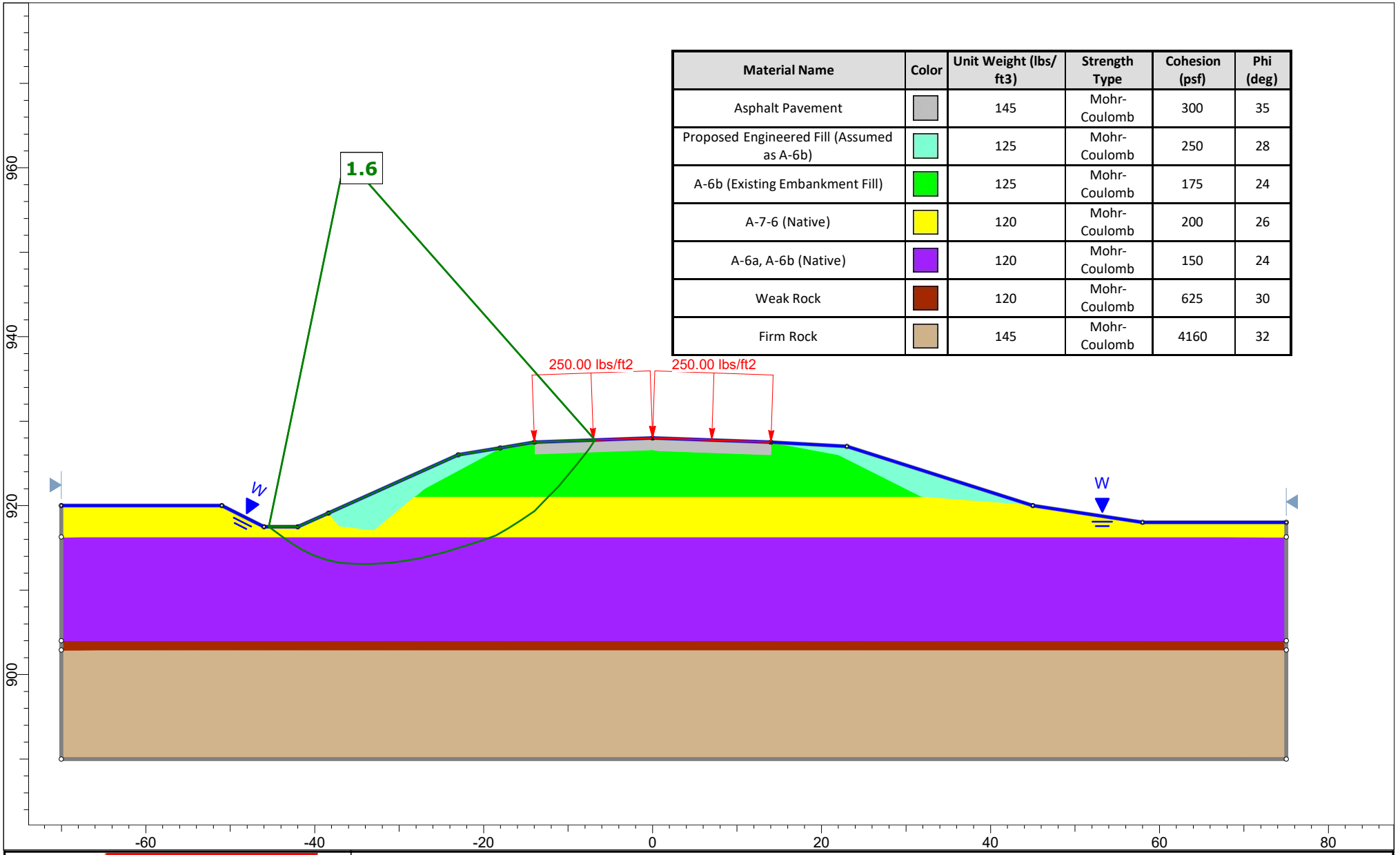
Project: BRO-68-44.12
Location: Stations 142+00, 143+79
Boring No.: B-001-0-22, B-002-0-22
Date: 7/27/22

					Effective Stress		Total Stress		
Layer No.	Type	Total Weight (pcf)	N_{60} value (bpf)	Moisture Content (%)	Cohesion (psf)	Friction Angle (degrees)	Cohesion (psf)	Friction Angle (degrees)	Reference
1	Asphalt Pavement	145	NA	NA	200	35	200	35	5
2	Proposed Engineered Fill (Assumed as A-6b)	125	NA	NA	250	28	2500	0	7
3	A-6b (Existing Embankment Fill)	125	22 37 15 13	8 16 12 15					
	A-6b (Existing Embankment Fill)	125	22	13	175	24	2750	0	1,2,3,4,5
4	A-7-6 (Native)	120	15 48	17 18					
	A-7-6 (Native)	120	32	18	200	26	4000	0	1,2,3,4,5
5	A-6a, A-6b (Native)	120	9 13 7 12 15	18 20 28 14 11					
	A-6a, A-6b (Native)	120	11	11	150	24	1400	0	1,2,3,4,5
3	Weak Rock	140	50	11					
	Weak Rock	140	50	11	625	30	6250	0	1,2,5
4	Firm Rock	145	NA	NA					
	Firm Rock	145	NA	NA	4160	32	4160	25	5,6

Reference Key

1 Total Stress Cohesion estimated as 12.5% of average N-Value - Bowles "Foundation Analysis and Design"
2 Total Stess Friction Angle estimated to be 0
3 Effective Stress Cohesion estimated to be 10 to 25 percent of Total Stress Cohesion
4 Effective Stress Friction Angle estimated based on soil type
5 ODOT GB7
6 Based on RMR value according to Bieniawski (1989).
7 ODOT GB2, Table 1: Estimated Shear Strengths

Material Name	Color	Unit Weight (lbs/ ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Asphalt Pavement		145	Mohr-Coulomb	300	35
Proposed Engineered Fill (Assumed as A-6b)		125	Mohr-Coulomb	250	28
A-6b (Existing Embankment Fill)		125	Mohr-Coulomb	175	24
A-7-6 (Native)		120	Mohr-Coulomb	200	26
A-6a, A-6b (Native)		120	Mohr-Coulomb	150	24
Weak Rock		120	Mohr-Coulomb	625	30
Firm Rock		145	Mohr-Coulomb	4160	32

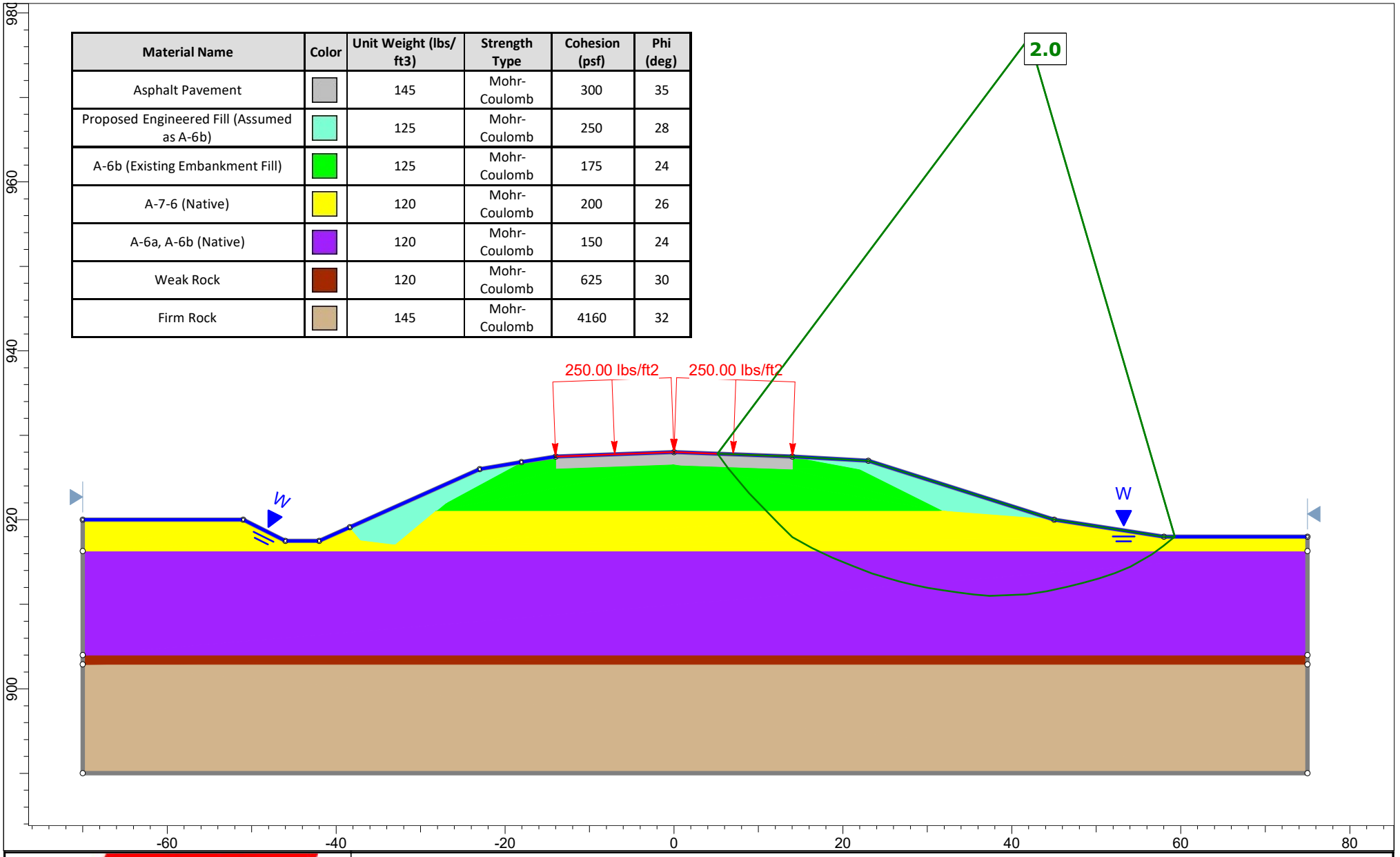


BRO-68-44.12 Fill Slope Section

Location	Station 142+00	*Analysis Type*	Long Term - Effective Stress
Drawn By	EH	*Company*	CTL Engineering Inc.
Date	7/25/2022, 10:20:31 AM	*Station*	142+00

SLIDEINTERPRET8.gsz

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Asphalt Pavement		145	Mohr-Coulomb	300	35
Proposed Engineered Fill (Assumed as A-6b)		125	Mohr-Coulomb	250	28
A-6b (Existing Embankment Fill)		125	Mohr-Coulomb	175	24
A-7-6 (Native)		120	Mohr-Coulomb	200	26
A-6a, A-6b (Native)		120	Mohr-Coulomb	150	24
Weak Rock		120	Mohr-Coulomb	625	30
Firm Rock		145	Mohr-Coulomb	4160	32

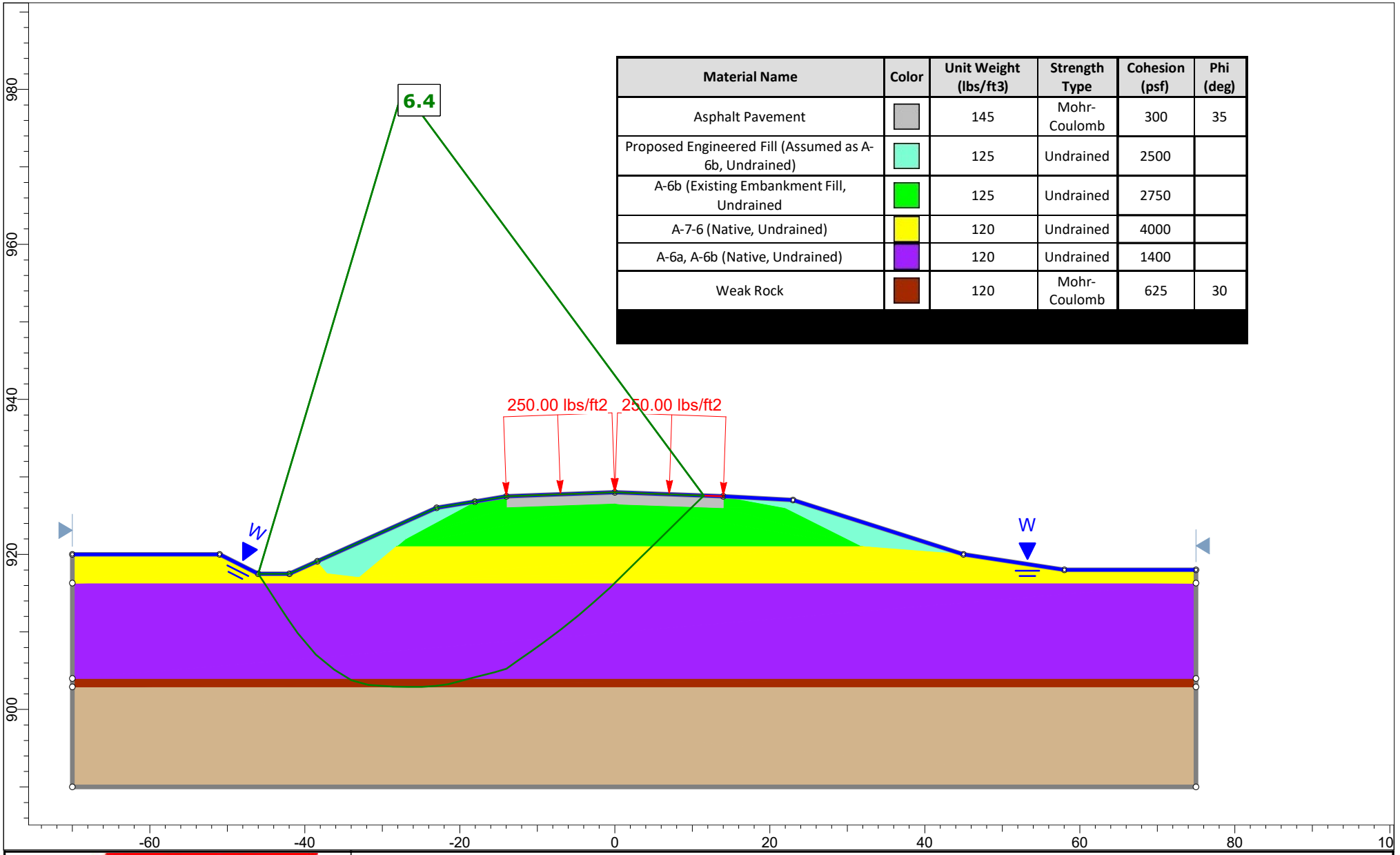


BRO-68-44.12 Fill Slope Section

Location	Station 142+00	Analysis Type	Long Term - Effective Stress
Drawn By	EH	Company	CTL Engineering Inc.
Date	7/25/2022, 10:20:31 AM	Station	142+00

SLIDEINTERPRET6.dat

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Asphalt Pavement		145	Mohr-Coulomb	300	35
Proposed Engineered Fill (Assumed as A-6b, Undrained)		125	Undrained	2500	
A-6b (Existing Embankment Fill, Undrained		125	Undrained	2750	
A-7-6 (Native, Undrained)		120	Undrained	4000	
A-6a, A-6b (Native, Undrained)		120	Undrained	1400	
Weak Rock		120	Mohr-Coulomb	625	30



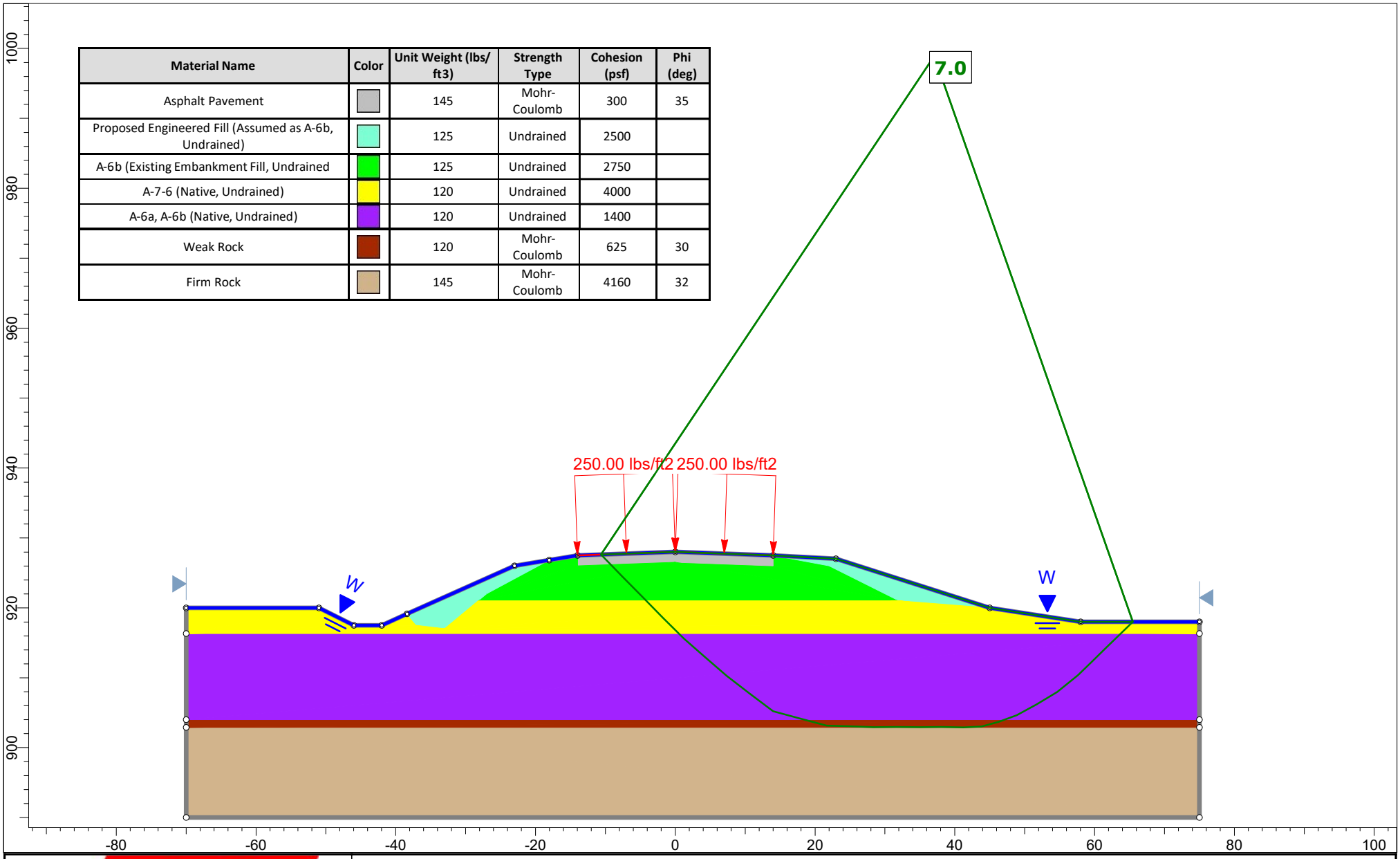
CTL ENGINEERING INC.

BRO-68-44.12 Fill Slope Section

Location	Station 142+00	*Analysis Type*	Short Term - Total Stress
Drawn By	EH	*Company*	CTL Engineering Inc.
Date	7/25/2022, 10:20:31 AM	*Station*	142+00

SLIDEINTERPRET6.018

Material Name	Color	Unit Weight (lbs/ ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Asphalt Pavement		145	Mohr-Coulomb	300	35
Proposed Engineered Fill (Assumed as A-6b, Undrained)		125	Undrained	2500	
A-6b (Existing Embankment Fill, Undrained		125	Undrained	2750	
A-7-6 (Native, Undrained)		120	Undrained	4000	
A-6a, A-6b (Native, Undrained)		120	Undrained	1400	
Weak Rock		120	Mohr-Coulomb	625	30
Firm Rock		145	Mohr-Coulomb	4160	32



BRO-68-44.12 Fill Slope Section

Location	Station 142+00	Analysis Type	Short Term - Total Stress
Drawn By	EH	Company	CTL Engineering Inc.
Date	7/25/2022, 10:20:31 AM	Station	142+00

SLIDEINTERPRET9.dat

APPENDIX F
DRILLED SHAFT DESIGN CALCULATIONS

Drilled Shaft - Side Resistance in Rock

BRO-68-44.12
Rear Abutment

Boring No	B-002-0-22		
Top of Rock Elevation	904.3	feet	(From Boring)
Shaft Tip Elevation	893.2	feet	(Assumed 10-foot shaft embeddment into coreable bedrock)

LRFD Side Resistance

											Compressive		Uplift	
Top Elev.	**Bottom Elev.**	**Layer Thickness (feet)**	**Material**	**q_u (ksf)**	**P_a (ksf)**	**C**	**f'_c (ksf)**	**q_s (ksf)**	**$q_s$max (ksf)**	**Check**	**Resistance Factor**	**Factored Side Resistance (ksf)**	**Resistance Factor**	**Factored Side Resistance (ksf)**
904.3	903.2	1.1	Rock	30.2	2.12	0.29	576	**2.3**	34.9	**OK**	0.55	1.3	0.4	0.9
903.2	893.2	10	Rock	302.7	2.12	1.00	576	**25.3**	34.9	**OK**	0.55	13.9	0.4	10.1

* Side Friction within upper several feet of rock should be neglected per ODOT BDM section 305.4.2- To be determined by the structural engineer

** Side Resistance should be neglected within the scour zone - To be determined by the Structural Engineer

Notes

P_a(ksf)= Atmospheric Pressure

C = regression Coefficient **(C=1 for corable rock and for augerable rock lowerbound value per AASHTO TABLE 10.8.3.5.4b-1)**

f'_c(ksi)= Concrete Compressive Strength **(4.0 ksi as per BDM 2020, Section C304.2.1)**

$q_s = CP_a(q_u/P_a)^{0.5}$ **(Equation 10.8.3.5.4b-1)**

$q_s$max $= P_a(f'_c/P_a)^{0.5}$

Resistance Factor= 0.55 Compressive **(AASHTO TABLE 10.5.5.2.4-1)**

0.40 Uplift **(AASHTO TABLE 10.5.5.2.4-1)**

Mean blowcount for augerable rock= 331.0 bpf

Energy ratio of SPT hammer= 89.3%

$q_{u\,1}$ (ksf)= 0.092x(89.3/90x331)= 30.22 ksf **(EQ 2.2 of FHWA-ICT-17-018)**

$q_{u\,2}$ (ksf)= 302.7 ksf **(Composite strength of interbedded shale (70%) and limestone (30%) per BDM 2020, Section 305.4.2)**

Compressive Strength of shale (psi)= 530 (B-002-0-22, Compressive Strength Test Result, R-3, 39.3'-39.7')

Compressive Strength of limestone (psi)= 5770 (B-002-0-22, Compressive Strength Test Result, R-1, 26.3'-26.7')

Drilled Shaft - Tip Resistance

BRO-68-44.12
Rear Abutment

Boring No B-002-0-22

Shaft Tip Elevation (feet)	Unconfined Compressive Strength, $q_{u\,(1)}$ (ksf)	Nominal Unit Tip Resistance, q_p (2) (ksf)	Resistance Factor, Tip Resistance (3)	Factored Unit Tip Resistance, q_p (ksf)
893.2	302.7	756.7	0.50	378.4

Reference Key

(1) Composite strength of interbedded shale (70%) and limestone (30%) per BDM 2020, Section 305.4.2

(2) AASHTO 10.8.3.5.4c-1

(3) AASHTO Table 10.5.5.2.4-1

L-PILE Rock Parameters

BRO-68-44.12
Rear Abutment

Boring No	B-002-0-22		
Top of Rock Elevation	904.3	feet	(From Boring B-002-0-22)
Shaft Tip Elevation	893.2	feet	(Assumed a 10.0-foot drileld shaft embeddment into coreable bedrock)

From 904.3 to 903.2

Use Rock Type-	Weak Rock (Reese)		
Effective Unit Weight =	77.6	pcf	(Assumed)
Compressive Strength (q_u) =	209.83	psi	(EQ 2.2 of FHWA-ICT-17-018)
Initial Rock Modulus =	18000	psi	(Per ODOT, OGE, Very Weak Rock)
RQD =	0%		(Assumed)
Use K_{rm} =	0.0005		(From L-pile)

Below 903.2

Use Rock Type-	Weak Rock (Reese)				
Effective Unit Weight =	82.6	pcf			(Assumed)
Composite strength of interbedded shale (70%) and limestone (30%) (q_u) =			2102	psi	(BDM 2020, Section 305.4.2)
					Compressive Strength of shale (psi)= 530
					Compressive Strength of limestone (psi)= 5770
Initial Rock Modulus =	100000	psi			(Per ODOT, OGE, Weak to Slightly Strong Rock)
RQD =	48%				(B-002-0-22, NQ-1, NQ-2, NQ-3, NQ-4)
Use K_{rm} =	0.00005				(From L-pile)

Drilled Shaft - Side Resistance in Rock

BRO-68-44.12
Forward Abutment

Boring No	B-003-0-22		
Top of Rock Elevation	908.9	feet	(From Boring)
Shaft Tip Elevation	896.3	feet	(Assumed 10-foot shaft embeddment into coreable bedrock)

LRFD Side Resistance

											Compressive		Uplift	
Top Elev.	**Bottom Elev.**	**Layer Thickness (feet)**	**Material**	**q_u (ksf)**	**P_a (ksf)**	**C**	**f'_c (ksf)**	**q_s (ksf)**	**$q_s$max (ksf)**	**Check**	**Resistance Factor**	**Factored Side Resistance (ksf)**	**Resistance Factor**	**Factored Side Resistance (ksf)**
908.9	906.3	2.6	Rock	13.7	2.12	0.29	576	**1.6**	34.9	**OK**	0.55	0.9	0.4	0.6
906.3	896.3	10	Rock	311.0	2.12	1.00	576	**25.7**	34.9	**OK**	0.55	14.1	0.4	10.3

* Side Friction within upper several feet of rock should be neglected per ODOT BDM section 305.4.2- To be determined by the structural engineer

** Side Resistance should be neglected within the scour zone - To be determined by the Structural Engineer

Notes

P_a(ksf)= Atmospheric Pressure

C = regression Coefficient **(C=1 for corable rock and for augerable rock lowerbound value per AASHTO TABLE 10.8.3.5.4b-1)**

f'_c(ksi)= Concrete Compressive Strength **(4.0 ksi as per BDM 2020, Section C304.2.1)**

$q_s = CP_a(q_u/P_a)^{0.5}$ **(Equation 10.8.3.5.4b-1)**

$q_s$max $= P_a(f'_c/P_a)^{0.5}$

Resistance Factor= 0.55 Compressive **(AASHTO TABLE 10.5.5.2.4-1)**

0.40 Uplift **(AASHTO TABLE 10.5.5.2.4-1)**

Mean blowcount for augerable rock= 150.0 bpf

Energy ratio of SPT hammer= 89.3%

$q_{u\,1}$ (ksf)= 0.092x(89.3/90x150)= 13.69 ksf **(EQ 2.2 of FHWA-ICT-17-018)**

$q_{u\,2}$ (ksf)= 311.0 ksf **(Composite strength of interbedded shale (70%) and limestone (30%) per BDM 2020, Section 305.4.2)**

Compressive Strength of shale (psi)= 1650 (B-003-0-22, Compressive Strength Test Result, R-2, 33.3'-33.6')

Compressive Strength of limestone (psi)= 3350 (B-003-0-22, Compressive Strength Test Result, R-4, 40.3'-40.7')

Drilled Shaft - Tip Resistance

BRO-68-44.12
Forward Abutment

Boring No B-003-0-22

Shaft Tip Elevation (feet)	Unconfined Compressive Strength, $q_{u\,(1)}$ (ksf)	Nominal Unit Tip Resistance, q_p (2) (ksf)	Resistance Factor, Tip Resistance (3)	Factored Unit Tip Resistance, q_p (ksf)
896.3	311.0	777.6	0.50	388.8

Reference Key

(1) Composite strength of interbedded shale (70%) and limestone (30%) per BDM 2020, Section 305.4.2

(2) AASHTO 10.8.3.5.4c-1

(3) AASHTO Table 10.5.5.2.4-1

L-PILE Rock Parameters

BRO-68-44.12
Forward Abutment

Boring No	B-003-0-22		
Top of Rock Elevation	908.9	feet	(From Boring B-003-0-22)
Shaft Tip Elevation	896.3	feet	(Assumed a 10.0-foot drileld shaft embeddment into coreable bedrock)

From 908.9 to 906.3

Use Rock Type-	Weak Rock (Reese)		
Effective Unit Weight =	77.6	pcf	(Assumed)
Compressive Strength (q_u) =	95.09	psi	(EQ 2.2 of FHWA-ICT-17-018)
Initial Rock Modulus =	18000	psi	(Per ODOT, OGE, Very Weak Rock)
RQD =	0%		(Assumed)
Use K_{rm} =	0.0005		(From L-pile)

Below 906.3

Use Rock Type-	Weak Rock (Reese)			
Effective Unit Weight =	82.6	pcf		(Assumed)
Composite strength of interbedded shale (70%) and limestone (30%) (q_u) =	2160	psi		(BDM 2020, Section 305.4.2)
				Compressive Strength of shale (psi)= 1650
				Compressive Strength of limestone (psi)= 3350
Initial Rock Modulus =	100000	psi		(Per ODOT, OGE, Weak to Slightly Strong Rock)
RQD =	73%			(B-002-0-22, NQ-1, NQ-2, NQ-3)
Use K_{rm} =	0.00005			(From L-pile)

APPENDIX G
ROCK CORE PHOTOS

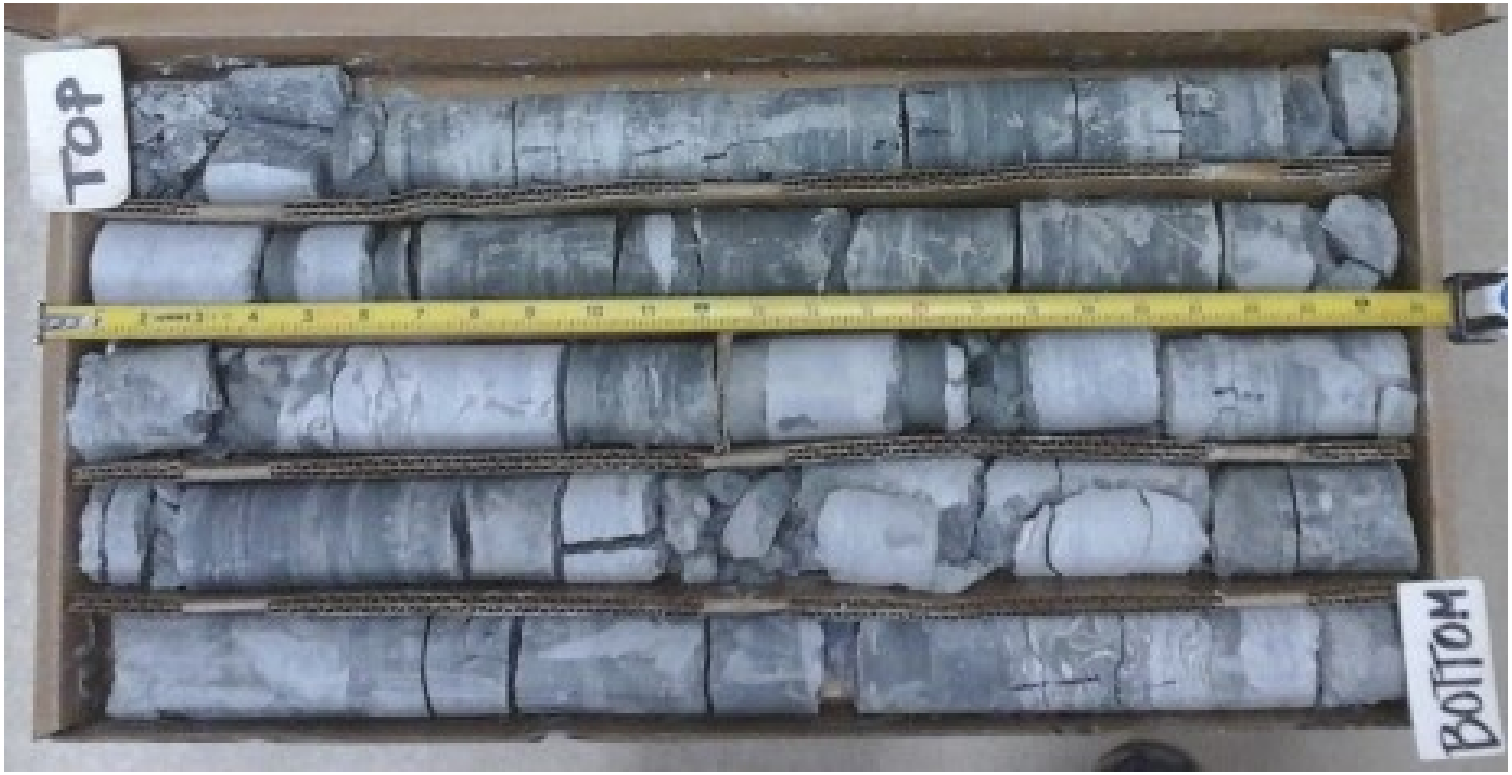
B-002-0-22

Run #	Depth (ft)		Recovery (in)		RQD (in)	
NQ-1	26.1	31.1	53/60	88%	27.5/60	46%
NQ-2	31.1	36.1	60/60	100%	30/60	50%

B-002-0-22

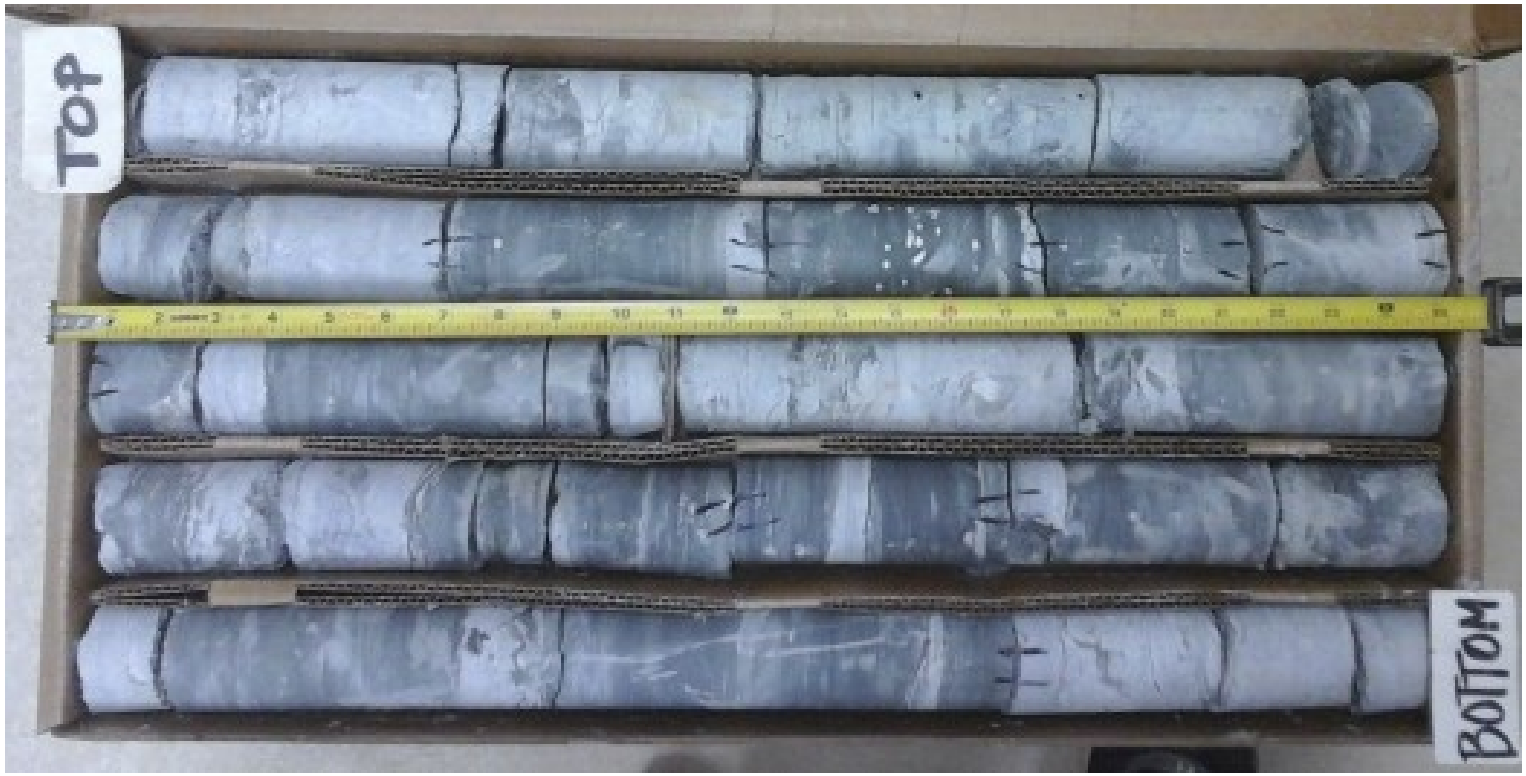
Run #	Depth (ft)		Recovery (in)		RQD (in)	
NQ-3	36.1	41.1	58/60	97%	16.5/60	28%
NQ-4	41.1	46.1	58/60	97%	40/60	67%

B-003-0-22



Run #	Depth (ft)		Recovery (in)		RQD (in)	
NQ-1	25.1	30.1	58/60	97%	31/60	52%
NQ-2	30.1	35.1	58/60	97%	43/60	72%

B-003-0-22



Run #	Depth (ft)		Recovery (in)		RQD (in)	
NQ-3	35.1	40.1	57/60	95%	53/60	88%
NQ-4	40.1	45.1	60/60	100%	48/60	80%