

September 17, 2024

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Attention: Mr. Scott Piazza, P.E.
Senior Project Manager - Highways

Reference: Roadway & Structural Foundation Exploration Report- Final
CUY-71-10.07 SW
PID 114536
Ramp I-71 NB to I-480 WB
Cleveland, Cuyahoga County, Ohio

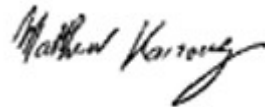
CTL Project No. 23050013CLE

Mr. Piazza:

CTL Engineering, Inc. has completed the Final Roadway and Structural Foundation Exploration Report for the above referenced project. Enclosed is the digital (pdf) copy of the draft report.

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.



H. Matthew Kairouz, P.E.
Project Manager

ROADWAY & STRUCTURAL FOUNDATION EXPLORATION REPORT
FINAL

**CUY-71-10.07 SW
PID 114536**

**RAMP I-71 NB TO I-480 WB
CLEVELAND, CUYAHOGA COUNTY, OHIO**

CTL PROJECT NO. 23050013CLE

PREPARED FOR

**MOTT MACDONALD
18013 CLEVELAND PARKWAY DRIVE
SUITE 200
CLEVELAND, OHIO 44135**

PREPARED BY

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September 17, 2024



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I. EXECUTIVE SUMMARY

CUY 71-10.07SW, known as Ramp T project, consists of replacing and widening the existing bridge in addition to widening the exiting roadway earthen embankment. The widening of the roadway will require sliver fill to be constructed at a grade of 2H: 1V over the existing slopes.

Subgrades:

The roadway may be designed using a California bearing Ration (CBR) of 8 %. The depth of excavation and replacement of subgrades should be based on proof roll test during construction. The Project Engineer in the field based upon proof rolling will determine the actual depths and limits of excavation/replacement.

Embankment:

CTL in coordination with Mott MacDonald designed the embankment in general accordance with ODOT Geotechnical Design Manual Section 805 Sidehill Sliver Fill on a Slight Slope where applicable and/or Section 803 General Case: Special Benched Embankment Construction. Based on our slope stability analyses, the proposed slopes at 2H:1V of the proposed embankment widening are expected to remain stable.

Bridge:

The bridge abutments and piers can be supported on deep foundation such as H piles driven to practical refusal into the underlying bedrock. The maximum factored structural resistance (RR max) for HP 10X42 driven to refusal on bedrock is 310 kips. The estimated pay lengths of driven HP 1x42 are summarized in Table 1 below.

Table 1: Estimated H pile Lengths Driven to Practical Refusal onto Bedrock.

Structure	Pile Cutoff Elevation (ft)	Pile Tip Elevation (ft)	Estimated Pile Length (ft)	Order Pay Length (ft)*
Rear Abut. (B-004)	801.2	745.8	60	65
Pier 1 (B-005)	785.5	747.4	40	45
Pier 2 (B-006)	785.5	749.0	40	45
Pier 3 (B-007)	785.0	749.0	40	45
Forward Abut. (B-008)	795.0	739.2	60	65

**Order Pay Length and Estimated Pile Length were provided in accordance with BDM Section 305.3.5.2*

All driven Piles should be furnished and installed in accordance with ODOT CMS Items 507 and 523.

II. INTRODUCTION

CUY-71-10.07 SW is the I-71 NB Exit Ramp to I-480 WB. This ramp is known as Ramp T. Ramp T includes roadway embankment and a 4-span single lane bridge over I-480. The project consists of widening and replacing the existing bridge in addition to widening the exiting roadway earthen embankment. The widening of the roadway will require sliver fill to be constructed at a grade of 2H: 1V over the existing slopes.

This report addresses geotechnical design parameters related to the subgrade, earthen embankment of the roadway, and to the bridge foundation design.

III. GEOLOGY AND OBSERVATIONS OF THE PROJECT

A. Geology

According to the Ohio Department of Natural Resources' Division of Geological Survey, the project site is located within Lavery Till of dark gray to dark brown silty to clayey strongly calcareous cohesive deposits and within finite made land areas of reclaimed land, cut and fill, dumps, and urban cover. The bedrock geology of the project site is Mississippian-age Berea Sandstone, and Ohio Shale.

According to Ohio Department of Natural Resources - Division of Mineral Resources website (www.ohiodnr.com/mineral), there is no mines listed in the immediate vicinity of the project area.

B. Site Conditions

The project site is located within a busy highway interchange in a busy suburban setting surrounded by commercial development and railroad yard to the north. The bridge deck of Ramp T is in poor condition with patched potholes and distressed joints along the shoulder. The superstructure exhibited corrosion across the existing structure's cross-frame. Ramp T embankment is covered by mowed grass with few trees and brush and has no sign of slope failures. The concrete shoulder of the pavement exhibited numerous longitudinal hair cracks.



IV. EXPLORATION

A. Historical Exploration:

One historical boring identified as B-10 dated back to 1965 was available from ODOT Transportation Information Mapping System at Ramp T Bridge Forward Abutment. This historical boring log is included in this report and was considered in the analyses and recommendations. The historic boring is referenced and identified in Table 2 below.

Table 2: Historic Soil Boring

Original Boring Number	Re-Numbered Boring	Depth (ft)	Station	Offset (ft)	Reference Alignment	Reference
B-10	B-010-0-65	36	33+29	9 LT	Ramp T	CUY-480-8.72
			333+29	9 LT	Ramp T	CUY-71-10.07 SW

B. Present Exploration:

The design team and ODOT District agreed to cancel rock coring along Ramp T at the abutments (borings B-004 and B-008) during the scoping and fee. The reason for the cancelation was to reduce/limit the duration of drilling to one day due to safety. Ramp T is very narrow.

During the period of July 20 to July 27, 2023 CTL Engineering advanced ten (10) soil borings as follows:

Table 3: Current Soil Borings

Boring No	Depth (ft)	Station	Offset (ft)	Latitude	Longitude	Reference Alignment
B-001-0-23	7.5	326+04	6.9 RT	41.419366	-81.816436	Ramp T
B-002-0-23	10	327+23	15.1 RT	41.419637	-81.816197	
B-003-0-23	20	328+89	54.7 RT	41.419937	-81.815740	
B-004-0-23	67.5	329+65	3.5 RT	41.420185	-81.815711	
B-005-0-23	50.5	330+88	28.9 RT	41.420381	-81.815338	
B-006-0-23	50	331+74	20.3 RT	41.420556	-81.815134	
B-007-0-23	49	332+90	16.9 RT	41.42076	-81.814818	
B-008-0-23	69.2	333+50	28 LT	41.420922	-81.814806	
B-009-0-23	20	336+11	72.1 RT	41.421068	-81.813740	
B-010-0-23	7.5	338+86	7 RT	41.421482	-81.812902	

CTL Engineering, in collaboration with Mott MacDonald selected the boring locations as shown approximately on the enclosed Plan and Profile sheets provided in Appendix A.

The drillers obtained split spoon soil samples at 2.5-foot interval in the upper 20 feet and at 5-foot interval thereafter. The drilling crew obtained NQ rock core samples from borings B-005-0-23 through B-007-0-23. The Split Spoon Samples were obtained in accordance with Standard Penetration (SPT) procedure. The SPT consists of driving a 2.0-inch outside diameter (OD) split-spoon sampler 18 inches into the soil with an automatic 140-pound hammer falling 30 inches. The SPT hammer used for this project was calibrated in June 30, 2023 and had energy ratio of 84.7 percent in obtaining industry standard N-values (N_{60} -values).

The drilling crew visually classified the soil samples then secured them in glass jars and cardboard boxes and delivered them to accredited CTL laboratory for further testing and analyses. A CTL geologist reclassified the soil and rock samples and performed laboratory testing on representative samples under the direction of the Geotechnical Engineer. The laboratory testing included hand penetrometer, moisture content, grain size distribution, and Atterberg limits. During the scoping and fee preparation we understood that the roadway work is very limited in size and chemical stabilization will not be considered, thus CTL eliminated the sulfate testing. Appendices A and B include boring location plan, test boring/lab records and rock core report.

Dynotec, representative of Mott MacDonald, provided the Stations, offsets, coordinates, and ground surface elevations at the test boring locations.

V. FINDINGS

A. Surface Materials:

The pavement section at soil borings B-004 and B-006 consisted of 12 inches of concrete and 12 inches of asphalt respectively. The surface material at the remaining borings consisted of about 12 inches of topsoil and/or topsoil/gravel mix.

B. Subsurface Soils and Rock:

The subsurface materials consisted of embankment fill material extending to depths varying from about 3 to 22 feet below existing grades. The fill consisted of variable material generally of medium dense gravel with sand and silt (A-2-4), medium dense to dense isolated silt pockets (A-4b), stiff to very stiff to hard silt and clay (A-6a), and sandy silt (A-4a).

The natural soil consisted of very stiff to hard clay (A-7-6), sandy silt (A-4a), silt and clay (A-6a), or medium dense to dense gravel with sand and silt (A-2-4), isolated silt pockets (A-4b), and gravel with sand, silt and clay (A-2-6).

Severely weathered, very weak grey shale and isolated fine-grained sandstone was noted at borings B-004 to B-008 at depths ranging from 37 to 68 feet below existing grades (about elevations ranging from 751 feet to 740 feet).



The standard penetration test (SPT, N_{60}) values and moisture content in the upper 10 feet ranged from 7 to over 50 blows per foot (bpf) and from 8 to 31 percent, respectively. The SPT and moisture content of the overburden soil below 10 feet ranged from 10 to over 50 blows per foot (bpf) and from 7 to 20 percent respectively. The Liquid Limits and Plasticity Index of the cohesive soils ranged from 20 to 47 percent and from 4 to 23 percent respectively.

Based on historical boring data, the subsurface material at borings consisted of very stiff to hard alternating layers of silt and clay (A-6a) and sandy silt (A-4a).

C. Groundwater:

Groundwater was noted only at B-003 during drilling at about 14 feet below existing grades (elevation 780.4).

VI. ANALYSES AND RECOMMENDATIONS

CTL performed subgrade, slope stability, and driven pile lateral capacity analyses based on the soil data obtained from the field and laboratory testing, and available plans.

A. Subgrades Analyses

CTL performed subgrade analyses in accordance with ODOT Geotechnical Design Manual using Roadway Subgrade Analyses Spreadsheet. The soil consistencies, moisture contents, indices, and pavement design parameters within the upper 3 feet of design and existing subgrades are summarized in Tables 4A and 4B below.

Table 4A: Summary of Subgrade Analyses

Reference Alignment	Lowest SPT Values (N_{60L})			In-Situ Moisture Content (%)			Estimated Optimum Moisture (%)		
	Low	High	Avg.	Low	High	Avg.	Low	High	Avg.
Ramp T	8	17	12	9	25	14	8	21	13

Table 4B: Summary of Subgrade Analyses

Reference Alignment	Plasticity Index (PI)			Group Index (GI)			Design C.B.R (%)
	Low	High	Avg.	Low	High	Avg.	
Ramp T	4	18	10	0	8	4	8

Analyses indicated that the subgrades along Ramp T at soil Boring B-004 near the bridge rear abutment approach exhibited marginally low Standard Penetration (SPT) and marginally high moisture content above anticipated optimum moisture.

B. Subgrade Stabilization Options

Based on our Subgrade Analyses (ODOT Spreadsheet in Appendix C) and interpolation, the subgrades along Ramp T from about Station 328+45 to the proposed bridge rear abutment at about Station 329+90 may exhibit marginally low Standard Penetration (SPT) and marginally high moisture content above anticipated optimum moisture. Per our discussion with ODOT Central Office and District 12, no subgrade stabilization is to be pre-considered for this project. The actual depth of excavation and replacement of subgrades should be based on proof roll test during construction. The Project Engineer in the field based upon proof rolling will determine the actual depths and limits of excavation/replacement. However, if the weather and schedule permit, drying and recompacting the top 12 inches of the subgrades may be considered.

The material to be excavated should be replaced with ODOT Item 703.16.C, Granular Material underlain by ODOT Item 712.09, Geotextile Fabric. Subgrade improvements should extend the entire pavement width and any paved shoulder sections including curbs and gutters and an additional 12 inches beyond the edge of the pavement.

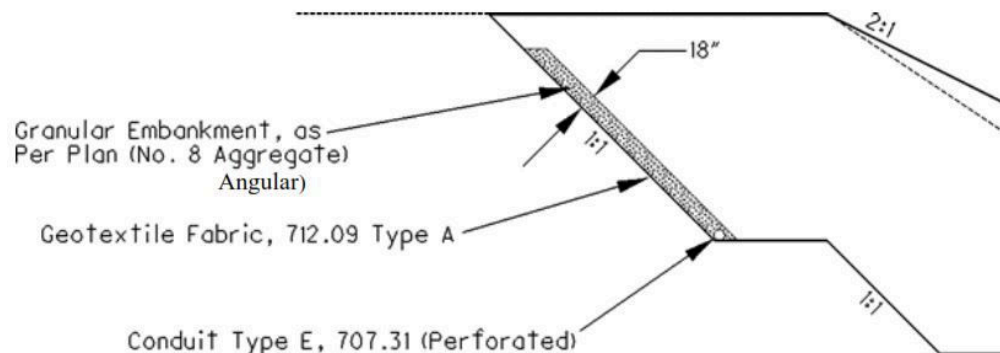
Group Index (GI) values were calculated for each of the soil samples tested. Group Index values ranged from 0 to 8 with an average of 4. Based on the GI, CTL recommend a design CBR of 8.

C. Embankment

Construction:

The project consists of widening the existing embankment of Ramp T. The widening consists of sidehill sliver fills over existing slight slopes that are steeper than 4H:1V. CTL in coordination with Mott MacDonald designed the widening of the embankment in accordance with ODOT Geotechnical Design Manual Section 805 Sidehill Sliver Fill on a Slight Slope where applicable and/or Section 803 General Case: Special Benched Embankment Construction.

Perforated slope drains shall be installed in seepage zone if encountered in accordance with ODOT Geotechnical Design Manual as shown on schematic below. All surface water and encountered seepage water should be diverted away from the slope or controlled and allowed to drain with erosion protection.



All embankments should be constructed per ODOT Item 203.

Embankment Stability Analyses

CTL considered four (4) slope sections along Ramp T at Stations 329+61, 334+10, 335+00, and 335+33 to be most critical for the slope stability analyses. The slope stability analyses were performed using Slide 2018, a 2-dimensional limiting equilibrium program. The soil profile was based on soil boring performed and available historic borings along the slopes. Random failure surfaces in the 100's were generated and analyzed in terms of factor of safety (FOS) against slope failure. The minimum factor of safety obtained for the proposed sections are summarized in Table 5. The summaries of the stability analyses including slope stability methods, soil layers and parameters are included in Appendix D.

Table 5: Summary Results of Slope Stability Analyses

Section (Station)	Average Minimum FOS		Required FOS
	Total Stress	Effective Stress	
329+61	1.8	1.7	≥ 1.5
334+10	3.3	1.5	≥ 1.5
335+00	3.3	1.6	≥ 1.3
335+33	3.8	1.8	≥ 1.3

For this project, the required minimum FOS of is 1.5 for the sections at the bridge abutments and 1.3 for the sections away from the bridge. The slope stability analyses indicated that the minimum FOS's were all well over 1.5 for both the long and short-term stability.

The embankment should be constructed per ODOT Item 203 and in conformance with ODOT Geotechnical Design Manual with perforated slope drains when/where required as indicated previously in this report.

D. Bridge Foundation

CTL Draft Exploration Report included options for conventional foundation and friction piles. However, per our discussion with Mott MacDonald, we understood that ODOT and the design team prefer driven H Piles for the support of the bridge. HP10x42 is the preferred pile.

Pile Foundation

Based on the soil borings and provided information, the bridge abutments and piers can be supported on deep foundation such as driven H piles. H piles driven to practical refusal into the underlying bedrock can be used. The maximum factored structural resistance R_R max for piles driven to practical refusal into bedrock is 310 kips for HP 10x42. The R_R max is valid for piles that are not subjected to bending moments or for piles that are supported by soil for their entire length. The estimated tip elevations, embedment length, and pay length for H Piles driven to practical refusal onto bedrock are tabulated below.

Table 6: Estimated H Pile Lengths Driven to Practical Refusal onto Bedrock.

Structure	Pile Cutoff Elevation (ft)	Pile Tip Elevation (ft)	Estimated Pile Length (ft)	Order Pay Length (ft)*
Rear Abut. (B-004)	801.2	745.8	60	65
Pier 1 (B-005)	785.5	747.4	40	45
Pier 2 (B-006)	785.5	749.0	40	45
Pier 3 (B-007)	785.0	749.0	40	45
Forward Abut. (B-008)	795.0	739.2	60	65

**Order Pay Length and Estimated Pile Length were provided in accordance with BDM Section 305.3.5.2*

H Piles driven to practical refusal into bedrock will encounter driving difficulties into hard or dense to very dense overburden soils. In addition, a 3-foot-thick cobble zone or previous construction debris was noted in Boring B-008 from 25 to 28 feet deep below grades (about elevations 782.7 to 779.7 feet) which is about 11 to 12 feet below pile cap. Contractor shall be prepared to encounter these conditions that may impact pile driving at this site. Pre-drilling may be considered for obstruction to pile driving installation.

CTL performed Drivability Analyses for an HP 10x42 and DELMAG D 19-42 Hammer using GRLWEAP 14. The analyses were based on pile capacity calculation using APILE at the Rear abutment which is deemed to be the most critical location in term of drivability. The results of GRLWEAP and APILE are included in Appendix E. Based on the results we believe that the DELMAG D-19-42 is able to drive the pile to practical refusal into rock. The pile is expected to be stressed to about 67 % of it is yielding stress (below the limit of 90 %) during driving.

All driven Piles should be furnished and driven in accordance with ODOT CMS Items 507 and 523. Stress applied to the pile from the pile-driving hammer should be monitored during driving so as not to damage the pile. A Pile Driving Analyzer (PDA) should be used to monitor the pile during driving and to determine the driving criteria of the piles to avoid pile damage.

E. Seismic Coefficients

Based on the soil type and the Standard Penetration Testing (SPT), the Site Class for the project is Class D. This Site Class was determined using the information obtained in the test borings as well as published information in the vicinity of the project site.

F. Retaining Walls

Structural elements subjected to lateral loads may be designed using the parameters listed in Table 7 below. These parameters are based on Rankine Theory and the assumption of a level backfill surface and no excessive hydrostatic pressure. The soil parameters should be adjusted for sloped backfill if any.

Table 7– Lateral Soil Parameters (Retaining Wall - Rankine)

Parameter	Overburden Soils (A-6a)
Moist Unit Weight, pcf	125
Angle of Internal Friction, Degrees	30
Soil Cohesion (c), psf	Ignore
Soil/Concrete Friction, Degrees	20
At Rest Earth Pressure Coefficient, K_o	0.50
Active Earth Pressure Coefficient, K_a	0.33
Passive Earth Pressure Coefficient, K_p *	3.03

** Passive resistance should be ignored in the upper 3.5 feet.*

Lateral pressure arising from surcharge loading should be added to the above soil earth pressures to determine the total lateral pressures that the walls must resist. In addition, transient loads imposed on the walls by construction equipment during backfilling should be taken into consideration during design and construction. Excessively heavy grading and construction equipment (that could impose temporary excessive pressures or long-term excessive pressures against the constructed walls) should not be allowed within five (5) feet (horizontally) of the walls.

Excavation (permanent or temporary) should be either shored or sloped for stability purposes. Temporary retaining walls (shoring) should be designed utilizing the relevant soil parameters shown in the Table 7 above.

Retaining walls such as abutments shall be backfilled in accordance with ODOT C&MS Item 518.

It is recommended those walls which are restrained from rotating be designed based on at-rest earth pressure conditions, and those walls which are allowed to rotate be designed based on the active earth pressure conditions.

G. Lateral Pile

Per Mott MacDonald, the H piles for the abutments support will be subject to a maximum Factored Load of 8.6 kips per pile. CTL performed Lateral Load Analyses using L-Pile software. The soil parameters and the Lateral Load Analyses are included in Appendix F. Per our discussion with Mott MacDonald based on the results of Deflection (0.3 inch), Maximum Shear (9 kips), and Bending (42 kip-ft), the HP 10X42 is considered acceptable.

H. General Construction and Earthwork

1. Site preparation and earthwork should be performed in accordance with the ODOT Construction and Material Specifications 200/201, 202, 203, 204, and 206.
2. All fill over slopes shall be overfilled to achieve compaction along the slope face, and then cut back the overfill material to the finish grade.
3. Filter fabric should be used to separate open graded material from fine-grained soils to prevent migration of fines.
4. Embankment side slopes should be seeded and vegetation growth permitted to limit erosion, sloughing and slope failure.
5. Temporary excavations in excess of 4 feet in depth should be sloped or shored according to OSHA requirements.

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 be 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.



Matthew Kairouz, P.E.
Project Manager



APPENDIX A

▣ PLAN AND SOIL PROFILE SHEETS

PROJECT DESCRIPTION

CUY-71-10.07 SW IS THE I-71 NB EXIT RAMP TO I-480 WB. THIS RAMP IS KNOWN AS RAMP T. RAMP T INCLUDES ROADWAY EMBANKMENT AND A 4-SPAN SINGLE LANE BRIDGE OVER I-480. THE PROJECT CONSISTS OF WIDENING AND REPLACING THE EXISTING BRIDGE IN ADDITION TO WIDENING THE EXITING ROADWAY EARTHEN EMBANKMENT. THE WIDENING OF THE ROADWAY WILL REQUIRE SLIVER FILL TO BE CONSTRUCTED AT A GRADE OF 2H: 1V OVER THE EXISTING SLOPES.

HISTORIC RECORDS

HISTORICAL GEOTECHNICAL RECORDS WERE OBTAINED FROM ODOT'S TRANSPORTATION INFORMATION MAPPING SYSTEM (TIMS) FOR CUY- 480-8.72 COMPLETED IN 1965 FOR THE CURRENT ROADWAY ALIGNMENT. RESULTS OF THESE EXPLORATIONS INDICATED THAT THE SUBSURFACE MATERIAL CONSISTED OF ALTERNATING LAYERS OF VERY STIFF TO HARD SILT AND CLAY (A- 6A) AND SANDY SILT (A- 4A). THESE RESULTS WERE UTILIZED DURING THE CURRENT DESIGN. ONE HISTORIC BORING B-010-0-65 WAS INCLUDED.

GEOLOGY

ACCORDING TO THE OHIO DEPARTMENT OF NATURAL RESOURCES' DIVISION OF GEOLOGICAL SURVEY, THE PROJECT SITE IS LOCATED WITHIN LAVERY TILL OF DARK GRAY TO DARK BROWN SILTY TO CLAYEY STRONGLY CALCAREOUS COHESIVE DEPOSITS AND WITHIN FINITE MADE LAND AREAS OF RECLAIMED LAND, CUT AND FILL, DUMPS, AND URBAN COVER. THE BEDROCK GEOLOGY OF THE PROJECT SITE IS MISSISSIPPIAN- AGE BEREA SANDSTONE, AND OHIO SHALE.

SUBSURFACE EXPLORATION

DURING THE PERIOD OF JULY 20 TO JULY 27, 2023 CTL ENGINEERING ADVANCED TEN (10) SOIL BORINGS IDENTIFIED AS B-001-0-23 TO B-010-0-23 TO DEPTHS RANGING FROM 7.5 TO ABOUT 70 FEET BELOW EXISTING GRADES. THE DRILLERS OBTAINED SPLIT SPOON SOIL SAMPLES AT 2.5- FOOT INTERVAL IN THE UPPER 20 FEET AND AT 5- FOOT INTERVAL THEREAFTER. THE DRILLING CREW OBTAINED 10- FOOT NQ ROCK CORE SAMPLES FROM BORINGS B-005-0-23 THROUGH B-007-0-23. THE SPLIT SPOON SAMPLES WERE OBTAINED IN ACCORDANCE WITH STANDARD PENETRATION (SPT) PROCEDURE. THE SPT CONSISTS OF DRIVING A 2.0-INCH OUTSIDE DIAMETER (OD) SPLIT-SPOON SAMPLER 18 INCHES INTO THE SOIL WITH AN AUTOMATIC 140-POUND HAMMER FALLING 30 INCHES. THE SPT HAMMER USED FOR THIS PROJECT WAS CALIBRATED IN JUNE 30, 2023 AND HAD ENERGY RATIO OF 84.7 PERCENT IN OBTAINING INDUSTRY STANDARD N-VALUES (N₆₀-VALUES).

THE DRILLING CREW VISUALLY CLASSIFIED THE SOIL SAMPLES THEN SECURED THEM IN GLASS JARS AND CARD BOARD BOXES AND DELIVERED THEM TO ACCREDITED CTL LABORATORY FOR FURTHER TESTING AND ANALYSIS. A CTL GEOLOGIST RECLASSIFIED THE SOIL AND ROCK SAMPLES AND PERFORMED LABORATORY TESTING ON REPRESENTATIVE SAMPLES UNDER THE DIRECTION OF THE GEOTECHNICAL ENGINEER. THE LABORATORY TESTING INCLUDED HAND PENETROMETER, MOISTURE CONTENT, GRAIN SIZE DISTRIBUTION, AND ATTERBERG LIMITS.

EXPLORATION FINDINGS

THE PAVEMENT SECTION AT SOIL BORINGS B-004 AND B-006 CONSISTED OF 12 INCHES OF CONCRETE AND 12 INCHES OF ASPHALT RESPECTIVELY. THE SURFACE MATERIAL AT THE REMAINING BORINGS CONSISTED OF ABOUT 12 INCHES OF TOPSOIL AND/OR TOPSOIL/GRAVEL MIX.

THE SUBSURFACE MATERIALS CONSISTED OF EMBANKMENT FILL MATERIAL EXTENDING TO DEPTHS VARYING FROM ABOUT 3 TO 22 FEET BELOW EXISTING GRADES. THE FILL CONSISTED OF VARIABLE MATERIAL GENERALLY OF MEDIUM DENSE GRAVEL WITH SAND AND SILT (A-2-4), MEDIUM DENSE TO DENSE ISOLATED SILT POCKETS (A-4B), STIFF TO VERY STIFF TO HARD SILT AND CLAY (A-6A), AND SANDY SILT (A-4A). THE NATURAL SOIL CONSISTED OF VERY STIFF TO HARD CLAY (A-7-6), SANDY SILT (A-4A), SILT AND CLAY (A-6A), OR MEDIUM DENSE TO DENSE GRAVEL WITH SAND AND SILT (A-2-4), ISOLATED SILT POCKETS (A-4B), AND GRAVEL WITH SAND, SILT AND CLAY (A-2-6).

SEVERELY WEATHERED, VERY WEAK GREY SHALE AND ISOLATED FINE- GRAINED SANDSTONE WAS NOTED AT BORINGS B-004 TO B-008 AT DEPTHS RANGING FROM 37 TO 68 FEET BELOW EXISTING GRADES (ABOUT ELEVATIONS RANGING FROM 751 FEET TO 740 FEET).

THE STANDARD PENETRATION TEST (SPT, N₆₀) VALUES AND MOISTURE CONTENT IN THE UPPER 10 FEET RANGED FROM 7 TO OVER 50 BLOWS PER FOOT (BPF) AND FROM 8 TO 31 PERCENT, RESPECTIVELY. THE SPT AND MOISTURE CONTENT OF THE OVERBURDEN SOIL BELOW 10 FEET RANGED FROM 10 TO OVER 50 BLOWS PER FOOT (BPF) AND FROM 7 TO 20 PERCENT RESPECTIVELY. THE LIQUID LIMITS AND PLASTICITY INDEX OF THE COHESIVE SOILS RANGED FROM 20 TO 47 PERCENT AND FROM 4 TO 23 PERCENT RESPECTIVELY.

LEGEND

DESCRIPTION	ODOT CLASS	CLASSIFIED MECH./VISUAL	
GRAVEL AND/OR STONE FRAGMENTS WITH SAND	A-1-b (0)	2	0
GRAVEL AND/OR STONE FRAGMENTS W/SAND AND SILT	A-2-4 (0)	4	2
GRAVEL AND/OR STONE FRAGMENTS W/SAND, SILT AND CLAY	A-2-6 (0)	3	1
COARSE AND FINE SAND	A-3a (0)	2	1
SANDY SILT	A-4a (5)	14	13
SILT	A-4b (7)	4	3
SILT AND CLAY	A-6a (6)	11	16
SILTY CLAY	A-6b (12)	2	6
CLAY	A-7-6 (10)	5	17
	TOTAL	47	59
SANDSTONE	VISUAL		
SHALE	VISUAL		
PAVEMENT OR BASE = X = APPROXIMATE THICKNESS	VISUAL		
SOD AND TOPSOIL = X = APPROXIMATE THICKNESS	VISUAL		
BORING LOCATION - PLAN VIEW			
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.		
●	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.		

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 JULY 2023.

AVAILABLE INFORMATION

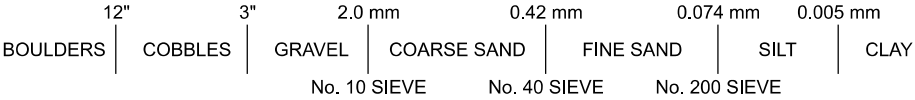
THE SOIL, BEDROCK, AND GROUNDWATER INFORMATION COLLECTED FOR THIS SUBSURFACE EXPLORATION THAT CAN BE CONVENIENTLY DISPLAYED ON THE SOIL PROFILE SHEETS HAS BEEN PRESENTED. GEOTECHNICAL REPORTS, IF PREPARED, ARE AVAILABLE FOR REVIEW ON THE OFFICE OF CONTRACT SALES WEBSITE.



LOCATION MAP
SCALE : NOT TO SCALE



PARTICLE SIZE DEFINITIONS



INDEX OF SHEETS						
SUMMARY OF SOIL TEST DATA 2						
LOCATION FROM STA. TO STA.		PLAN VIEW SHEET	PROFILE SHEET	CROSS- SECTION SHEET	CUT MAX.	FILL EMB. MAX.
RAMP T						
322+00	334+50	3	3	-	-	-
334+50	342+00	4	4	-	-	-
RAMP T						
329+00	334+50	5	5	-	-	0.4
CROSS SECTION						
329+60.81		-	-	6	-	6.0
335+00.00		-	-	7	-	4.0
BORING LOGS / ROCK CORE PHOTOS SHEETS 8 TO 20						

RECON. - HMK 07/10/2023
DRILLING - ADAM/CTL (D-50 TRACK) 07/20/2023 - 07/27/2023
DRAWN - NKS 12/04/2023
REVIEWED - HMK 12/04/2023

CUY-71-10.07 SW

MODEL: Sheet PAPER SIZE: 11x17 (in.) DATE: 04-12-2023 TIME: 02:16:14 USER: hp
D:\Drop_Box\CTL_2023\December\Dept_05\CLE\Matthew\23050013CLE_ODOT\Mod_01.12.23\114536ID001.dgn



SUMMARY OF SOIL TEST DATA
I-71

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-001-0-23	01.00-02.50	SS-1	17	100	-	49	6	9	27	9	28	24	4	25	A-4a (0)	-
STA. 326+04, 7' RT.	03.50-05.00	SS-2	24	100	-	11	10	10	53	16	22	18	4	10	A-4b (7)	-
LATITUDE = 41.419366																
LONGITUDE = -81.816436	06.00-07.50	SS-3	21	100	-				SAME AS SS-2					16	A-4b (VISUAL)	-
B-002-0-23	01.00-02.50	SS-1	13	100	4.50	0	12	15	51	22	31	20	11	12	A-6a (8)	-
STA. 327+23, 15' RT.	03.50-05.00	SS-2	20	100	-	57	4	5	18	16	36	20	16	9	A-2-6 (1)	-
LATITUDE = 41.419637	06.00-07.50	SS-3	13	100	-				SAME AS SS-2					12	A-2-6 (VISUAL)	-
LONGITUDE = -81.816197	08.50-10.00	SS-4	45	100	-	3	32	31	31	3	NP	NP	NP	11	A-3a (0)	-
FOR STRUCTURE AND EMBANKMENT BORINGS B-003-0-23 TO B-009-0-23 AND B-010-0-65 SEE BORING LOGS ON SHEETS 8 TO 15 AND 17 TO 23 RESPECTIVELY.																
B-010-0-23	01.00-02.50	SS-1	13	100	2.25	40	9	9	34	8	42	24	18	14	A-7-6 (4)	-
STA. 338+86, 7' RT.	03.50-05.00	SS-2	25	100	-	44	10	7	31	8	34	26	8	18	A-4a (1)	-
LATITUDE = 41.421482	06.00-07.50	SS-3	37	100	-				SAME AS SS-2					11	A-4a (VISUAL)	-
LONGITUDE = -81.812902																

DESIGN AGENCY



CTL
ENGINEERING
677 ENGINE RD. SUITE 111
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FAX (216) 266-5267

DESIGNER

N.K.S

REVIEWER

HMK 12-04-23

PROJECT ID

114536

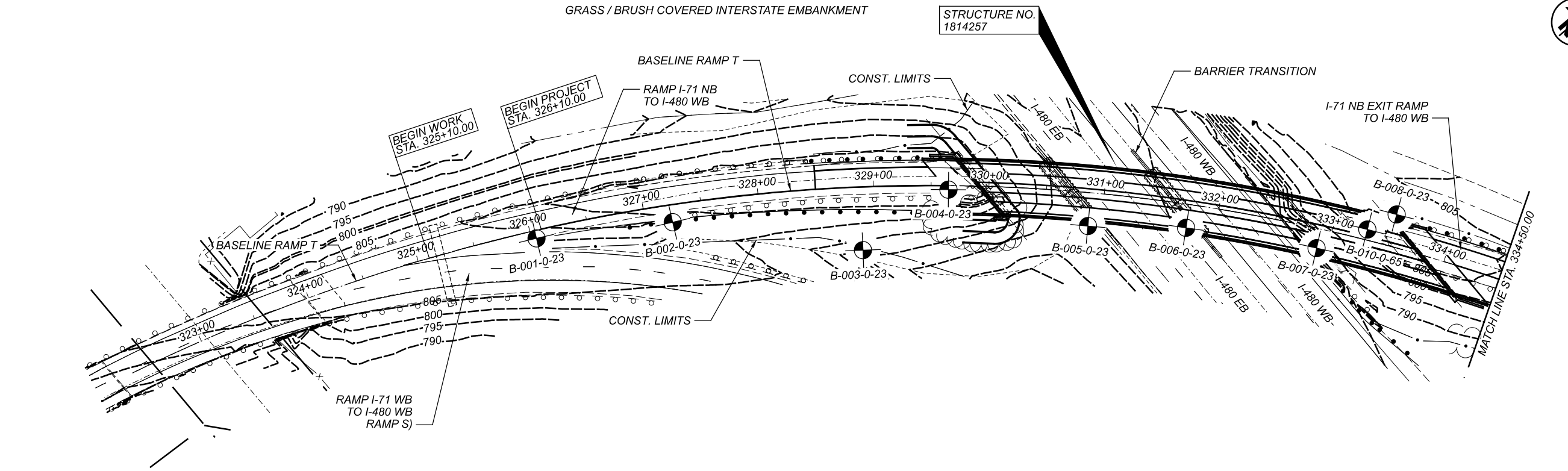
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2 20

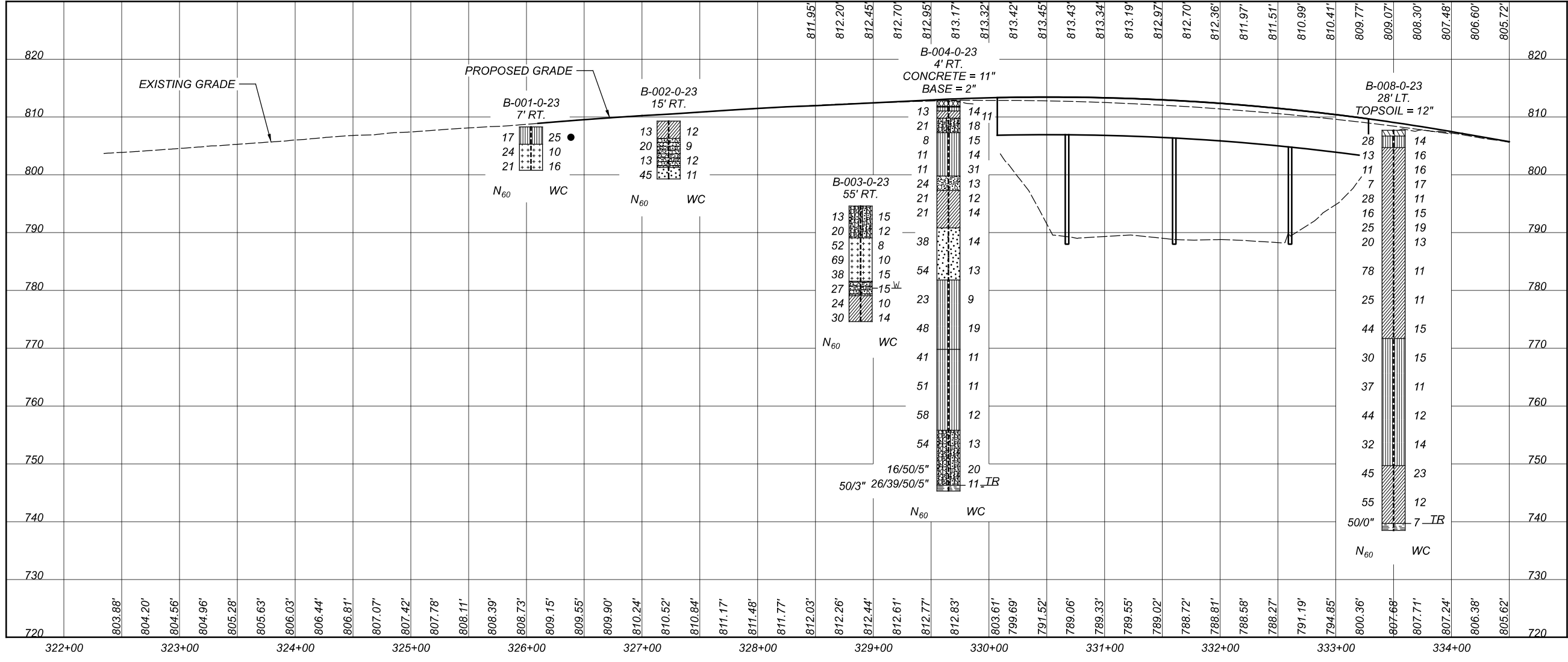
SHEET TOTAL

1 1

GEOTECHNICAL PROFILE - ROADWAY
SUMMARY OF SOIL TEST DATA



NOTE: SEE SHEET 05 OF 23 FOR BORINGS B-005-0-23, B-006-0-23, B-007-0-23 & B-010-0-65 SOIL PROFILE.



HORIZONTAL
SCALE IN FEET
0 25 50 100

GEOTECHNICAL PROFILE - ROADWAY
STA. 322+00.00 TO STA. 334+50.00

DESIGN AGENCY
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REVIEWER
HMK 12-04-23

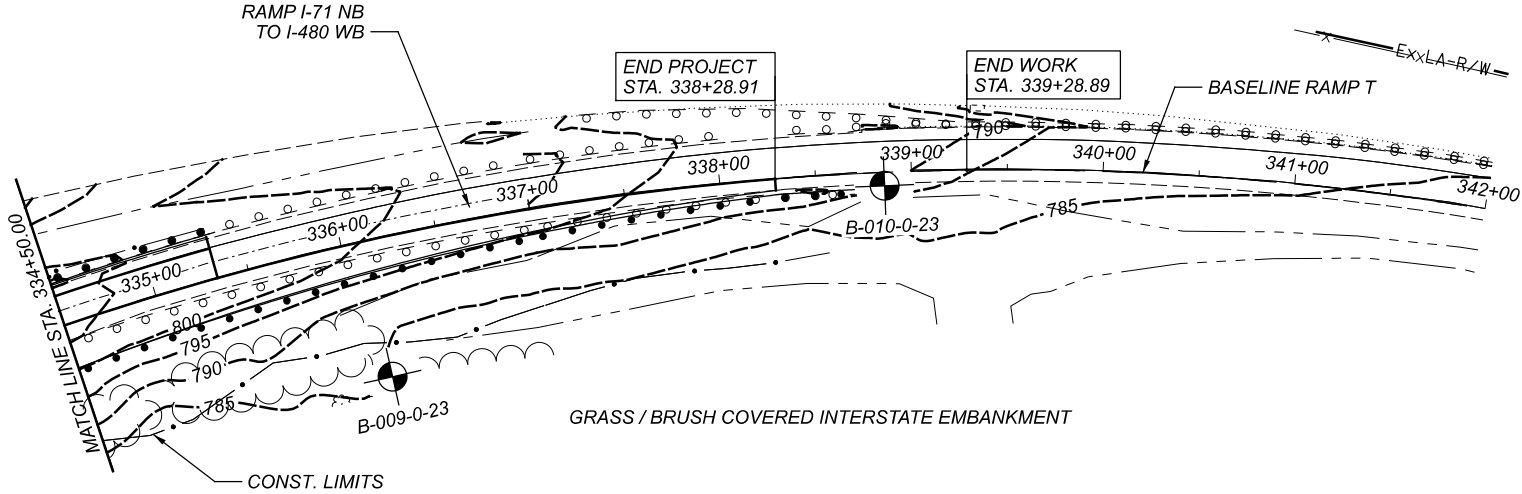
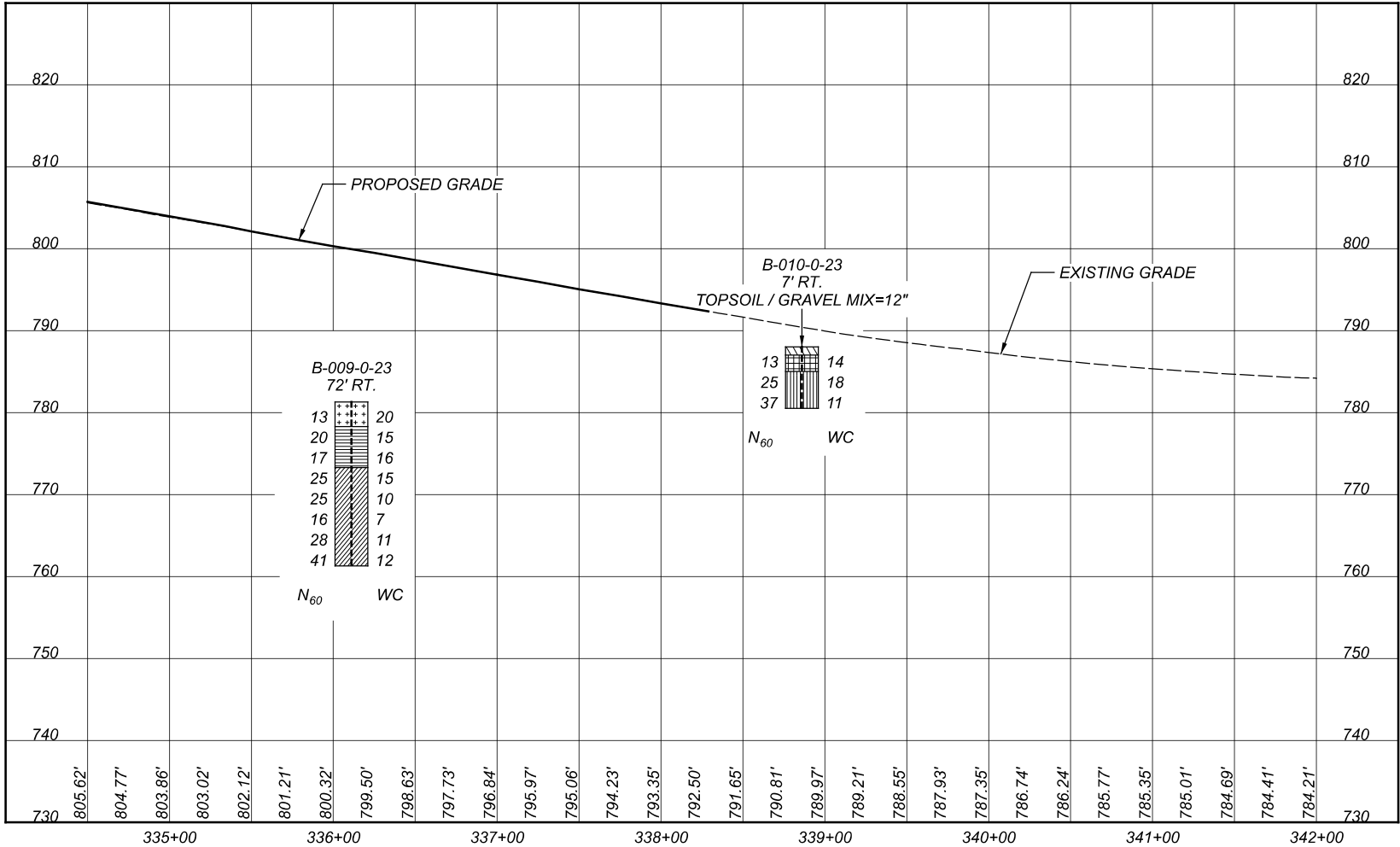
PROJECT ID
114536

SUBSET
3

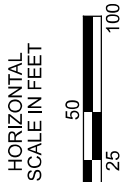
TOTAL
20

SHEET
A

TOTAL
-



GEOTECHNICAL PROFILE - ROADWAY
STA. 334+50.00 TO STA. 342+00.00



DESIGN AGENCY



DESIGNER

N.K.S

REVIEWER

HMK 12-04-23

PROJECT ID

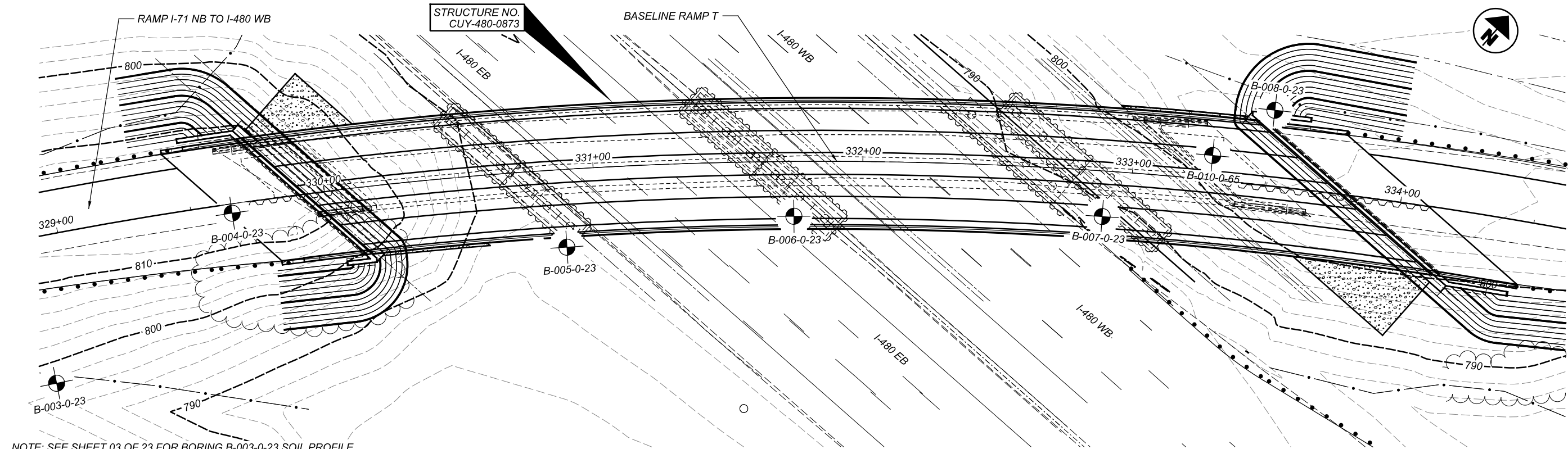
114536

SUBSET TOTAL

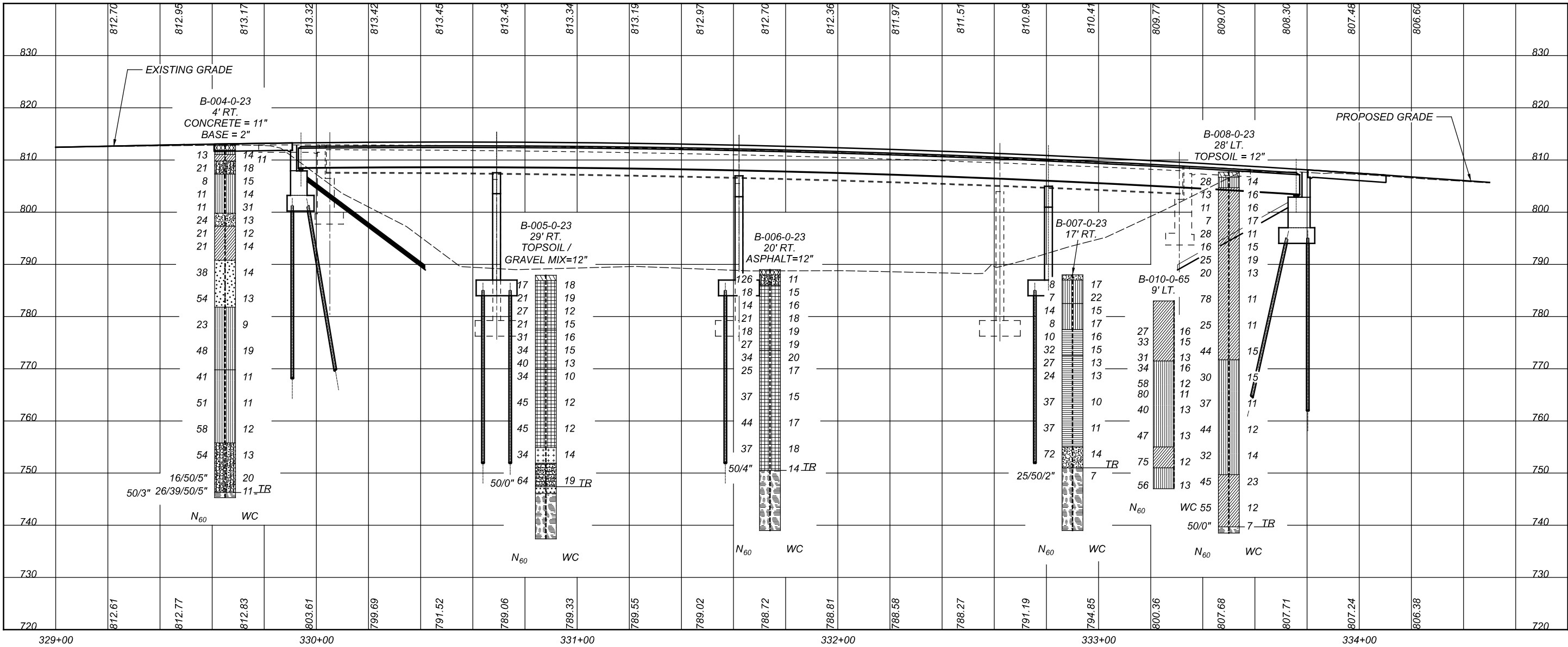
4 20

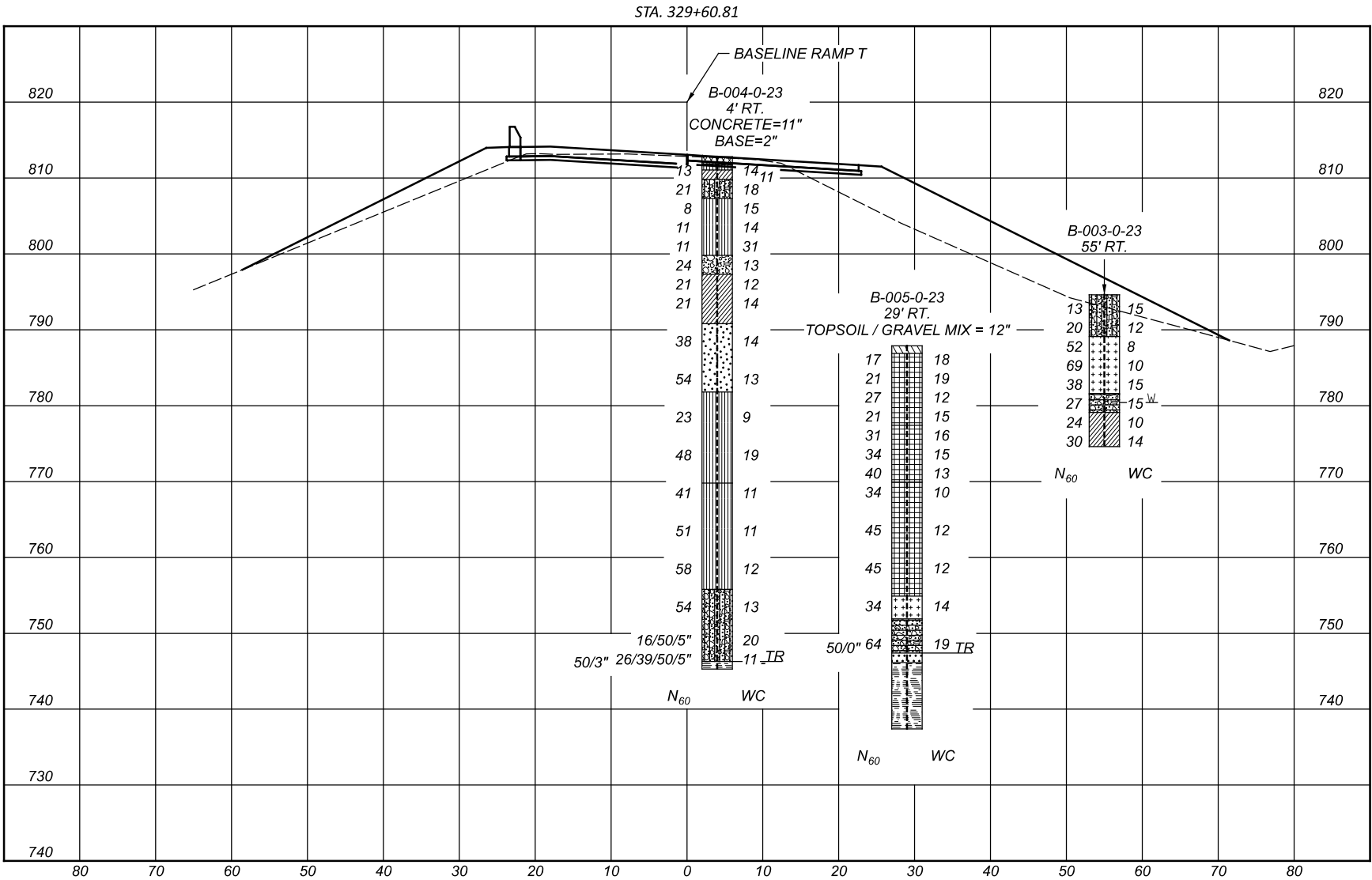
SHEET TOTAL

1 -



NOTE: SEE SHEET 03 OF 23 FOR BORING B-003-0-23 SOIL PROFILE.





GEOTECHNICAL PROFILE - ROADWAY
CROSS SECTION STA. 329+60.81

DESIGN AGENCY

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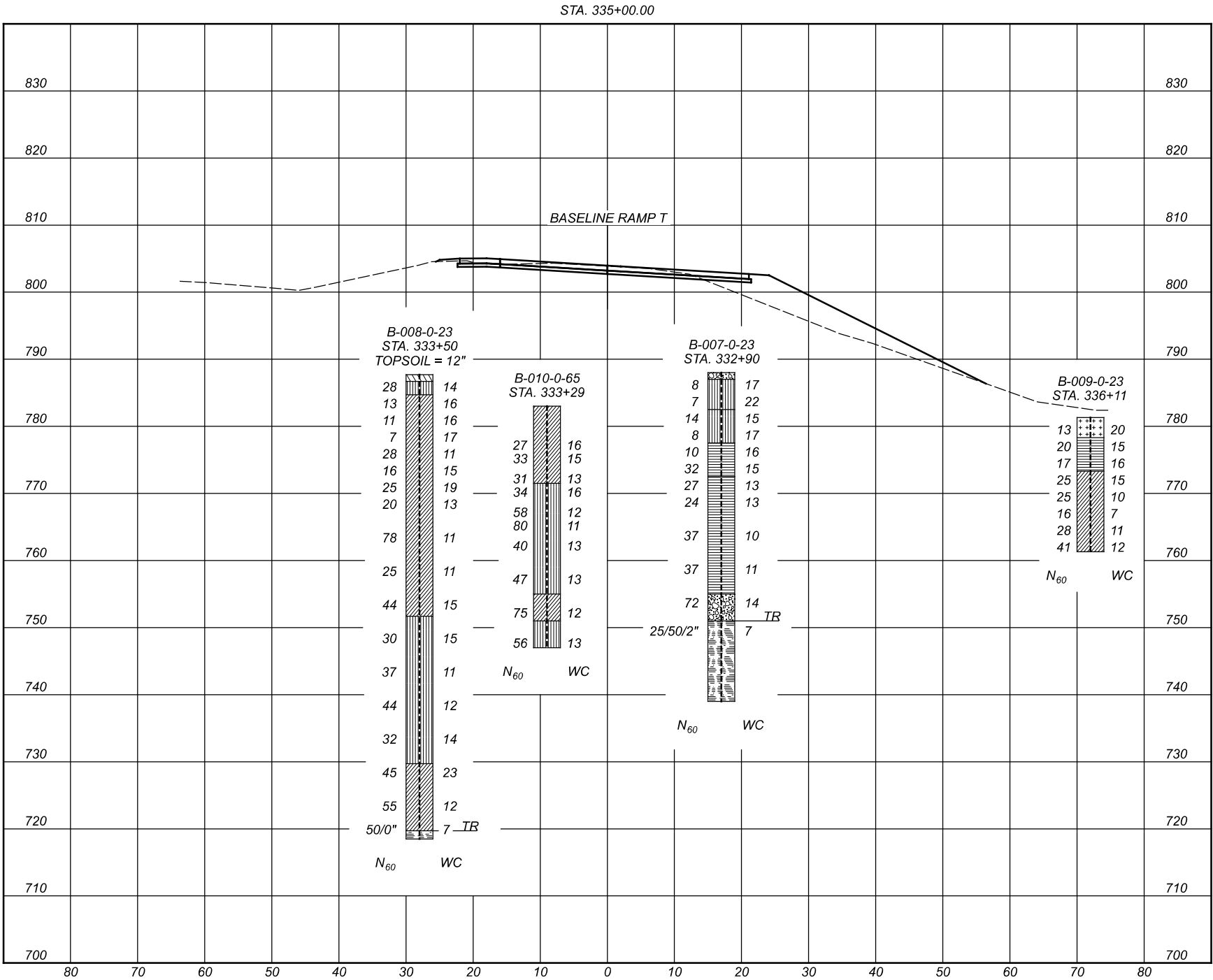
REVIEWER
HMK 12-04-23

PROJECT ID
114536

SUBSET	TOTAL
6	20
SHEET	TOTAL
P:0	0

HORIZONTAL
SCALE IN FEET

0 5 10 20



GEOTECHNICAL PROFILE - ROADWAY
CROSS SECTION STA. 335+00.00

PROJECT: CUY-71-10.07 SW			DRILLING FIRM / OPERATOR: CTL / ADAM			DRILL RIG: D-50 TRACK CTL			STATION / OFFSET: 328+89, 55' RT.			EXPLORATION ID																											
TYPE: ROADWAY			SAMPLING FIRM / LOGGER: CTL / ADAM			HAMMER: CME AUTOMATIC			ALIGNMENT: RAMP T			B-003-0-23																											
PID: 114536 SFN:			DRILLING METHOD: 3.25" HSA			CALIBRATION DATE: 6-30-23			ELEVATION: 794.6 (MSL) EOB: 20.0 ft.			PAGE																											
START: 7-24-23 END: 7-24-23			SAMPLING METHOD: SPT			ENERGY RATIO (%): 84.7			LAT / LONG: 41.419937, -81.815740			1 OF 1																											
MATERIAL DESCRIPTION AND NOTES						ELEV.		DEPTHS		SPT/ RQD		N ₆₀		REC SAMPLE ID		HP (tsf)		GRADATION (%)		ATTERBERG		WC		ODOT CLASS (GI)		SO4 ppm		BACK FILL											
MEDIUM DENSE, BROWNISH GREY, GRAVEL AND STONE FRAGMENTS WITH SAND AND SILT, MOIST (FILL)						794.6		1		3 4 5		13		100 SS-1		44		18 18 2		29 22 7		15		A-2-4 (0)		-													
								2																															
								3																															
								4																															
								5																															
DENSE TO VERY DENSE, BLACK, SILT, LITTLE SAND, GRAVEL, MOIST						789.1		6		6 7 7		20		100 SS-2										12		A-2-4 (V)		-											
								7																															
								8																															
								9																															
								10																															
MEDIUM DENSE, GREY, GRAVEL WITH SAND, SILT, AND CLAY, WET						781.6		11		12 17 20		52		100 SS-3		20		9		6		62		3		NP		NP		8		A-4b (6)		-					
								12																															
								13																															
								14																															
								15																															
VERY STIFF TO HARD, BROWN, SILT AND CLAY, WITH SAND, WET						779.1		16		8 9 11		27		100 SS-6		71		4		4		13		8		35		24		11		15		A-2-6 (0)		-			
								17																															
								18																															
								19																															
								20																															

STANDARD ODOT LOG W/ SULFATES (11 X 17) - OH DOT GDT - 31-8-23 16:08 - G:\2023\AUGUST\ST28\23050013CLE\23020013CLE.GPJ

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: AUGER CUTTINGS

CUY-71-10.07 SW

MODEL: Sheet PAPER SIZE: 17x11 (in.) DATE: 04-12-2023 TIME: 02:48:36 USER: hp
D:\Drop_Box\CTL 2023\December\Dept 05\CLE\Matthew\23050013CLE_ODOT\Mod_01_12_23\114536Z\002.dgn

PROJECT: CUY-71-10.07 SW				DRILLING FIRM / OPERATOR: CTL / ADAM				DRILL RIG: D-50 TRACK CTL				STATION / OFFSET: 329+65, 4' RT.				EXPLORATION ID	
TYPE: BRIDGE				SAMPLING FIRM / LOGGER: CTL / ADAM				HAMMER: CME AUTOMATIC				ALIGNMENT: RAMP T				B-004-0-23	
PID: 114536 SFN: 1814257				DRILLING METHOD: 3.25" HSA				CALIBRATION DATE: 6-30-23				ELEVATION: 812.8 (MSL) EOB: 67.5 ft.				PAGE	
START: 7-27-23 END: 7-27-23				SAMPLING METHOD: SPT				ENERGY RATIO (%): 84.7				LAT / LONG: 41.420185, -81.815711				1 OF 2	
MATERIAL DESCRIPTION AND NOTES				ELEV. 812.8		DEPTHS		REC SAMPLE ID		GRADATION (%)		ATTERBERG		WC		SO4 ppm	
								N ₆₀		HP (tsf)		GR CS FS SI CL		LL PL PI			
CONCRETE (11")				811.9		1											
	BASE (2")			811.7		2		13		SS-1A		51 8 5 28 8		NP NP NP		14	
	MEDIUM DENSE, GREY, SANDY SILT, AND GRAVEL, TRACE CLAY, MOIST (FILL)			811.1		3		4		4.50 0 6 6 71 17 29 18 11		8 71 17 29 18 11		11		A-4a (0)	
	HARD, GREY, SILT AND CLAY, LITTLE SAND, MOIST (FILL)			809.8		4		21		67		SS-2		4 6 21 12 34 25 9		18	
	MEDIUM DENSE, GREY, GRAVEL AND STONE FRAGMENTS WITH SAND AND SILT, LITTLE CLAY, MOIST (FILL)			807.3		5		8								A-2-4 (0)	
	STIFF, GREY, SANDY SILT, SOME GRAVEL, CLAY, MOIST (FILL)					6		4		100		SS-3		2.00 34 6 9 30 21 24 16 8		15	
						7		4		2						A-4a (3)	
						8											
						9		11		100		SS-4		2.00 - - - - -		14	
						10		4								A-4a (V)	
MEDIUM DENSE, GREY, GRAVEL AND STONE FRAGMENTS WITH SAND, TRACE SILT, CLAY, MOIST (FILL)				799.8		11		3		100		SS-5		2.00 - - - - -		31	
						12		3		100		SS-6		2.00 - - - - -		A-4a (V)	
						13		5									
						14		9		100		SS-6		- 44 14 23 9 10 24 18 6		13	
						15		8								A-1-b (0)	
						16		7									
						17		21		100		SS-7		4.50 - - - - -		12	
						18		8								A-6a (V)	
						19		21		100		SS-8		3.75 24 8 8 31 29 38 24 14		14	
						20		8								A-6a (7)	
DENSE TO VERY DENSE, DARK GREY, COARSE AND FINE SAND, SOME SILT, LITTLE GRAVEL, MOIST				790.8		21											
						22											
						23											
						24		38		100		SS-9		- 19 19 32 27 3 NP NP NP		14	
						25		10		100		SS-10		- - - - -		A-3a (0)	
						26		17								A-3a (V)	
						27		7		100		SS-11		- - - - -		9	
						28		8								A-4a (V)	
						29		23		100		SS-12		- 25 9 6 43 17 32 24 8		19	
						30		8								A-4a (5)	
MEDIUM DENSE TO DENSE, BROWNISH GREY, SANDY SILT, SOME GRAVEL, LITTLE CLAY, MOIST				781.8		31		6		100		SS-13		- - - - -		11	
						32		13		100		SS-14		- - - - -		A-4a (V)	
						33		16									
						34		9		100		SS-15		- - - - -		11	
						35		17		100		SS-16		- - - - -		A-4a (V)	
						36		14		100		SS-17		- - - - -			
						37		22		100		SS-18		- - - - -			
						38		16		100		SS-19		- - - - -			
						39		13		100		SS-20		- - - - -			
						40		17		100		SS-21		- - - - -			
HARD, GREY, SANDY SILT, SOME GRAVEL, LITTLE CLAY, MOIST				769.8		41		10		100		SS-22		- - - - -		11	
						42		13		100		SS-23		- - - - -		A-4a (V)	
						43		16									
						44		9		100		SS-24		- - - - -		11	
						45		17		100		SS-25		- - - - -		A-4a (V)	
						46		14		100		SS-26		- - - - -			
						47		22		100		SS-27		- - - - -			
						48		16		100		SS-28		- - - - -			
						49		13		100		SS-29		- - - - -			
						50		17		100		SS-30		- - - - -			
DENSE, GREY, GRAVEL AND STONE FRAGMENTS WITH SAND AND SILT, MOIST				755.8		51		10		100		SS-31		- - - - -		11	
						52		13		100		SS-32		- - - - -		A-4a (V)	
						53		16		100		SS-33		- - - - -			
						54		25		100		SS-34		- - - - -			
						55		13		100		SS-35		- - - - -			
						56		16		100		SS-36		- - - - -			
						57		25		100		SS-37		- - - - -			
						58		13		100		SS-38		- - - - -			
						59		16		100		SS-39		- - - - -			
						60		25		100		SS-40		- - - - -			

STANDARD ODOT LOG W/ SULFATES (11 X 17) - G:\2023\DECEMBER\B01\23050013\CLE\23020013\CLE-23_11_30.GPJ

GEOTECHNICAL PROFILE - ROADWAY
BORING LOG B-004-0-23

DESIGN AGENCY



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PHONE: (440) 238-9526
FAX: (440) 238-9528

DESIGNER

N.K.S

REVIEWER

HMK 12-04-23

PROJECT ID

114536

SUBSET

9

TOTAL

20

SHEET

A

TOTAL

-

PID: 114536	SFN: 1814257	PROJECT:	CUY-71-10.07 SW	STATION / OFFSET: 329+65.4' RT.				START: 7-27-23				END: 7-27-23				PG 2 OF 2		B-004-0-23		
MATERIAL DESCRIPTION AND NOTES				ELEV.	DEPTHS	SPT/ RQD	REC SAMPLE N ₆₀ ID (%)	HP (tsf)	GRADATION (%)				ATTERBERG		ODOT CLASS (GI)	SO4 ppm	BACK FILL			
DENSE, GREY, GRAVEL AND STONE FRAGMENTS WITH SAND AND SILT, MOIST (continued)				752.8																
					61															
					62															
					63															
					64	16 50/5"	100	SS-17	-	-	-	-	-	-	-	-	20	A-2-4 (V)	-	
					65															
					66	26 39 50/5"														
SHALE, GREY, SEVERELY WEATHERED, VERY WEAK.				746.3	TR		100	SS-18	-	-	-	-	-	-	11	Rock (V)	-			
				745.3	FOR	50/3"	100	SS-19	-	-	-	-	-	-	-	-	Rock (V)	-		

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: AUGER CUTTINGS

DESIGN AGENCY



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FAX: (440) 238-9528

DESIGNER

N.K.S

REVIEWER

HMK 12-04-23

PROJECT ID

114536

SUBSET

10

TOTAL

20

SHEET

1

TOTAL

1

GEOTECHNICAL PROFILE - ROADWAY

BORING LOG B-004-0-23 CONTINUED

.CUY-71-10.07 SW

MODEL: Sheet PAPER SIZE: 17x11 (in.) DATE: 04-12-2023 TIME: 02:54:28 USER: hp
D:\Drop Box\CTL 2023\December\Dept 05\CLE\Matthew\23050013\CLE_ODOT\Mod_01_12.23\114536ZL004.dgn

PROJECT: CUY-71-10.07 SW				DRILLING FIRM / OPERATOR: CTL / ADAM				DRILL RIG: D-50 TRACK CTL				STATION / OFFSET: 330+88, 29' RT.				EXPLORATION ID: B-005-0-23			
TYPE: BRIDGE				SAMPLING FIRM / LOGGER: CTL / ADAM				HAMMER: CME AUTOMATIC				ALIGNMENT: RAMP T							
PID: 114536 SFN: 1814257				DRILLING METHOD: 3.25' HSA / NX				CALIBRATION DATE: 6-30-23				ELEVATION: 787.9 (MSL) EOB: 50.5 ft.				PAGE 1 OF 1			
START: 7-25-23 END: 7-25-23				SAMPLING METHOD: SPT				ENERGY RATIO (%): 84.7				LAT / LONG: 41.420381, -81.815338							
MATERIAL DESCRIPTION AND NOTES				ELEV. 787.9				REC SAMPLE HP GRADATION (%)				ATTERBERG				SO4 BACK FILL			
				786.9				N ₆₀ (%) ID (tsf) GR CS SI CL PL PI WC ODOT CLASS (gi)											
TOPSOIL/GRAVEL MIX (12")																			
STIFF TO VERY STIFF, BROWN, CLAY, SOME GRAVEL, SAND, SILT, MOIST																			
VERY STIFF TO HARD, BROWN, CLAY, SOME SILT, SAND, MOIST				777.4															
HARD, GREY, CLAY, SOME ROCK FRAGMENTS, MOIST				769.9															
DENSE, GREY, SILT, AND SAND, TRACE CLAY, MOIST				754.9															
VERY DENSE, GREY, GRAVEL AND STONE FRAGMENTS WITH SAND, SILT, AND CLAY, MOIST				751.9															
SANDSTONE, LIGHT GREY, MODERATELY WEATHERED, SLIGHTLY STRONG, FINE GRAINED. SHALE, GREY, SEVERELY WEATHERED, WEAK.				747.4															

STANDARD ODOT LOG W/ SULFATES (11 X 17) - OH DOT.GDT - 1-12-23 18:27 - G:\2023\DECEMBER\10123050013CLE\23020013CLE-23.11.30.GPJ

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: AUGER CUTTINGS:

DESIGN AGENCY



6777 ENGLE RD, BLDG. 11
CLEVELAND, OHIO 44130
PHONE: (440)239-9526
FAX: (440)239-9529

DESIGNER

N.K.S

REVIEWER

HMK 12-04-23

PROJECT ID
114536

SUBSET	TOTAL
11	20

SHEET	TOTAL
2	-

GEOTECHNICAL PROFILE - ROADWAY
BORING LOG B-005-0-23

B-005-0-23



Run #:	Depth	Recovery	RQD
NQ2-1	40.5'	42/60	70% /60
NQ2-2	45.5'	45.6/60	76% 0/60
CUY-71-10.07SW PID 114536			

.CUY-71-10.07 SW

MODEL: Sheet PAPER SIZE: 17x11 (in.) DATE: 04-12-2023 TIME: 02:59:27 USER: hp
D:\Drop Box\CTL 2023\December\Dept 05\CLE\Matthew\23050013\CLE_ODOT\Mod_01_12.23\114536ZL006.dgn

[illegible]

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: AUGER CUTTINGS

DESIGN AGENCY	
	
6777 ENGLE RD. BLDG. 111 CLEVELAND, OHIO 44130 PHONE: (440) 238-9526 FAX: (440) 239-9529	
DESIGNER	
N.K.S	
REVIEWER	
HMK 12-04-23	
PROJECT ID	
114536	
SUBSET	TOTAL
13	20
SHEET	TOTAL
▲	-

GEOTECHNICAL PROFILE - ROADWAY
BORING LOG B-006-0-23



PROJECT: CUY-71-10.07 SW				DRILLING FIRM / OPERATOR: CTL / ADAM				DRILL RIG: D-50 TRACK CTL				STATION / OFFSET: 332+90, 17' RT.				EXPLORATION ID											
TYPE: BRIDGE				SAMPLING FIRM / LOGGER: CTL / ADAM				HAMMER: CME AUTOMATIC				ALIGNMENT: RAMP T				B-007-0-23											
PID: 114536 SFN: 1814257				DRILLING METHOD: 3.25" HSA / NX				CALIBRATION DATE: 6-30-23				ELEVATION: 788.0 (MSL) EOB: 49.0 ft.				PAGE											
START: 7-20-23 END: 7-20-23				SAMPLING METHOD: SPT				ENERGY RATIO (%): 84.7				LAT / LONG: 41.420760, -81.814818				1 OF 1											
MATERIAL DESCRIPTION AND NOTES				ELEV. 788.0		DEPTHS		SPT/ RQD		REC SAMPLE ID		HP (tsf)		GRADATION (%)		ATTERBERG		WC		PI		SO4 ppm		BACK FILL			
Gravel and stone fragments Base (12")				787.0		1		3		8		-		-		-		-		-		-		-			
						2		3		100		SS-1		-		-		-		-		-		-			
						3																					
MEDIUM STIFF, GREY, SANDY SILT, SOME ROCK FRAGMENTS, CINDERS, MOIST (FILL)				782.5		4		1		7		-		20		14		38		16		31		22		9	
						5		4		100		SS-2		-		-		-		-		-		-		-	
						6																					
VERY STIFF, GREY, SANDY SILT, SOME ROCK FRAGMENTS, LITTLE CLAY, MOIST				777.5		7		3		8		3.00		-		-		-		-		-		-		-	
						8		3		100		SS-3		-		-		-		-		-		-		-	
						9																					
VERY STIFF TO HARD, BROWN, SILTY CLAY, SOME SAND, MOIST				772.5		10		3		100		2.50		-		-		-		-		-		-		-	
						11		3		100		SS-4		-		-		-		-		-		-		-	
						12																					
HARD, GREY, SILTY CLAY, SOME SAND, MOIST						13		2		10		3.00		0		15		44		27		37		16		21	
						14		2		100		SS-5		-		-		-		-		-		-		-	
						15																					
VERY DENSE, GREY, GRAVEL AND STONE FRAGMENTS WITH SAND, LITTLE SILT, TRACE CLAY, MOIST				755.0		16		7		32		4.50		-		-		-		-		-		-		-	
						17		10		100		SS-6		-		-		-		-		-		-		-	
						18																					
SHALE, GREY, SEVERELY WEATHERED, VERY WEAK.						19		5		27		4.50		-		-		-		-		-		-		-	
						20		8		100		SS-7		-		-		-		-		-		-		-	
						21																					
@40.0' VERTICAL FRACTURE						22		7		37		4.50		-		-		-		-		-		-		-	
						23		12		100		SS-8		-		-		-		-		-		-		-	
						24																					
@48' ANGULAR FRACTURE				739.0		25		8		37		4.50		-		-		-		-		-		-		-	
						26		12		100		SS-9		-		-		-		-		-		-		-	
						27																					

STANDARD ODOT LOG W/ SULFATES (11 X 17) - OH DOT GDT - 1-12-23 18-28 - G:\2023\DECEMBER\RI01\23050013\CLE\23020013\CLE-23-11-30.GPJ

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: AUGER CUTTINGS



PROJECT: CUY-71-10.07 SW				DRILLING FIRM / OPERATOR: CTL / ADAM				DRILL RIG: D-50 TRACK CTL				STATION / OFFSET: 333+50, 28' LT.				EXPLORATION ID											
TYPE: BRIDGE				SAMPLING FIRM / LOGGER: CTL / ADAM				HAMMER: CME AUTOMATIC				ALIGNMENT: RAMP T				B-008-0-23											
PID: 114536 SFN: 1814257				DRILLING METHOD: 3.25" HSA				CALIBRATION DATE: 6-30-23				ELEVATION: 807.7 (MSL) EOB: 69.2 ft.				PAGE											
START: 7-26-23 END: 7-26-23				SAMPLING METHOD: SPT				ENERGY RATIO (%): 84.7				LAT / LONG: 41.420922, -81.814806				1 OF 2											
MATERIAL DESCRIPTION AND NOTES								ELEV. 807.7		DEPTHS		SPT/ RQD		REC SAMPLE ID		GRADATION (%)		ATTERBERG		WC		OOOT CLASS (G)		SO4 ppm		BACK FILL	
TOPSOIL (12") MEDIUM DENSE, BROWNISH GREY, SANDY SILT, SOME ROCK FRAGMENTS, CLAY, MOIST (FILL) VERY STIFF, BROWNISH GREY, SILT AND CLAY, SOME GRAVEL, SAND, MOIST <																											

STANDARD ODOT LOG W/ SULFATES (11 X 17) - OH DOT GDT - 1-12-23 18-28 - G:\2023\DECEMBER\01\23050013\CLE\23050013\CLE-23-11-30.GPJ

PID: 114536	SFN: 1814257	PROJECT:	CUY-71-10.07 SW	STATION / OFFSET: 333+50.28' LT.				START: 7-26-23			END: 7-26-23			PG 2 OF 2		B-008-0-23			
MATERIAL DESCRIPTION AND NOTES				ELEV. 747.7	DEPTHS	SPT/ RQD	REC N ₆₀	SAMPLE ID	HP (tsf)	GRADATION (%)			ATTERBERG			WC	ODOT CLASS (GI)	SO4 ppm	BACK FILL
										GR	CS	FS	SI	CL	LL				
HARD, GREY, SILT AND CLAY, LITTLE SAND, MOIST (continued)				747.7	61 62 63 64 65 66 67 68 69		12 16 23	55	100	-						12	A-6a (V)	-	

STANDARD ODOT LOG W/ SULFATES (11 X 17) - OH DOT.GDT - 1-12-23 18:28 - G:\2023\DECEMBER\BRI01\23050013\CLE\23020013\CLE-23_11_30.GPJ

NOTES: AUGUR REFUSAL AT 69.2 FEET
ABANDONMENT METHODS, MATERIALS, QUANTITIES: AUGER CUTTINGS

DESIGN AGENCY



6777 ENGLE RD, BLDG. 111
CLEVELAND, OHIO 44130
PHONE: (440) 238-9526
FAX: (440) 238-9528

DESIGNER

N.K.S

REVIEWER

HMK 12-04-23

PROJECT ID

114536

SUBSET

18

TOTAL

20

SHEET

1

TOTAL

1

GEOTECHNICAL PROFILE - ROADWAY
BORING LOG B-008-0-23 CONTINUED

.CUY-71-10.07 SW

MODEL: Sheet PAPER SIZE: 17x11 (in.) DATE: 04-12-2023 TIME: 03:17:06 USER: hp
D:\Drop Box\CTL 2023\December\Dept 05\CLE\Matthew\23050013\CLE_ODOT\Mod_01_12.23\114536ZL012.dgn

PROJECT: CUY-71-10.07 SW			DRILLING FIRM / OPERATOR: CTL / ADAM			D-50 TRACK CTL			STATION / OFFSET: 336+11, 72' RT.			EXPLORATION ID								
TYPE: ROADWAY			SAMPLING FIRM / LOGGER: CTL / ADAM			HAMMER: CME AUTOMATIC			ALIGNMENT: RAMP T			B-009-0-23								
PID: 114536 SFN:			DRILLING METHOD: 3.25" HSA			CALIBRATION DATE: 6-30-23			ELEVATION: 781.3 (MSL) EOB: 20.0 ft.			PAGE								
START: 7-20-23 END: 7-20-23			SPT			ENERGY RATIO (%): 84.7			LAT / LONG: 41.421068, -81.813740			1 OF 1								
MATERIAL DESCRIPTION			ELEV. 781.3			SPT/ RQD			GRADATION (%)			ODOT CLASS (GI)			SO4 ppm					
MEDIUM DENSE, BROWN, SILT, SOME SAND, LITTLE CLAY, MOIST (FILL)			781.3			DEPTHS			REC SAMPLE HP			ATTERBERG			BACK FILL					
									N ₆₀			GR CS FS SI T CL			LL PL PI			WC		
VERY STIFF, BROWN, SILTY CLAY, SOME SAND			778.3			1			-			-			-			-		
						3 4 5			-			-			-			-		
						2			-			-			-			-		
						3			-			-			-			-		
						4			-			-			-			-		
						6			-			-			-			-		
						7			-			-			-			-		
						8			-			-			-			-		
						9			-			-			-			-		
						10			-			-			-			-		
VERY STIFF TO HARD, GREY, SILT AND CLAY, WITH SAND, MOIST			773.3			11			-			-			-					
						12			-			-			-					
						13			-			-			-					
						14			-			-			-					
						15			-			-			-					
						16			-			-			-					
						17			-			-			-					
						18			-			-			-					
						19			-			-			-					
						20			-			-			-					

STANDARD ODOT LOG W/ SULFATES (11 X 17) - OH DOT.GDT - 31-8-23 16:08 - G:\2023\AU\GUST\28123050013CLE\23020013CLE.GPJ

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: AUGER CUTTINGS:

DESIGN AGENCY	
	
6777 EGGLE RD. 5LDG. 11F CLIVE, OHIO 44130 PHONE: (440) 239-9526 FAX: (440) 239-9529	
DESIGNER	
N.K.S	
REVIEWER	
HMK 12-04-23	
PROJECT ID	
114536	
SUBSET	TOTAL
19	20
SHEET	TOTAL
▲	-

GEOTECHNICAL PROFILE - ROADWAY
BORING LOG B-009-0-23

B-010-0-65

Date Started 6-3-63
Date Completed 6-8-63
Boring No. X-10 Ramp "P"

Sampler Type S3 Dia. 1 3/8"
Casing Length Dia.
Station & Offset 33+29.09' Lts (Forward Abutment)

Water Elev.
Surface Elev. 783.5'

NAVD88 ELV. ELV = NGVD29 ELV -.502 ft

Elev.	Depth	Std. Pen. (N)	Rec. ft.	Loss ft.	Description	Sample No.	Physical Characteristics								SHTL Class.
							% Agg.	% C.S.	% F.S.	% Silt	% Clay	L.L.	P.I.	W.C.	
783.5	0														
	2														
	4														
778.5	6	10/17			Brownish-Gray Sandy Clay	1	8	5	8	39	40	34	15	16	
776.0	8	12/21			Brown and Gray Gravelly Sandy Clay	2	15	9	9	33	34	32	12	15	
	10														
773.5	12	13/18			Gray Gravelly Clay	3	16	6	9	33	36	28	11	13	
771.0	14	15/19			Gray Sandy Silt	4	12	6	9	36	37	27	10	16	
	16														
768.5	18	24/34			Gray Sandy Silt	5	12	8	10	39	31	21	5	12	
766.0	20	30/50			Gray Gravelly Sandy Silt	6	17	8	10	36	29	22	5	11	
	22														
763.5	24	17/23			Gray Sandy Silt	7	10	9	8	36	37	25	8	13	
	26														
758.5	28	20/27			Gray Gravelly Silt	8	18	5	6	35	36	25	8	13	
	30														
753.5	32	30/45			Gray Sandy Gravelly Clay	9	27	9	7	25	32	28	11	12	
	34														
748.5	36	20/36			Gray clayey Silt	10	0	1	11	49	39	23	8	13	
747.5															

APPENDIX B

- ▣ **BORING LOCATION PLAN**
- ▣ **TEST BORING RECORDS**



		SITE LOCATION MAP			
 CTL ENGINEERING, INC. GEOTECHNICAL ENGINEERS TESTING * INSPECTION LABORATORY SERVICES	Date	Mott MacDonald CUY-71-10.07 SW I-71 NB Ramp to I-480 WB Cleveland, Cuyahoga County, Ohio			
	9/6/2023				
	Scale	Reviewed By	Page	Project No.	
	None				
	Drawn By		1 of 1		
	MK				

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT GDT - 11/30/23 19:53 - O:\PROJECT\2023\CLE-05123050013\CLE MOTT MACDONALD CUY 71 10 07 SW BORING LOGS & LAB\23020013

PROJECT: CUY-71-10.07 SW		DRILLING FIRM / OPERATOR: CTL / ADAM		DRILL RIG: D-50 TRACK CTL		STATION / OFFSET: 326+04, 7' RT.		EXPLORATION ID														
TYPE: ROADWAY		SAMPLING FIRM / LOGGER: CTL / ADAM		HAMMER: CME AUTOMATIC		ALIGNMENT: RAMP T		B-001-0-23														
PID: 114536 SFN:		DRILLING METHOD: 3.25" HSA		CALIBRATION DATE: 6/30/23		ELEVATION: 808.3 (MSL) EOB: 7.5 ft.		PAGE														
START: 7/27/23 END: 7/27/23		SAMPLING METHOD: SPT		ENERGY RATIO (%): 84.7		LAT / LONG: 41.419366, -81.816436		1 OF 1														
MATERIAL DESCRIPTION AND NOTES			ELEV.	DEPTHS		SPT/ RQD	N ₆₀	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG				ODOT CLASS (GI)	BACK FILL	
			808.3								GR	CS	FS	SI	CL	LL	PL	PI	WC			
MEDIUM DENSE, BROWN, SANDY SILT, WITH GRAVEL, TRACE CLAY, MOIST (FILL)				1		3																
				2		4	17	100	SS-1	-	49	6	9	27	9	28	24	4	25	A-4a (0)		
			805.3	3																		
MEDIUM DENSE, BROWN, SILT, LITTLE GRAVEL, SAND, CLAY, MOIST (FILL)				4		4	24	100	SS-2	-	11	10	10	53	16	22	18	4	10	A-4b (7)		
				5		8	9															
				6		7																
			800.8	7		8	21	100	SS-3	-	-	-	-	-	-	-	-	-	16	A-4b (V)		
				EOB		7																
NOTES: NONE																						
ABANDONMENT METHODS, MATERIALS, QUANTITIES: AUGER CUTTINGS																						

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT GDT - 11/30/23 19:53 - O:\PROJECT\2023\CLE-0512305013\CLE MOTT MACDONALD CUY 71 10 07 SW BORING LOGS & LAB\23020013

PROJECT: CUY-71-10.07 SW		DRILLING FIRM / OPERATOR: CTL / ADAM		DRILL RIG: D-50 TRACK CTL		STATION / OFFSET: 327+23, 15' RT.		EXPLORATION ID											
TYPE: ROADWAY		SAMPLING FIRM / LOGGER: CTL / ADAM		HAMMER: CME AUTOMATIC		ALIGNMENT: RAMP T		B-002-0-23											
PID: 114536 SFN:		DRILLING METHOD: 3.25" HSA		CALIBRATION DATE: 6/30/23		ELEVATION: 809.3 (MSL) EOB: 10.0 ft.		PAGE											
START: 7/24/23 END: 7/24/27		SAMPLING METHOD: SPT		ENERGY RATIO (%): 84.7		LAT / LONG: 41.419637, -81.816197		1 OF 1											
MATERIAL DESCRIPTION AND NOTES		ELEV.	DEPTHS	SPT/ RQD	N ₆₀	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG				ODOT CLASS (GI)	BACK FILL
		809.3							GR	CS	FS	SI	CL	LL	PL	PI	WC		
HARD, GREY, SILT AND CLAY, WITH SAND, MOIST (FILL)			1	3															
			2	3	13	100	SS-1	4.50	0	12	15	51	22	31	20	11	12	A-6a (8)	
		806.3	3																
MEDIUM DENSE, GREY, GRAVEL AND STONE FRAGMENTS WITH SAND, SILT, AND CLAY, MOIST (FILL)			4	8	20	100	SS-2	-	57	4	5	18	16	36	20	16	9	A-2-6 (1)	
			5	9															
			6	4															
			7	4	13	100	SS-3	-	-	-	-	-	-	-	-	-	12	A-2-6 (V)	
		801.3	8																
DENSE, BLACK, COARSE AND FINE SAND, SOME SILT, MOIST			9	4															
			10	12	45	100	SS-4	-	3	32	31	31	3	NP	NP	NP	11	A-3a (0)	
		799.3	EOB	20															
NOTES: NONE																			
ABANDONMENT METHODS, MATERIALS, QUANTITIES: AUGER CUTTINGS																			

[illegible]

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: AUGER CUTTINGS

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT GDT - 11/30/23 19:52 - O:\PROJECT\2023\CLE-05123050013\CLE MOTT MACDONALD CUY 71 10 07 SW BORING LOGS & LAB\23020013

PROJECT: CUY-71-10.07 SW		DRILLING FIRM / OPERATOR: CTL / ADAM		DRILL RIG: D-50 TRACK CTL		STATION / OFFSET: 329+65, 4' RT.		EXPLORATION ID												
TYPE: BRIDGE		SAMPLING FIRM / LOGGER: CTL / ADAM		HAMMER: CME AUTOMATIC		ALIGNMENT: RAMP T		B-004-0-23												
PID: 114536 SFN: 18114257		DRILLING METHOD: 3.25" HSA		CALIBRATION DATE: 6/30/23		ELEVATION: 812.8 (MSL) EOB: 67.5 ft.		PAGE												
START: 7/27/23 END: 7/27/23		SAMPLING METHOD: SPT		ENERGY RATIO (%): 84.7		LAT / LONG: 41.420185, -81.815711		1 OF 3												
MATERIAL DESCRIPTION AND NOTES		ELEV.	DEPTHS		SPT/ RQD	N ₆₀	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	BACK FILL
		812.8																		
CONCRETE (11")		811.9																		
BASE (2")		811.7	1		8															
MEDIUM DENSE, GREY, SANDY SILT, AND GRAVEL, TRACE CLAY, MOIST (FILL)		811.1	2		4 5	13	100	SS-1A SS-1B	- 4.50	51 0	8 6	5 6	28 71	8 17	NP 29	NP 18	NP 11	14 11	A-4a (0) A-6a (8)	
HARD, GREY, SILT AND CLAY, LITTLE SAND, MOIST (FILL)		809.8	3																	
MEDIUM DENSE, GREY, GRAVEL AND STONE FRAGMENTS WITH SAND AND SILT, LITTLE CLAY, MOIST (FILL)		807.3	4		6	21	67	SS-2	-	57	4	6	21	12	34	25	9	18	A-2-4 (0)	
			5		7 8															
STIFF, GREY, SANDY SILT, SOME GRAVEL, CLAY, MOIST (FILL)			6		4															
			7		4 2	8	100	SS-3	2.00	34	6	9	30	21	24	16	8	15	A-4a (3)	
			8																	
			9		3 4	11	100	SS-4	2.00	-	-	-	-	-	-	-	-	14	A-4a (V)	
			10																	
			11		3															
			12		3 5	11	100	SS-5	2.00	-	-	-	-	-	-	-	-	31	A-4a (V)	
		799.8	13																	
MEDIUM DENSE, GREY, GRAVEL AND STONE FRAGMENTS WITH SAND, TRACE SILT, CLAY, MOIST (FILL)		797.3	14		5 9	24	100	SS-6	-	44	14	23	9	10	24	18	6	13	A-1-b (0)	
			15																	
VERY STIFF TO HARD, GREY, SILT AND CLAY, SOME GRAVEL, LITTLE CLAY, MOIST (FILL)			16		7															
			17		7 8	21	100	SS-7	4.50	-	-	-	-	-	-	-	-	12	A-6a (V)	
			18																	
			19		6 7	21	100	SS-8	3.75	24	8	8	31	29	38	24	14	14	A-6a (7)	
			20																	
		790.8	21																	
DENSE TO VERY DENSE, DARK GREY, COARSE AND FINE SAND, SOME SILT, LITTLE GRAVEL, MOIST			22																	
			23																	
			24		8 10 17	38	100	SS-9	-	19	19	32	27	3	NP	NP	NP	14	A-3a (0)	
			25																	
			26																	
			27																	
			28																	
			29		9 22 16	54	100	SS-10	-	-	-	-	-	-	-	-	-	13	A-3a (V)	

MATERIAL DESCRIPTION AND NOTES		ELEV. 750.7	DEPTHS		SPT/ RQD	N ₆₀	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG				ODOT CLASS (GI)	BACK FILL
										GR	CS	FS	SI	CL	LL	PL	PI	WC		
DENSE, GREY, GRAVEL AND STONE FRAGMENTS WITH SAND AND SILT, MOIST (continued)		746.3	—TR	63																
				64	16 50/5"	-	100	SS-17	-	-	-	-	-	-	-	-	20	A-2-4 (V)		
				65																
				66	26 39 50/5"	-	100	SS-18	-	-	-	-	-	-	-	-	11	Rock (V)		
SHALE, GREY, SEVERELY WEATHERED, VERY WEAK.		745.3	FOR	67	60/3"	-	100	SS-19	-	-	-	-	-	-	-	-	-	-	Rock (V)	

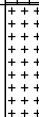
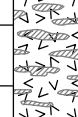
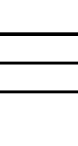
NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: AUGER CUTTINGS

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT GDT - 11/30/23 19:52 - O:\PROJECT\2023\CLE-05123050013CLE MOTT MACDONALD - CUY 71 10 07SWBORING LOGS & LAB\23020013

PROJECT: CUY-71-10.07 SW		DRILLING FIRM / OPERATOR: CTL / ADAM		DRILL RIG: D-50 TRACK CTL		STATION / OFFSET: 330+88, 29' RT.		EXPLORATION ID													
TYPE: BRIDGE		SAMPLING FIRM / LOGGER: CTL / ADAM		HAMMER: CME AUTOMATIC		ALIGNMENT: RAMP T		B-005-0-23													
PID: 114536 SFN: 18114257		DRILLING METHOD: 3.25" HSA / NX		CALIBRATION DATE: 6/30/23		ELEVATION: 787.9 (MSL) EOB: 50.5 ft.		PAGE													
START: 7/25/23 END: 7/25/23		SAMPLING METHOD: SPT		ENERGY RATIO (%): 84.7		LAT / LONG: 41.420381, -81.815338		1 OF 2													
MATERIAL DESCRIPTION AND NOTES			ELEV.	DEPTHS		SPT/ RQD	N ₆₀	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG				ODOT CLASS (GI)	BACK FILL
			787.9								GR	CS	FS	SI	CL	LL	PL	PI	WC		
TOPSOIL/GRAVEL MIX (12")			786.9																		
STIFF TO VERY STIFF, BROWN, CLAY , SOME GRAVEL, SAND, SILT, MOIST				1	4																
				2	6	17	100	SS-1	1.00	-	-	-	-	-	-	-	-	-	18	A-7-6 (V)	
				3																	
				4	3	21	100	SS-2	2.00	22	11	10	32	25	47	24	23	19	A-7-6 (10)		
				5	4																
				6	8	27	100	SS-3	2.00	-	-	-	-	-	-	-	-	12	A-7-6 (V)		
				7	11																
				8																	
VERY STIFF TO HARD, BROWN, CLAY , SOME SILT, SAND, MOIST				9	6	21	100	SS-4	3.50	-	-	-	-	-	-	-	-	15	A-7-6 (V)		
				10	7																
				11	7	31	100	SS-5	3.50	0	12	9	34	45	43	20	23	16	A-7-6 (14)		
				12	10																
				13																	
				14	8	34	100	SS-6	4.50	-	-	-	-	-	-	-	-	15	A-7-6 (V)		
				15	11																
				16																	
HARD, GREY, CLAY , SOME ROCK FRAGMENTS, MOIST				17	7	40	100	SS-7	4.50	-	-	-	-	-	-	-	-	13	A-7-6 (V)		
				18	12																
				19	8	34	100	SS-8	4.50	-	-	-	-	-	-	-	-	10	A-7-6 (V)		
				20	9																
				21	15																
				22																	
				23																	
				24	8	45	100	SS-9	4.50	-	-	-	-	-	-	-	-	12	A-7-6 (V)		
				25	14																
				26	18																
				27																	
				28																	
	29	21	45	100	SS-10	4.50	-	-	-	-	-	-	-	-	12	A-7-6 (V)					
		17																			
		15																			

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT GDT - 11/30/23 19:52 - O:\PROJECT\2023\CLE-051230501\3CLE-MOTT MACDONALD - CUY 71 10 07\SWBORING LOGS & LAB\23020013

PID: 114536	SFN: 18114257	PROJECT: CUY-71-10.07 SW	STATION / OFFSET: 330+88, 29' RT.		START: 7/25/23	END: 7/25/23	PG 2 OF 2		B-005-0-23												
MATERIAL DESCRIPTION AND NOTES			ELEV. 757.9	DEPTHS	SPT/ RQD	N ₆₀	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG				ODOT CLASS (GI)	BACK FILL	
HARD, GREY, CLAY , SOME ROCK FRAGMENTS, MOIST (continued)				754.9	31																
DENSE, GREY, SILT , AND SAND, TRACE CLAY, MOIST				751.9	32	12	34	100	SS-11	-	0	5	34	51	10	27	18	9	14	A-4b (5)	
VERY DENSE, GREY, GRAVEL AND STONE FRAGMENTS WITH SAND, SILT, AND CLAY , MOIST						33	12														
SANDSTONE , LIGHT GREY, MODERATELY WEATHERED, SLIGHTLY STRONG, FINE GRAINED. SHALE , GREY, SEVERELY WEATHERED, WEAK.				747.4		34															
					35																
				746.2	36	14	64	100	SS-12	-	31	28	10	29	2	25	14	11	19	A-2-6 (0)	
					37	14	31														
				737.4	38	50/0"	-		SS-13	-	-	-	-	-	-	-	-	-	-	Rock (V)	
					39	44		70	NQ-1												Rock (V) CORE
					40																
					41	0		76	NQ-2												Rock (V) CORE
					42																
					43																
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					117																

PROJECT: CUY-71-10.07 SW		DRILLING FIRM / OPERATOR: CTL / ADAM		DRILL RIG: D-50 TRACK CTL		STATION / OFFSET: 331+74, 20' RT.		EXPLORATION ID													
TYPE: BRIDGE		SAMPLING FIRM / LOGGER: CTL / ADAM		HAMMER: CME AUTOMATIC		ALIGNMENT: RAMP T		B-006-0-23													
PID: 114536 SFN: 18114257		DRILLING METHOD: 3.25" HSA / NX		CALIBRATION DATE: 6/30/23		ELEVATION: 789.0 (MSL) EOB: 50.0 ft.		PAGE													
START: 8/2/23 END: 8/2/23		SAMPLING METHOD: SPT		ENERGY RATIO (%): 84.7		LAT / LONG: 41.420556, -81.815134		1 OF 2													
MATERIAL DESCRIPTION AND NOTES			ELEV.	DEPTHS		SPT/ RQD	N ₆₀	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG				ODOT CLASS (GI)	BACK FILL
			789.0																		
ASPHALT (12")			788.0	1		10															
VERY DENSE, BROWN, STONE FRAGMENTS WITH SAND AND SILT , SOME CINDERS, MOIST (FILL)			786.0	2		43 46	126	100	SS-1	-	55	6	4	25	10	NP	NP	NP	11	A-2-4 (0)	
HARD, BROWNISH-GREY, CLAY , SOME SAND, MOIST				3																	
				4		9 6 7	18	100	SS-2	4.50	-	-	-	-	-	-	-	-	15	A-7-6 (V)	
				5																	
				6		3 5 5	14	100	SS-3	4.50	-	-	-	-	-	-	-	-	16	A-7-6 (V)	
				7																	
				8																	
				9		3 7 8	21	100	SS-4	4.50	-	-	-	-	-	-	-	-	18	A-7-6 (V)	
				10																	
				11		5 6 7	18	100	SS-5	4.50	0	15	10	37	38	41	19	22	19	A-7-6 (13)	
				12																	
				13																	
				14		6 8 11	27	100	SS-6	4.50	-	-	-	-	-	-	-	-	19	A-7-6 (V)	
			773.5	15																	
HARD, GREY, CLAY , WITH SAND, MOIST				16		7 11 13	34	100	SS-7	4.50	0	19	14	39	28	42	22	20	20	A-7-6 (11)	
				17																	
				18																	
				19		7 7 11	25	100	SS-8	4.50	-	-	-	-	-	-	-	-	17	A-7-6 (V)	
				20																	
				21																	
				22																	
				23																	
				24		8 11 15	37	100	SS-9	4.50	-	-	-	-	-	-	-	-	15	A-7-6 (V)	
				25																	
				26																	
				27																	
				28																	
				29		11 14 17	44	100	SS-10	4.50	-	-	-	-	-	-	-	-	17	A-7-6 (V)	

MATERIAL DESCRIPTION AND NOTES		ELEV. 745.6	DEPTHS	SPT/ RQD	N ₆₀	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	BACK FILL
									GR	CS	FS	SI	CL	LL	PL	PI			
HARD, GREY, SILT AND CLAY, LITTLE SAND, MOIST (continued)				63															
				64	12 16 23	55	100	SS-17	-	-	-	-	-	-	-	12	A-6a (V)		
				65															
				66															
				67															
SHALE, GRAY, SEVERELY WEATHERED, VERY WEAK.		739.7	TR	68															
		738.5	FOR	69	50/0"			SS-18	-	-	-	-	-	-	-	7	Rock (V)		

NOTES: AUGUR REFUSAL AT 69.2 FEET

ABANDONMENT METHODS, MATERIALS, QUANTITIES: AUGER CUTTINGS

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT GDT - 11/30/23 19:54 - O:\PROJECT\2023\CLE-051230501\3CLE MOTT MACDONALD CUY 71 10 07SWBORING LOGS & LAB\2302001

PROJECT: CUY-71-10.07 SW		DRILLING FIRM / OPERATOR: CTL / ADAM		DRILL RIG: D-50 TRACK CTL		STATION / OFFSET: 336+11, 72' RT.		EXPLORATION ID											
TYPE: ROADWAY		SAMPLING FIRM / LOGGER: CTL / ADAM		HAMMER: CME AUTOMATIC		ALIGNMENT: RAMP T		B-009-0-23											
PID: 114536 SFN:		DRILLING METHOD: 3.25" HSA		CALIBRATION DATE: 6/30/23		ELEVATION: 781.3 (MSL) EOB: 20.0 ft.		PAGE											
START: 7/20/23 END: 7/20/23		SAMPLING METHOD: SPT		ENERGY RATIO (%): 84.7		LAT / LONG: 41.421068, -81.813740		1 OF 1											
MATERIAL DESCRIPTION AND NOTES		ELEV.	DEPTHS	SPT/ RQD	N ₆₀	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG				ODOT CLASS (GI)	BACK FILL
		781.3							GR	CS	FS	SI	CL	LL	PL	PI	WC		
MEDIUM DENSE, BROWN, SILT, SOME SAND, LITTLE CLAY, MOIST (FILL)		++++	1	3															
		++++	2	4	13	100	SS-1	-	0	13	12	63	12	26	18	8	20	A-4b (8)	
		++++		5															
VERY STIFF, BROWN, SILTY CLAY, SOME SAND		++++	3																
		778.3	4	4	20	100	SS-2	3.00	-	-	-	-	-	-	-	-	15	A-6b (V)	
			5	6	8														
			6	4															
			7	6	17	100	SS-3	3.00	0	15	13	47	25	36	16	20	16	A-6b (11)	
		773.3	8																
VERY STIFF TO HARD, GREY, SILT AND CLAY, WITH SAND, MOIST			9	4	25	100	SS-4	3.00	0	19	23	41	17	37	25	12	15	A-6a (5)	
			10	7	11														
			11	6															
			12	7	25	100	SS-5	3.00	-	-	-	-	-	-	-	-	10	A-6a (V)	
			13																
			14	3	16	100	SS-6	4.50	-	-	-	-	-	-	-	-	7	A-6a (V)	
			15	5	6														
			16	7															
			17	9	28	100	SS-7	4.50	-	-	-	-	-	-	-	-	11	A-6a (V)	
			18	11															
			19	9															
		761.3	20	12	41	100	SS-8	4.50	-	-	-	-	-	-	-	-	12	A-6a (V)	
			EOB	17															
NOTES: NONE																			
ABANDONMENT METHODS, MATERIALS, QUANTITIES: AUGER CUTTINGS																			

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT GDT - 11/30/23 19:54 - O:\PROJECT\2023\CLE-05123050013\CLE MOTT MACDONALD CUY 71 10 07 SW BORING LOGS & LAB\23020013

PROJECT: CUY-71-10.07 SW		DRILLING FIRM / OPERATOR: CTL / ADAM		DRILL RIG: D-50 TRACK CTL		STATION / OFFSET: 338+86, 7' RT.		EXPLORATION ID														
TYPE: ROADWAY		SAMPLING FIRM / LOGGER: CTL / ADAM		HAMMER: CME AUTOMATIC		ALIGNMENT: RAMP T		B-010-0-23														
PID: 114536 SFN:		DRILLING METHOD: 3.25" HSA		CALIBRATION DATE: 6/30/23		ELEVATION: 788.1 (MSL) EOB: 7.5 ft.		PAGE														
START: 7/27/23 END: 7/27/23		SAMPLING METHOD: SPT		ENERGY RATIO (%): 84.7		LAT / LONG: 41.421482, -81.812902		1 OF 1														
MATERIAL DESCRIPTION AND NOTES			ELEV.	DEPTHS		SPT/ RQD	N ₆₀	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG				ODOT CLASS (GI)	BACK FILL	
			788.1																			
TOPSOIL/Gravel Mix (12")			787.1	1																		
VERY STIFF, GREY, CLAY , WITH GRAVEL, SOME CINDERS, LITTLE SAND, MOIST (FILL)				2		3	2	13	100	SS-1	2.25	40	9	9	34	8	42	24	18	14	A-7-6 (4)	
			785.1	3																		
MEDIUM DENSE TO DENSE, GREY, SANDY SILT , WITH GRAVEL, TRACE CLAY, MOIST				4		13	11	25	100	SS-2	-	44	10	7	31	8	34	26	8	18	A-4a (1)	
				5																		
				6		16	13															
			780.6	7		13	37	100	SS-3	-	-	-	-	-	-	-	-	-	11	A-4a (V)		
				EOB																		
NOTES: NONE																						
ABANDONMENT METHODS, MATERIALS, QUANTITIES: AUGER CUTTINGS																						

B-010-0-65

NAVD88 ELV. ELV = NGVD29 ELV -.502 ft

LOG OF BORING

Date Started 6-3-65Sampler Type S9Dia. 1 3/8"

Water Elev. _____

Date Completed 6-8-65

Casing: Length _____

Dia. _____

Boring No. R-10 Ramp "1"Station & Offset 33+29.09' Lts (Forward Abutment)Surface Elev. 783.5'

Elev.	Depth	Std. Pen. (N)	Rec. ft.	Loss ft.	Description	Sample No.	Physical Characteristics								SHTL Class.
							% Agg.	% C.S.	% F.S.	% Silt	% Clay	L.L.	P.I.	W.C.	
783.5	0														
	2														
	4														
778.5	6	10/17			Brownish-Gray Sandy Clay	1	8	5	8	39	40	34	15	16	
776.0	8	12/21			Brown and Gray Gravelly Sandy Clay	2	15	9	9	33	34	32	12	15	
773.5	10	13/18			Gray Gravelly Clay	3	16	6	9	33	36	28	11	13	
771.0	12	15/19			Gray Sandy Silt	4	12	6	9	36	37	27	10	16	
768.5	14	24/34			Gray Sandy Silt	5	12	8	10	39	31	21	5	12	
766.0	16	30/50			Gray Gravelly Sandy Silt	6	17	8	10	36	29	22	5	11	
763.5	20	17/23			Gray Sandy Silt	7	10	9	8	36	37	25	8	13	
	22														
	24														
758.5	26	20/27			Gray Gravelly Silt	8	18	5	6	35	36	25	8	13	
	28														
753.5	30	30/45			Gray Sandy Gravelly Clay	9	27	9	7	25	32	28	11	12	
	32														
	34														
748.5					BOTTOM OF BORING										
747.5	36	20/36			Gray Clayey Silt	10	0	1	11	49	39	23	8	13	

APPENDIX C

▣ SUBGRADE ANALYSES



OHIO DEPARTMENT OF TRANSPORTATION

OFFICE OF GEOTECHNICAL ENGINEERING

PLAN SUBGRADES

Geotechnical Design Manual Section 600

Instructions: Enter data in the shaded cells only.

(Enter state route number, project description, county, consultant's name, prepared by name, and date prepared. This information will be transferred to all other sheets. The date prepared must be entered in the appropriate cell on this sheet to remove these instructions prior to printing.)

**CUY-71-10.07 SW
114536**

I-71 N Exit Ramp to I-480 W Widening

CTL Engineering, Inc.

Prepared By: **Matthew Kairouz**
Date prepared: **Monday, August 28, 2023**

**3085 Interstate Pky
Brunswick, Ohio 44212**

**330-220-8900
mkairouz@ctleng.com**

NO. OF BORINGS: 5



#	Boring ID	Alignment	Station	Offset	Dir	Drill Rig	ER	Boring EL.	Proposed Subgrade EL	Cut Fill
1	B-001-0-23	Ramp T	326+04	7	RT	D-50 Track CTL	85	808.3	806.8	1.5 C
2	B-002-0-23	Ramp T	327+23	15	Rt	D-50 Track CTL	85	809.3	807.8	1.5 C
3	B-004-0-23	Ramp T	329+65	4	Rt	D-50 Track CTL	85	812.8	811.5	1.3 C
4	B-008-0-23	Ramp T	333+50	28	Lt	D-50 Track CTL	85	807.7	806.8	0.9 C
5	B-010-0-23	Ramp T	338+86	7	Rt	D-50 Track CTL	85	788.1	786.6	1.5 C

[illegible]

PID: 114536

County-Route-Section: CUY-71-10.07 SW

No. of Borings: 5

Geotechnical Consultant: CTL Engineering, Inc.

Prepared By: Matthew Kairouz

Date prepared: 8/28/2023

Chemical Stabilization Options		
320	Rubblize & Roll	Option
206	Cement Stabilization	Option
	Lime Stabilization	No
206	Depth	12"

Excavate and Replace Stabilization Options	
Global Geotextile Override(N60L):	12"
Override(HP):	0"
Global Geogrid Override(N60L):	0"
Override(HP):	0"

Design CBR	8
------------	---

% Samples within 6 feet of subgrade			
N ₆₀ ≤ 5	0%	HP ≤ 0.5	0%
N ₆₀ < 12	13%	0.5 < HP ≤ 1	0%
12 ≤ N ₆₀ < 15	38%	1 < HP ≤ 2	13%
N ₆₀ ≥ 20	44%	HP > 2	25%
M+	13%		
Rock	0%		
Unsuitable	11%		

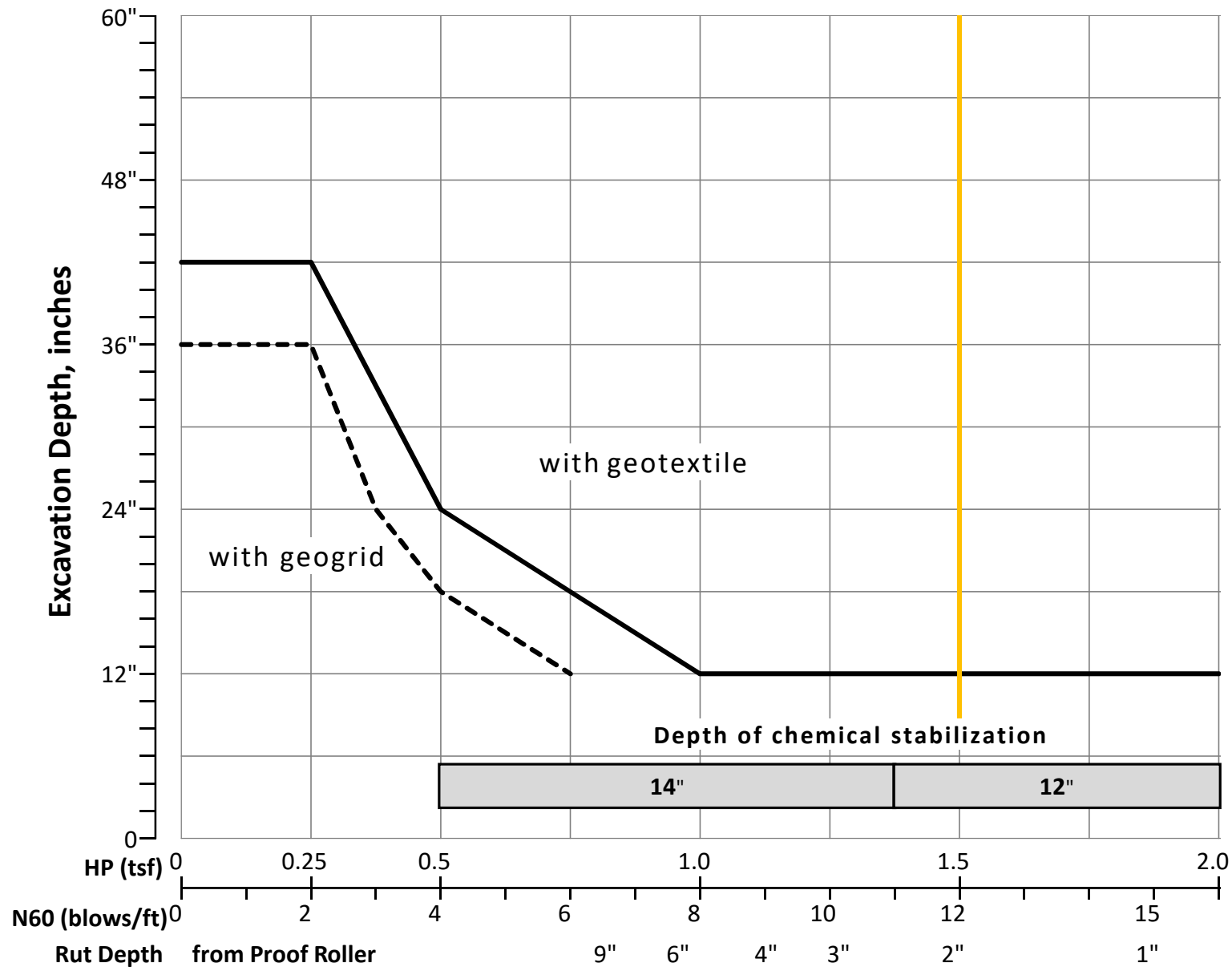
Excavate and Replace at Surface	
Average	0"
Maximum	0"
Minimum	0"

% Proposed Subgrade Surface	
Unstable & Unsuitable	27%
Unstable	18%
Unsuitable	9%

	N ₆₀	N _{60L}	HP	LL	PL	PI	Silt	Clay	P 200	M _C	M _{OPT}	GI
Average	19	12	3.21	30	21	10	36	14	49	14	13	4
Maximum	45	17	4.50	42	26	18	71	22	88	25	21	8
Minimum	7	8	2.00	22	16	4	18	3	33	9	8	0

Classification Counts by Sample																			Totals
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	
Count	0	0	0	1	0	2	0	0	1	6	2	0	5	0	0	1	0	0	18
Percent	0%	0%	0%	6%	0%	11%	0%	0%	6%	33%	11%	0%	28%	0%	0%	6%	0%	0%	100%
% Rock Granular Cohesive	0%	56%										44%							100%
Surface Class Count	0	0	0	1	0	1	0	0	0	4	1	0	3	0	0	1	0	0	11
Surface Class Percent	0%	0%	0%	9%	0%	9%	0%	0%	0%	36%	9%	0%	27%	0%	0%	9%	0%	0%	100%

Fig. 600-1 – Subgrade Stabilization



OVERRIDE TABLE

Calculated Average	New Values	Check to Override
3.21	3.20	☒ HP
12.40	12.00	☒ N60L

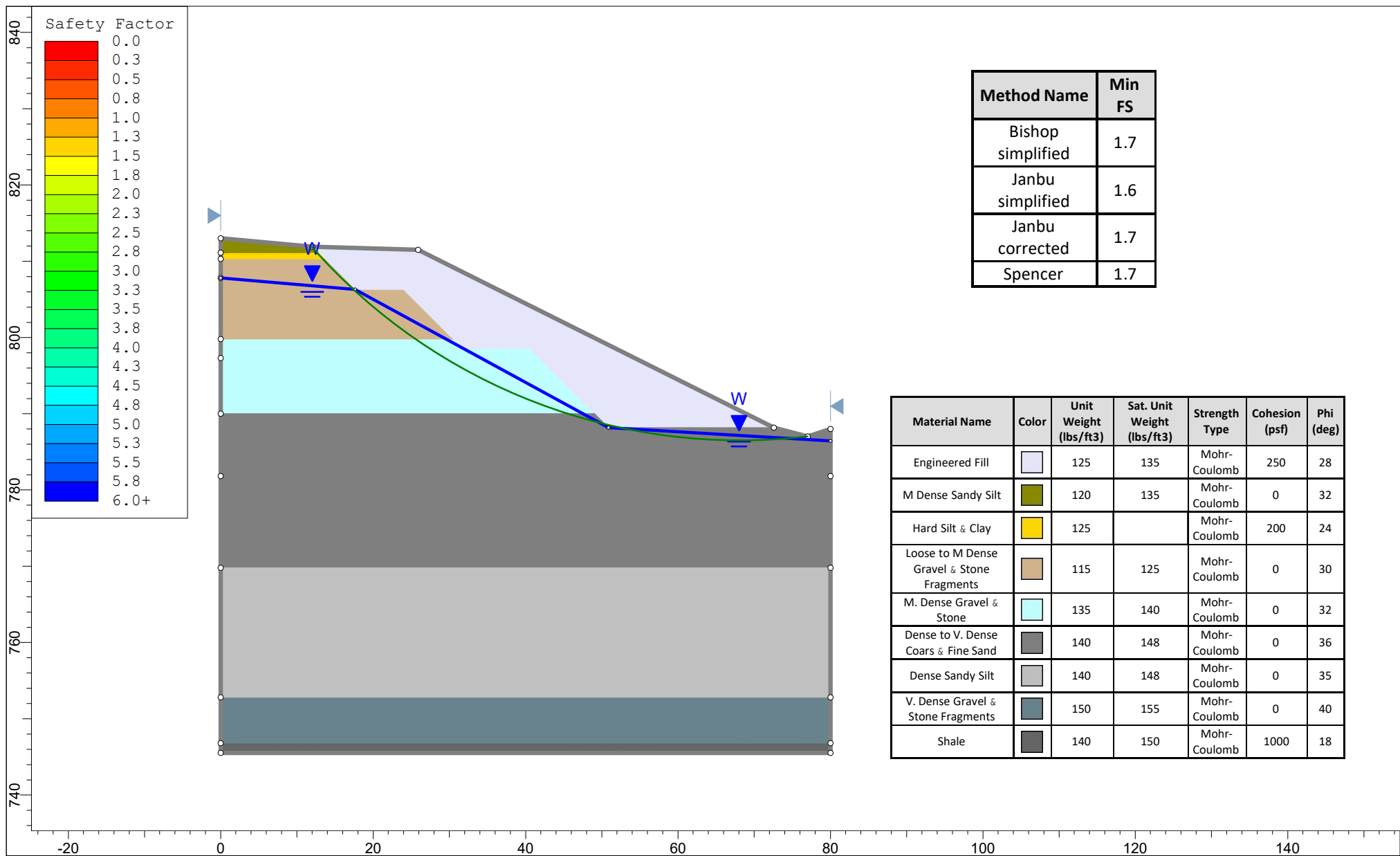
Average HP

Average N_{60L}



APPENDIX D

▣ SLOPE STABILITY ANALYSES

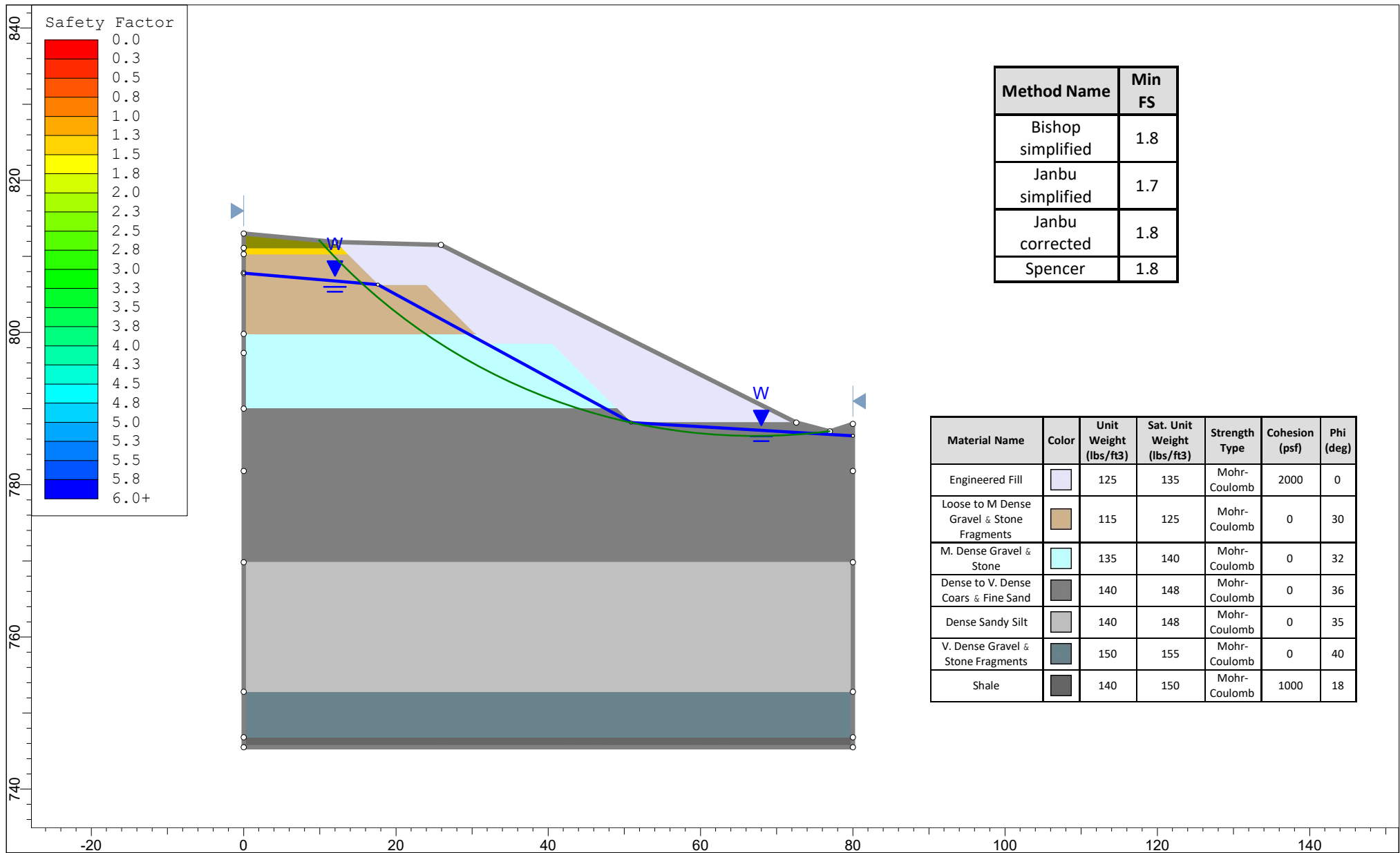


Method Name	Min FS
Bishop simplified	1.7
Janbu simplified	1.6
Janbu corrected	1.7
Spencer	1.7

Material Name	Color	Unit Weight (lbs/ft ³)	Sat. Unit Weight (lbs/ft ³)	Strength Type	Cohesion (psf)	Phi (deg)
Engineered Fill		125	135	Mohr-Coulomb	250	28
M Dense Sandy Silt		120	135	Mohr-Coulomb	0	32
Hard Silt & Clay		125		Mohr-Coulomb	200	24
Loose to M Dense Gravel & Stone Fragments		115	125	Mohr-Coulomb	0	30
M. Dense Gravel & Stone		135	140	Mohr-Coulomb	0	32
Dense to V. Dense Coars & Fine Sand		140	148	Mohr-Coulomb	0	36
Dense Sandy Silt		140	148	Mohr-Coulomb	0	35
V. Dense Gravel & Stone Fragments		150	155	Mohr-Coulomb	0	40
Shale		140	150	Mohr-Coulomb	1000	18



Project	CUY-71+10.07SW		
Group	Drain Condition	Scenario:	STA 329+60.81
Drawn By	LHI	Company	CTL Engineering, Inc.
Date	8/15/2023, 9:31:49 AM	File Name	STA 329+60 Proposed-ODOT.slmd



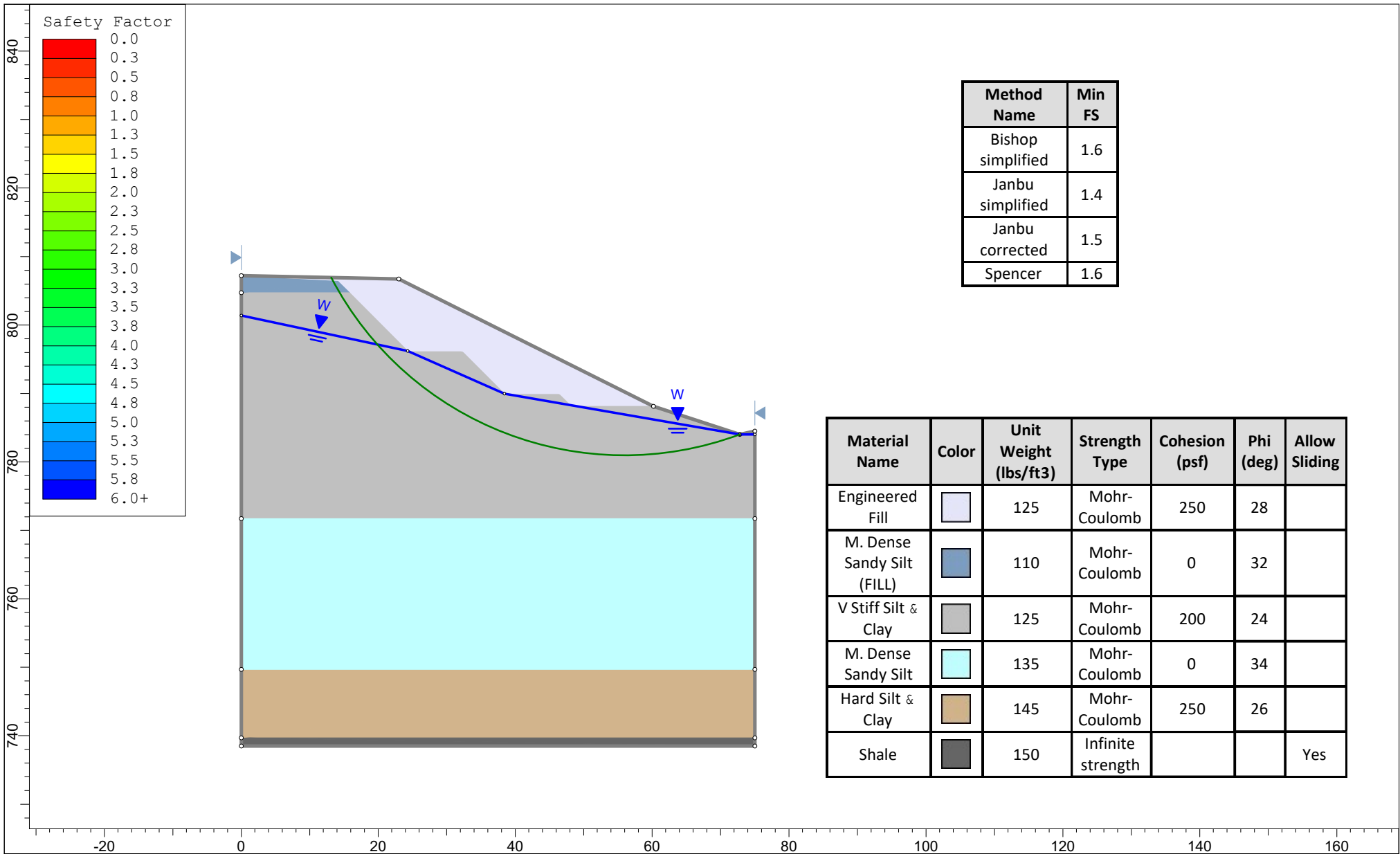
Method Name	Min FS
Bishop simplified	1.8
Janbu simplified	1.7
Janbu corrected	1.8
Spencer	1.8

Material Name	Color	Unit Weight (lbs/ft ³)	Sat. Unit Weight (lbs/ft ³)	Strength Type	Cohesion (psf)	Phi (deg)
Engineered Fill		125	135	Mohr-Coulomb	2000	0
Loose to M Dense Gravel & Stone Fragments		115	125	Mohr-Coulomb	0	30
M. Dense Gravel & Stone		135	140	Mohr-Coulomb	0	32
Dense to V. Dense Coars & Fine Sand		140	148	Mohr-Coulomb	0	36
Dense Sandy Silt		140	148	Mohr-Coulomb	0	35
V. Dense Gravel & Stone Fragments		150	155	Mohr-Coulomb	0	40
Shale		140	150	Mohr-Coulomb	1000	18

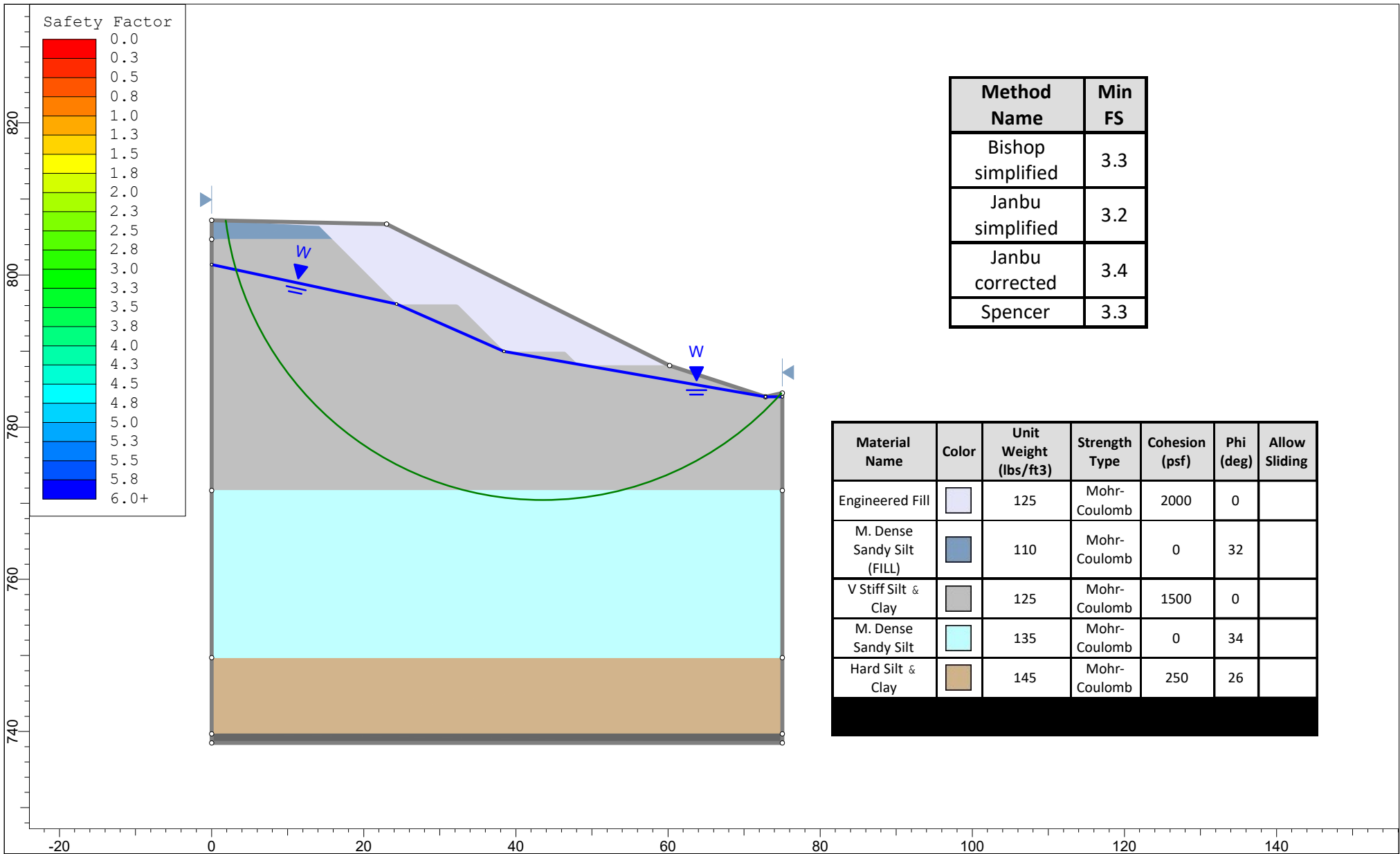


SLIDEINTERPRET 9.025

Project	CUY-71+10.07SW	
Group	Undrain Condition	Scenario: STA 329+60.81
Drawn By	LHI	Company CTL Engineering, Inc.
Date	8/15/2023, 9:31:49 AM	File Name STA 329+60 Proposed-ODOT.slmd



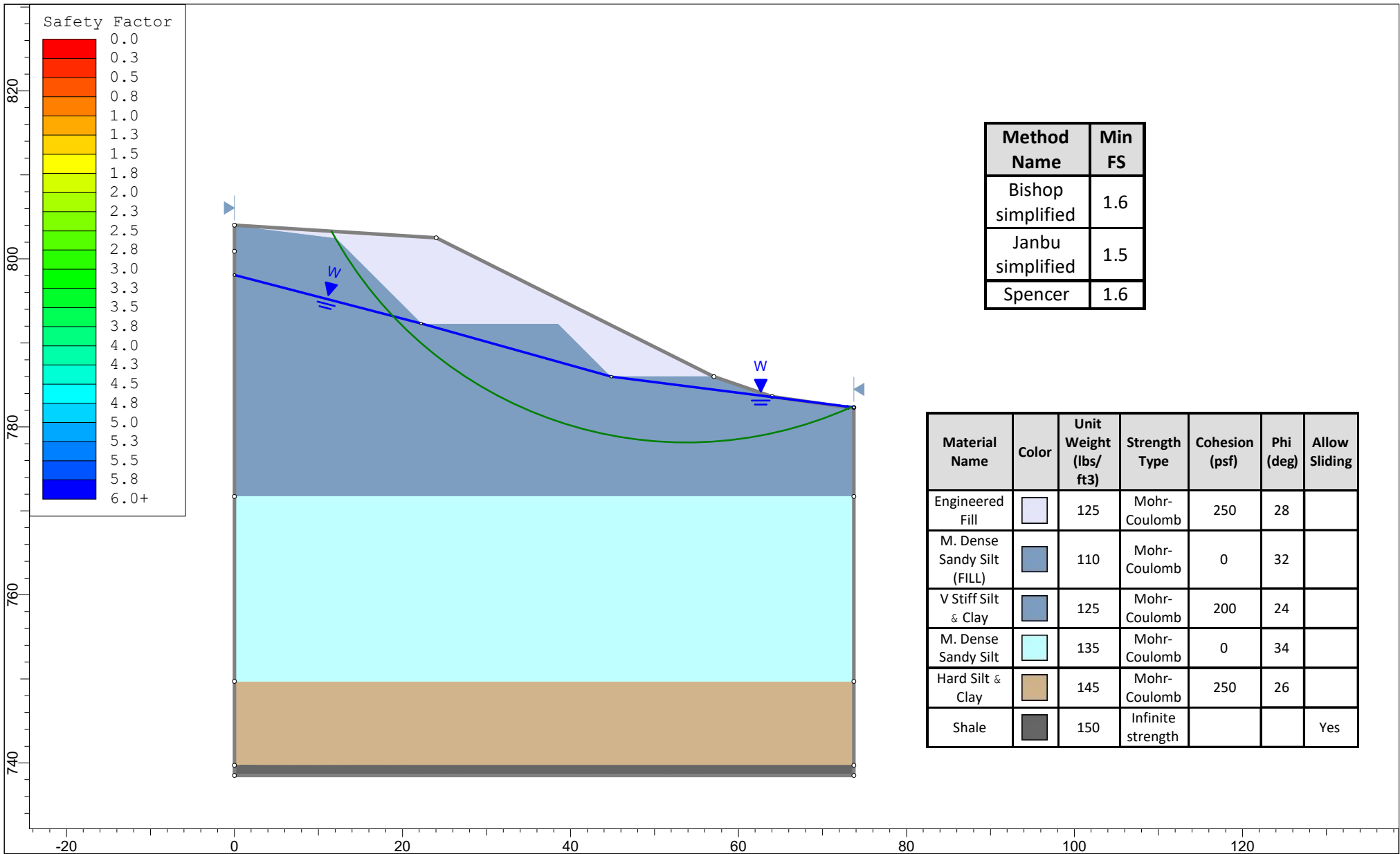
Project		CUY-71+10.07SW	
Group	Drain Condition	Scenario:	STA 334+10
Drawn By	LHI	Company	CTL Engineering, Inc.
Date	8/15/2023, 10:00:02 PM	File Name	STA 334+10.slmd



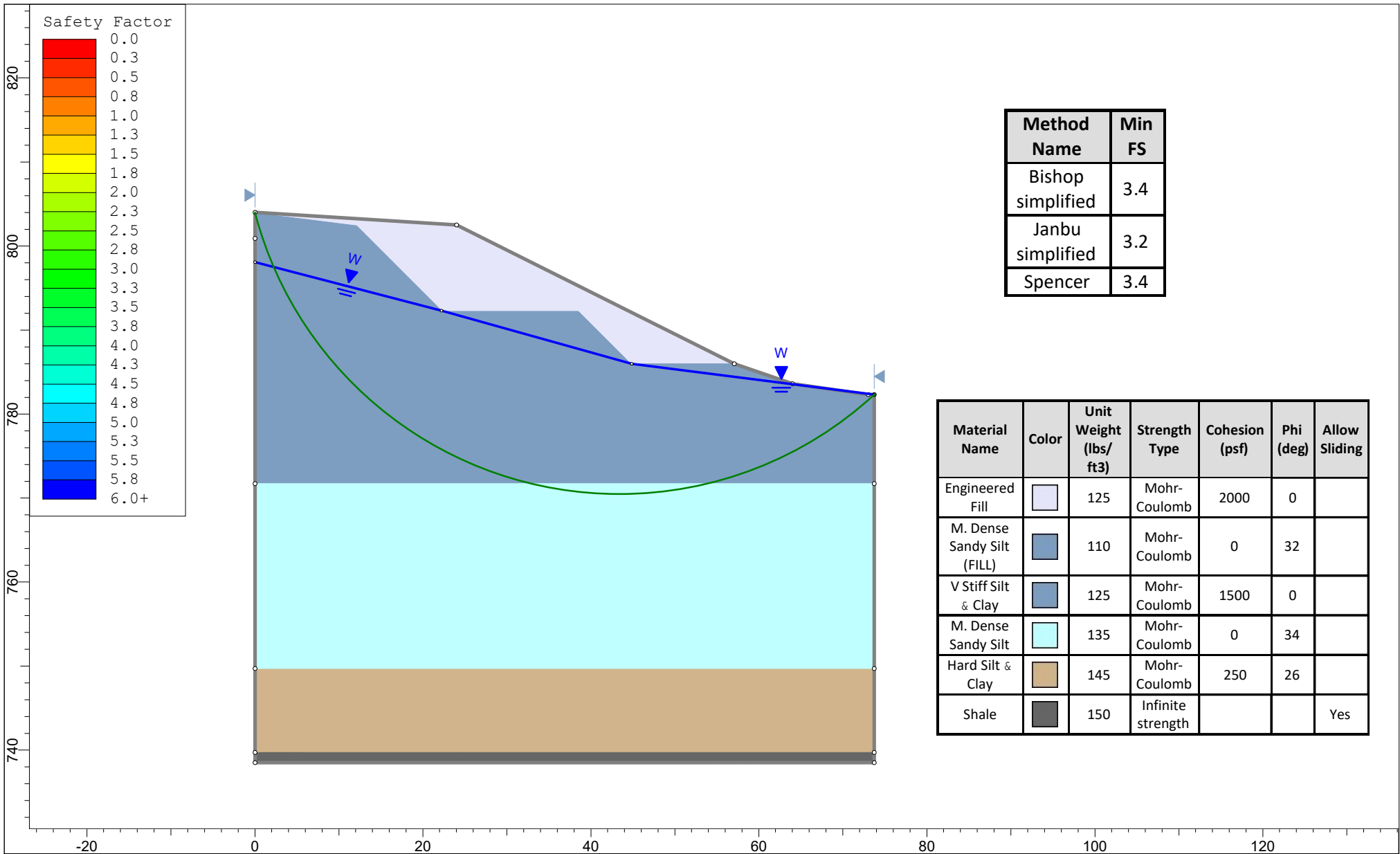
Method Name	Min FS
Bishop simplified	3.3
Janbu simplified	3.2
Janbu corrected	3.4
Spencer	3.3

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Allow Sliding
Engineered Fill		125	Mohr-Coulomb	2000	0	
M. Dense Sandy Silt (FILL)		110	Mohr-Coulomb	0	32	
V Stiff Silt & Clay		125	Mohr-Coulomb	1500	0	
M. Dense Sandy Silt		135	Mohr-Coulomb	0	34	
Hard Silt & Clay		145	Mohr-Coulomb	250	26	

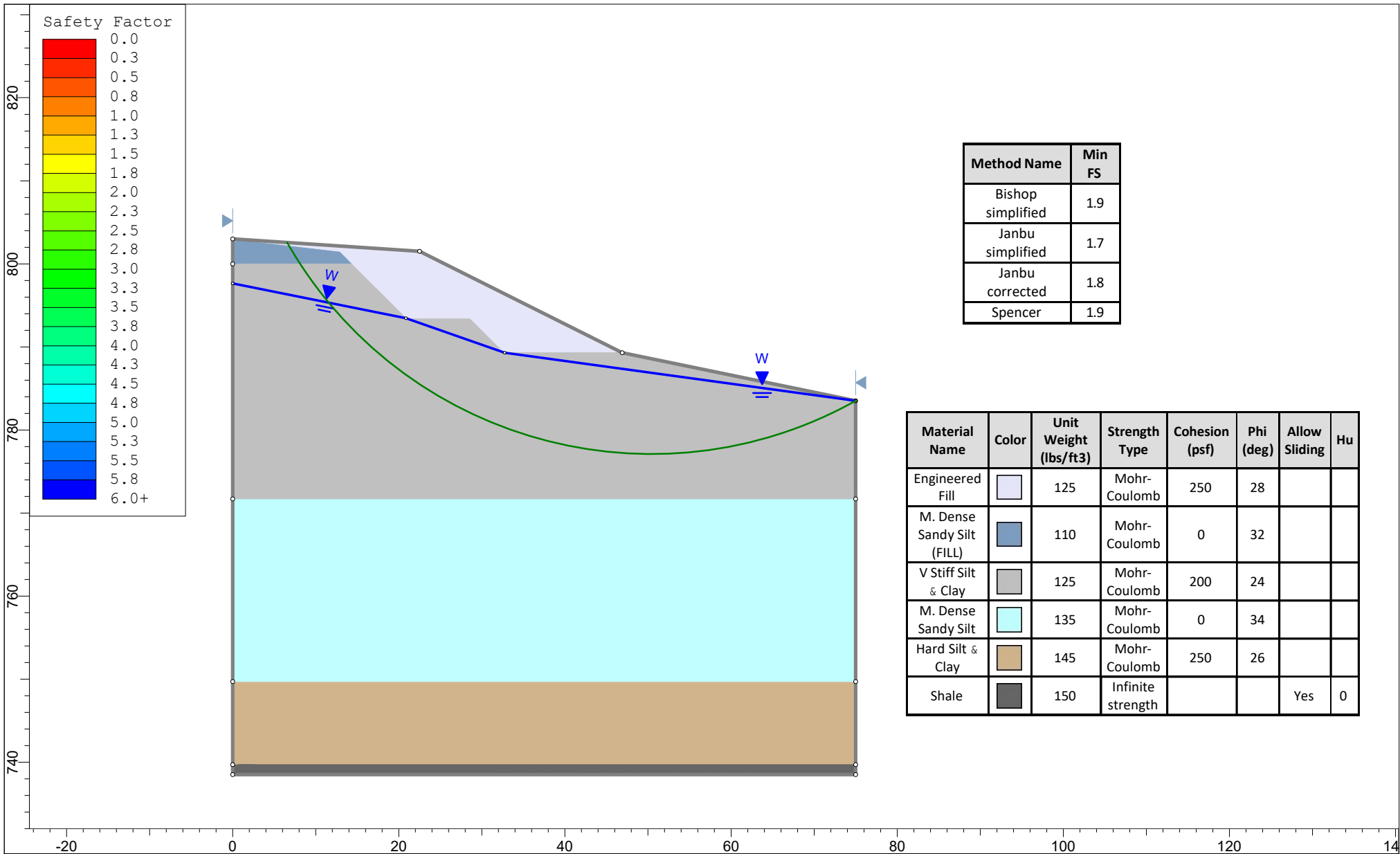
	Project		CUY-71+10.07SW	
	Group		Undrain Condition	Scenario: STA 334+10
	Drawn By		LHI	Company CTL Engineering, Inc.
	Date		8/15/2023, 10:00:02 PM	File Name STA 334+10.slmd
	SLIDEINTERPRET 9.025			



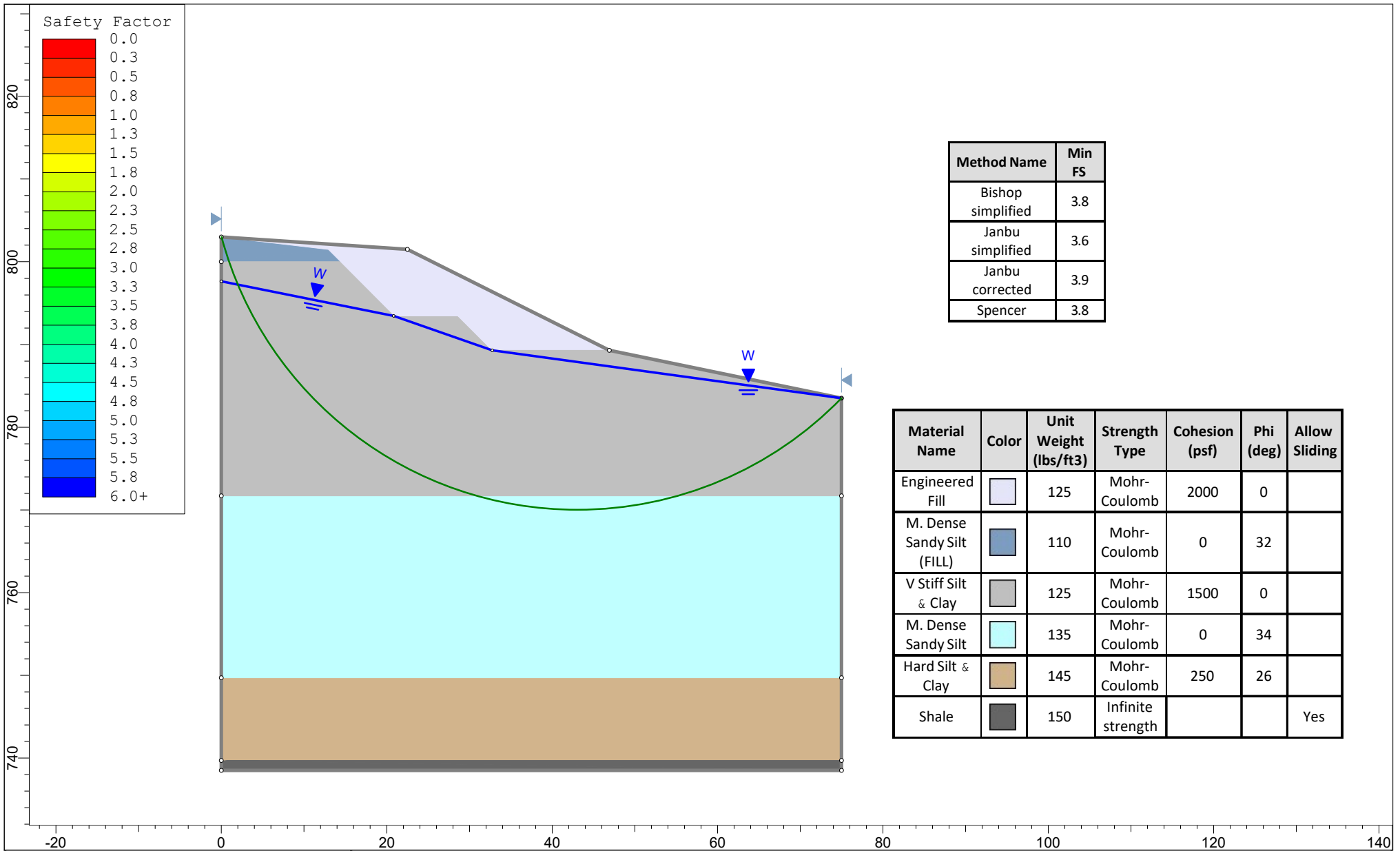
Project		CUY-71+10.07SW	
Group	Drain Condition	Scenario:	STA 335+00
Drawn By	LHI	Company	CTL Engineering, Inc.
Date	8/15/2023, 2:21:54 PM	File Name	STA 335+00 Proposed.slmd



	Project		CUY-71+10.07SW	
	Group		Undrain Condition	Scenario: STA 335+00
	Drawn By		LHI	Company CTL Engineering, Inc.
	Date		8/15/2023, 2:21:54 PM	File Name STA 335+00 Proposed.slmd
	SLIDEINTERPRET 9.025			



	Project		CUY-71+10.07SW	
	Group		Drain Condition	Scenario: STA 335+33
	Drawn By		LHI	Company CTL Engineering, Inc.
	Date		8/15/2023, 6:48:56 PM	File Name STA 335+33.slm
	SLIDEINTERPRET 9.025			



Method Name	Min FS
Bishop simplified	3.8
Janbu simplified	3.6
Janbu corrected	3.9
Spencer	3.8

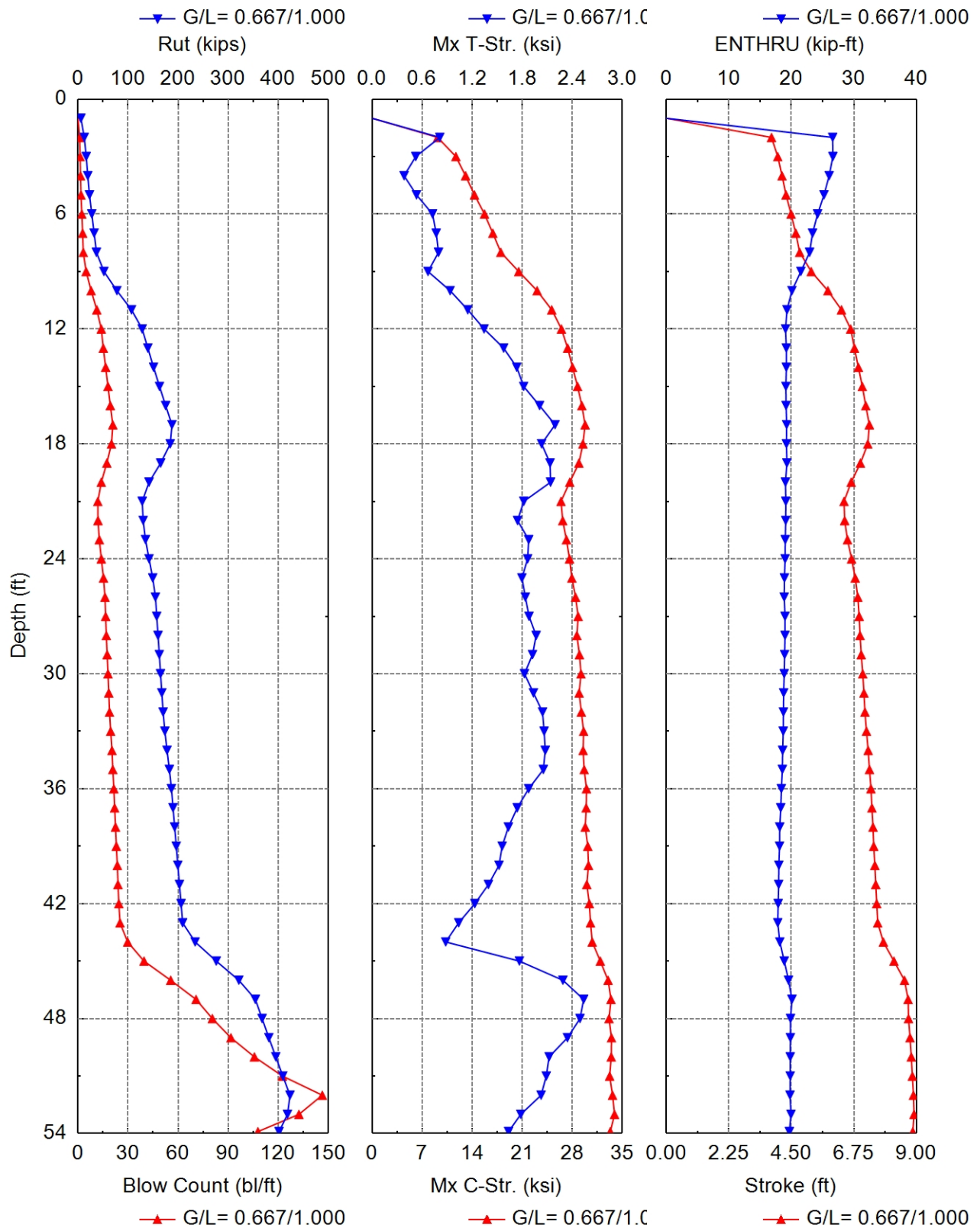
Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Allow Sliding
Engineered Fill		125	Mohr-Coulomb	2000	0	
M. Dense Sandy Silt (FILL)		110	Mohr-Coulomb	0	32	
V Stiff Silt & Clay		125	Mohr-Coulomb	1500	0	
M. Dense Sandy Silt		135	Mohr-Coulomb	0	34	
Hard Silt & Clay		145	Mohr-Coulomb	250	26	
Shale		150	Infinite strength			Yes

	Project			CUY-71+10.07SW		
	Group		Undrain Condition		Scenario:	STA 335+33
	Drawn By		LHI		Company	CTL Engineering, Inc.
	Date		8/15/2023, 6:48:56 PM		File Name	STA 335+33.slmd
	SLIDEINTERPRET 9.025					

APPENDIX E

▣ DRIVABILITY ANALYSES

Driveability Analysis Summary



Gain/Loss Factor at Shaft/Toe = 0.667/1.000

Depth ft	Rut kips	Rshaft kips	Rtoe kips	Blow Ct bl/ft	Mx C-Str ksi	Mx T-Str ksi	Stroke ft	ENTHRU kip-ft	Hammer -
1.0	5.9	0.2	5.7	0.3	0.000	0.000	10.81	0.0	D 19-42
2.0	12.6	0.8	11.8	1.0	9.169	0.812	3.79	26.6	D 19-42
3.0	16.6	1.6	15.0	1.3	11.721	0.524	4.01	26.6	D 19-42
4.0	19.6	3.3	16.3	1.5	13.075	0.384	4.17	26.1	D 19-42
5.0	23.0	7.0	16.0	1.8	14.326	0.532	4.31	25.2	D 19-42
6.0	27.7	11.7	16.0	2.3	15.723	0.724	4.49	24.2	D 19-42
7.0	32.3	16.3	16.0	2.8	16.890	0.769	4.66	23.4	D 19-42
8.0	37.0	21.0	16.0	3.2	18.013	0.797	4.80	22.9	D 19-42
9.0	51.9	25.6	26.3	4.9	20.513	0.671	5.22	21.5	D 19-42
10.0	77.8	32.8	45.0	7.9	23.084	0.935	5.82	20.1	D 19-42
11.0	107.0	41.9	65.1	11.3	25.135	1.147	6.30	19.3	D 19-42
12.0	128.4	49.6	78.8	14.0	26.492	1.343	6.64	19.1	D 19-42
13.0	139.6	56.8	82.8	15.2	27.365	1.578	6.77	19.2	D 19-42
14.0	151.1	64.4	86.7	16.6	28.041	1.735	6.91	19.2	D 19-42
15.0	163.0	72.3	90.7	18.0	28.747	1.818	7.05	19.1	D 19-42
16.0	175.3	80.7	94.6	19.4	29.347	2.008	7.18	19.2	D 19-42
17.0	187.9	89.3	98.6	20.9	29.805	2.194	7.31	19.2	D 19-42
18.0	184.4	98.3	86.1	20.1	29.495	2.033	7.25	19.2	D 19-42
19.0	165.4	104.9	60.5	17.3	28.934	2.134	6.99	19.3	D 19-42
20.0	142.1	108.5	33.6	14.0	27.653	2.141	6.65	19.1	D 19-42
21.0	128.5	110.9	17.6	11.9	26.430	1.819	6.40	19.1	D 19-42
22.0	130.3	112.7	17.6	12.0	26.668	1.744	6.42	19.1	D 19-42
23.0	135.0	114.4	20.6	12.8	27.191	1.878	6.52	19.0	D 19-42
24.0	142.0	116.2	25.8	14.0	27.621	1.865	6.67	19.0	D 19-42
25.0	149.4	118.4	31.0	15.3	27.949	1.797	6.80	18.9	D 19-42
26.0	154.9	120.9	34.0	16.2	28.465	1.838	6.89	18.9	D 19-42
27.0	157.4	123.4	34.0	16.6	28.826	1.882	6.94	19.0	D 19-42
28.0	160.0	126.0	34.0	17.0	28.647	1.967	6.97	19.0	D 19-42
29.0	162.6	128.6	34.0	17.5	29.009	1.924	7.01	18.9	D 19-42
30.0	165.1	131.1	34.0	18.0	29.230	1.828	7.07	18.9	D 19-42
31.0	167.6	133.6	34.0	18.5	28.966	1.935	7.11	18.8	D 19-42
32.0	170.2	136.2	34.0	18.9	29.275	2.044	7.15	18.7	D 19-42
33.0	173.7	138.7	35.0	19.6	29.594	2.063	7.20	18.7	D 19-42
34.0	178.0	141.3	36.7	20.4	29.524	2.077	7.27	18.6	D 19-42
35.0	182.7	144.2	38.5	20.9	29.673	2.054	7.31	18.6	D 19-42
36.0	186.8	147.3	39.5	21.5	29.995	1.878	7.37	18.4	D 19-42
37.0	190.0	150.5	39.5	22.0	29.958	1.741	7.40	18.3	D 19-42

38.0	193.3	153.8	39.5	22.5	29.822	1.635	7.44	18.1	D 19-42
39.0	196.4	156.9	39.5	23.0	30.180	1.560	7.46	18.1	D 19-42
40.0	199.6	160.1	39.5	23.6	30.272	1.522	7.51	18.0	D 19-42
41.0	202.9	163.4	39.5	24.0	30.041	1.396	7.54	18.0	D 19-42
42.0	206.1	166.6	39.5	24.5	30.393	1.232	7.57	17.9	D 19-42
43.0	209.2	169.7	39.5	25.2	30.557	1.038	7.61	17.8	D 19-42
44.0	234.2	172.9	61.3	29.8	30.798	0.883	7.81	18.2	D 19-42
45.0	276.4	177.1	99.3	39.6	31.928	1.766	8.19	18.9	D 19-42
46.0	321.5	184.3	137.3	55.6	33.014	2.289	8.57	19.6	D 19-42
47.0	354.6	195.4	159.2	70.8	33.428	2.537	8.70	20.1	D 19-42
48.0	368.0	208.8	159.2	80.6	33.149	2.494	8.72	19.9	D 19-42
49.0	381.6	222.4	159.2	91.7	33.492	2.343	8.77	19.9	D 19-42
50.0	395.4	236.2	159.2	105.8	33.460	2.123	8.82	19.8	D 19-42
51.0	409.5	250.3	159.2	122.6	33.239	2.089	8.85	19.8	D 19-42
52.0	423.7	264.5	159.2	146.5	33.639	2.027	8.89	19.8	D 19-42
53.0	418.8	279.0	139.8	132.5	33.920	1.783	8.92	19.9	D 19-42
53.9	401.9	292.5	109.4	107.9	33.328	1.637	8.87	19.7	D 19-42

Total driving time: 37 minutes; Total Number of Blows: 1546 (starting at penetration 1.0 ft)

GRLWEAP: Wave Equation Analysis of Pile Foundations

CUY-71-10.07 SW + Rear Abutment HP10x42

5/13/2024

CTL ENGINEERING, INC.

GRLWEAP 14.1.20.1

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 stresses (e.g., helmet or clamp contact, uneven rock surfaces etc.), prestress effects and others 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 structure and other factors.

PILE INPUT

Uniform Pile		Pile Type:	H Pile
Pile Length: (ft)	65.000	Pile Penetration: (ft)	53.900
Pile Size: (ft)	1.00	Toe Area: (in ²)	97.73

Pile Profile

Lb Top ft	X-Area in ²	E-Modulus ksi	Spec. Wt lb/ft ³	Perim. ft	Crit. Index -
0.0	15.5	30,000.0	492.0	4.0	0
65.0	15.5	30,000.0	492.0	4.0	0

HAMMER INPUT

ID	41	Made By:	DELMAG
Model	D 19-42	Type:	OED

Hammer Data

ID	Ram Wt kips	Ram L. in	Ram Ar. in ²	Rtd. Stk ft	Effic. -	Rtd. Energy kip-ft
41	4.000	129.1	124.7	10.8	0.80	43.2

DRIVE SYSTEM FOR DELMAG D 19-42-OED

Type	X-Area in ²	E-Modulus ksi	Thickness in	COR	Round-out in	Stiffness kips/in
Hammer C.	227.000	530.000	2.000	0.800	0.120	60155.550
Helmet Wt.	1.900	kips				

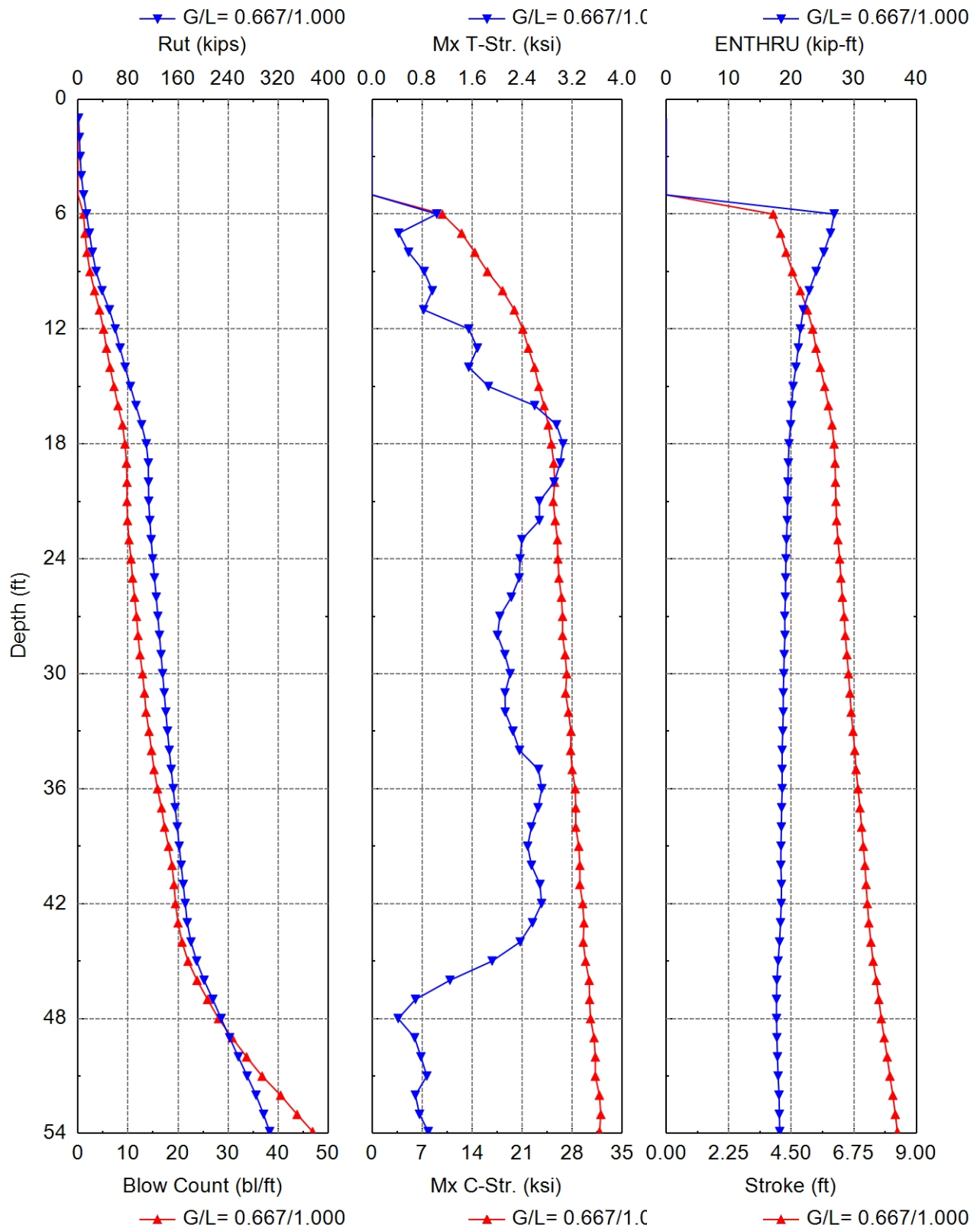
SOIL RESISTANCE DISTRIBUTION

Depth ft	Unit Rs ksf	Unit Rt ksf	Qs in	Qt in	Js s/ft	Jt s/ft	Set. F. -	Limit D. ft	Set. T. Hours	EB Area in ²
0.0	0.0	3.7	0.10	0.12	0.05	0.15	1.0	6.0	1.0	97.7
1.0	0.1	8.4	0.10	0.12	0.05	0.15	1.0	6.0	1.0	97.7
2.0	0.2	17.4	0.10	0.12	0.05	0.15	1.0	6.0	1.0	97.7
3.0	0.3	22.1	0.10	0.11	0.15	0.15	1.5	6.0	168.0	97.7
4.0	1.0	24.0	0.10	0.11	0.15	0.15	1.5	6.0	168.0	97.7
5.0	1.8	23.6	0.10	0.11	0.15	0.15	1.5	6.0	168.0	97.7
6.0	1.8	23.6	0.10	0.11	0.15	0.15	1.5	6.0	168.0	97.7
7.0	1.8	23.6	0.10	0.11	0.15	0.15	1.5	6.0	168.0	97.7
8.0	1.8	23.6	0.10	0.11	0.15	0.15	1.5	6.0	168.0	97.7
9.0	1.8	38.8	0.10	0.11	0.15	0.15	1.5	6.0	168.0	97.7
10.0	2.6	66.3	0.10	0.10	0.05	0.15	1.0	6.0	1.0	97.7

11.0	2.1	95.9	0.10	0.10	0.05	0.15	1.0	6.0	1.0	97.7
12.0	1.8	116.1	0.10	0.10	0.05	0.15	1.0	6.0	1.0	97.7
13.0	1.9	122.0	0.10	0.10	0.05	0.15	1.0	6.0	1.0	97.7
14.0	2.0	127.7	0.10	0.10	0.05	0.15	1.0	6.0	1.0	97.7
15.0	2.0	133.6	0.10	0.10	0.05	0.15	1.0	6.0	1.0	97.7
16.0	2.2	139.4	0.10	0.10	0.05	0.15	1.0	6.0	1.0	97.7
17.0	2.2	145.3	0.10	0.10	0.05	0.15	1.0	6.0	1.0	97.7
18.0	2.3	126.9	0.10	0.10	0.05	0.15	1.0	6.0	1.0	97.7
19.0	1.6	89.1	0.10	0.10	0.15	0.15	1.5	6.0	168.0	97.7
20.0	1.2	49.5	0.10	0.10	0.15	0.15	1.5	6.0	168.0	97.7
21.0	0.7	25.9	0.10	0.10	0.15	0.15	1.5	6.0	168.0	97.7
22.0	0.7	25.9	0.10	0.10	0.15	0.15	1.5	6.0	168.0	97.7
23.0	0.7	30.4	0.10	0.10	0.15	0.15	1.5	6.0	168.0	97.7
24.0	0.7	38.0	0.10	0.09	0.15	0.15	1.5	6.0	168.0	97.7
25.0	0.9	45.7	0.10	0.09	0.15	0.15	1.5	6.0	168.0	97.7
26.0	1.0	50.1	0.10	0.09	0.15	0.15	1.5	6.0	168.0	97.7
27.0	1.0	50.1	0.10	0.09	0.15	0.15	1.5	6.0	168.0	97.7
28.0	1.0	50.1	0.10	0.09	0.15	0.15	1.5	6.0	168.0	97.7
29.0	1.0	50.1	0.10	0.09	0.15	0.15	1.5	6.0	168.0	97.7
30.0	1.0	50.1	0.10	0.09	0.15	0.15	1.5	6.0	168.0	97.7
31.0	0.9	50.1	0.10	0.09	0.15	0.15	1.5	6.0	168.0	97.7
32.0	1.0	50.1	0.10	0.09	0.15	0.15	1.5	6.0	168.0	97.7
33.0	1.0	51.6	0.10	0.09	0.15	0.15	1.5	6.0	168.0	97.7
34.0	1.0	54.1	0.10	0.09	0.15	0.15	1.5	6.0	168.0	97.7
35.0	1.2	56.7	0.10	0.09	0.15	0.15	1.5	6.0	168.0	97.7
36.0	1.2	58.2	0.10	0.09	0.15	0.15	1.5	6.0	168.0	97.7
37.0	1.2	58.2	0.10	0.09	0.15	0.15	1.5	6.0	168.0	97.7
38.0	1.2	58.2	0.10	0.09	0.15	0.15	1.5	6.0	168.0	97.7
39.0	1.2	58.2	0.10	0.09	0.15	0.15	1.5	6.0	168.0	97.7
40.0	1.2	58.2	0.10	0.09	0.15	0.15	1.5	6.0	168.0	97.7
41.0	1.2	58.2	0.10	0.09	0.15	0.15	1.5	6.0	168.0	97.7
42.0	1.2	58.2	0.10	0.09	0.15	0.15	1.5	6.0	168.0	97.7
43.0	1.2	58.2	0.10	0.09	0.15	0.15	1.5	6.0	168.0	97.7
44.0	1.2	90.3	0.10	0.09	0.15	0.15	1.5	6.0	168.0	97.7
45.0	1.6	146.3	0.10	0.09	0.10	0.15	1.2	6.0	24.0	97.7
46.0	2.8	202.3	0.10	0.09	0.10	0.15	1.2	6.0	24.0	97.7
47.0	4.0	234.6	0.10	0.09	0.10	0.15	1.2	6.0	24.0	97.7
48.0	4.1	234.6	0.10	0.09	0.10	0.15	1.2	6.0	24.0	97.7
49.0	4.2	234.6	0.10	0.09	0.10	0.15	1.2	6.0	24.0	97.7
50.0	4.2	234.6	0.10	0.09	0.10	0.15	1.2	6.0	24.0	97.7

51.0	4.3	234.6	0.10	0.09	0.10	0.15	1.2	6.0	24.0	97.7
52.0	4.4	234.6	0.10	0.09	0.10	0.15	1.2	6.0	24.0	97.7
53.0	4.4	206.0	0.10	0.09	0.10	0.15	1.2	6.0	24.0	97.7
54.0	5.4	156.2	0.10	0.08	0.20	0.15	1.4	6.0	24.0	97.7

Driveability Analysis Summary



Gain/Loss Factor at Shaft/Toe = 0.667/1.000

Depth ft	Rut kips	Rshaft kips	Rtoe kips	Blow CtMx bl/ft	C-StrMx ksi	T-Str. ksi	Stroke ft	ENTHRU kip-ft	Hammer -
1.0	0.9	0.2	0.7	0.3	0.000	0.000	10.81	0.0	D 19-42
2.0	2.3	0.8	1.5	0.3	0.000	0.000	10.81	0.0	D 19-42
3.0	3.5	1.6	1.9	0.3	0.000	0.000	10.81	0.0	D 19-42
4.0	5.4	3.3	2.1	0.3	0.000	0.000	10.81	0.0	D 19-42
5.0	9.0	7.0	2.0	0.0	0.000	0.000	0.00	0.0	D 19-42
6.0	13.7	11.7	2.0	1.1	9.823	1.034	3.85	26.9	D 19-42
7.0	18.4	16.3	2.0	1.4	12.522	0.425	4.11	26.3	D 19-42
8.0	23.0	21.0	2.0	1.8	14.372	0.584	4.31	25.2	D 19-42
9.0	29.0	25.6	3.3	2.4	16.136	0.833	4.54	24.0	D 19-42
10.0	38.5	32.8	5.7	3.3	18.248	0.963	4.82	22.9	D 19-42
11.0	50.2	41.9	8.3	4.3	19.897	0.824	5.08	21.9	D 19-42
12.0	59.6	49.6	10.0	5.1	21.081	1.546	5.27	21.4	D 19-42
13.0	67.4	56.8	10.5	5.7	21.860	1.684	5.39	21.1	D 19-42
14.0	75.4	64.4	11.0	6.4	22.728	1.547	5.55	20.7	D 19-42
15.0	83.8	72.3	11.5	7.2	23.323	1.861	5.70	20.3	D 19-42
16.0	92.7	80.7	12.0	8.0	24.059	2.599	5.83	20.1	D 19-42
17.0	101.8	89.3	12.5	8.9	24.649	2.948	5.96	19.9	D 19-42
18.0	109.2	98.3	10.9	9.4	25.080	3.052	6.04	19.6	D 19-42
19.0	112.5	104.9	7.7	9.7	25.419	3.008	6.07	19.5	D 19-42
20.0	112.7	108.5	4.3	9.8	25.531	2.911	6.09	19.5	D 19-42
21.0	113.1	110.9	2.2	9.8	25.339	2.675	6.11	19.4	D 19-42
22.0	114.9	112.7	2.2	9.9	25.617	2.675	6.13	19.3	D 19-42
23.0	117.0	114.4	2.6	10.2	25.931	2.394	6.18	19.2	D 19-42
24.0	119.5	116.2	3.3	10.6	25.989	2.366	6.24	19.1	D 19-42
25.0	122.4	118.4	3.9	10.9	26.140	2.352	6.29	19.1	D 19-42
26.0	125.2	120.9	4.3	11.3	26.493	2.227	6.34	19.1	D 19-42
27.0	127.7	123.4	4.3	11.7	26.652	2.043	6.40	18.9	D 19-42
28.0	130.3	126.0	4.3	12.0	26.644	2.004	6.44	19.0	D 19-42
29.0	132.9	128.6	4.3	12.4	27.006	2.123	6.50	18.9	D 19-42
30.0	135.4	131.1	4.3	12.9	27.238	2.208	6.56	18.8	D 19-42
31.0	137.9	133.6	4.3	13.3	27.075	2.127	6.61	18.7	D 19-42
32.0	140.5	136.2	4.3	13.6	27.475	2.128	6.65	18.7	D 19-42
33.0	143.2	138.7	4.4	14.2	27.825	2.252	6.72	18.6	D 19-42
34.0	146.0	141.3	4.7	14.7	27.779	2.357	6.78	18.5	D 19-42
35.0	149.1	144.2	4.9	15.2	27.988	2.660	6.83	18.5	D 19-42
36.0	152.3	147.3	5.0	15.9	28.419	2.714	6.90	18.5	D 19-42
37.0	155.5	150.5	5.0	16.7	28.489	2.653	6.97	18.5	D 19-42

38.0	158.8	153.8	5.0	17.3	28.489	2.548	7.03	18.4	D 19-42
39.0	162.0	156.9	5.0	18.1	28.914	2.487	7.09	18.4	D 19-42
40.0	165.1	160.1	5.0	18.8	29.065	2.548	7.15	18.3	D 19-42
41.0	168.4	163.4	5.0	19.2	29.062	2.684	7.19	18.4	D 19-42
42.0	171.6	166.6	5.0	19.5	29.465	2.710	7.24	18.4	D 19-42
43.0	174.7	169.7	5.0	20.0	29.644	2.566	7.29	18.3	D 19-42
44.0	180.7	172.9	7.8	20.8	29.535	2.368	7.36	18.1	D 19-42
45.0	189.7	177.1	12.6	22.0	29.867	1.919	7.44	17.9	D 19-42
46.0	201.7	184.3	17.4	23.8	30.367	1.245	7.56	17.7	D 19-42
47.0	215.6	195.4	20.2	25.9	30.431	0.694	7.65	17.6	D 19-42
48.0	229.0	208.8	20.2	28.1	30.562	0.417	7.74	17.6	D 19-42
49.0	242.6	222.4	20.2	30.8	31.052	0.681	7.84	17.7	D 19-42
50.0	256.4	236.2	20.2	33.7	31.234	0.781	7.95	17.8	D 19-42
51.0	270.5	250.3	20.2	36.8	31.229	0.875	8.05	17.9	D 19-42
52.0	284.7	264.5	20.2	40.5	31.807	0.692	8.15	18.0	D 19-42
53.0	296.8	279.0	17.7	43.8	32.009	0.758	8.24	18.1	D 19-42
53.9	306.4	292.5	13.9	46.9	31.820	0.898	8.31	18.1	D 19-42

Total driving time: 17 minutes; Total Number of Blows: 739 (starting at penetration 1.0 ft)

GRLWEAP: Wave Equation Analysis of Pile Foundations

CUY-71-10.07 SW + Rear Abutment HP10x42

5/13/2024

CTL ENGINEERING, INC.

GRLWEAP 14.1.20.1

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 stresses (e.g., helmet or clamp contact, uneven rock surfaces etc.), prestress effects and others 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 structure and other factors.

PILE INPUT

Uniform Pile		Pile Type:	H Pile
Pile Length: (ft)	65.000	Pile Penetration: (ft)	53.900
Pile Size: (ft)	1.00	Toe Area: (in ²)	12.40

Pile Profile

Lb Top ft	X-Area in ²	E-Modulus ksi	Spec. Wt lb/ft ³	Perim. ft	Crit. Index -
0.0	15.5	30,000.0	492.0	4.0	0
65.0	15.5	30,000.0	492.0	4.0	0

HAMMER INPUT

ID	41	Made By:	DELMAG
Model	D 19-42	Type:	OED

Hammer Data

ID	Ram Wt kips	Ram L. in	Ram Ar. in ²	Rtd. Stk ft	Effic. -	Rtd. Energy kip-ft
41	4.000	129.1	124.7	10.8	0.80	43.2

DRIVE SYSTEM FOR DELMAG D 19-42-OED

Type	X-Area in ²	E-Modulus ksi	Thickness in	COR	Round-out in	Stiffness kips/in
Hammer C.	227.000	530.000	2.000	0.800	0.120	60155.550
Helmet Wt.	1.900	kips				

SOIL RESISTANCE DISTRIBUTION

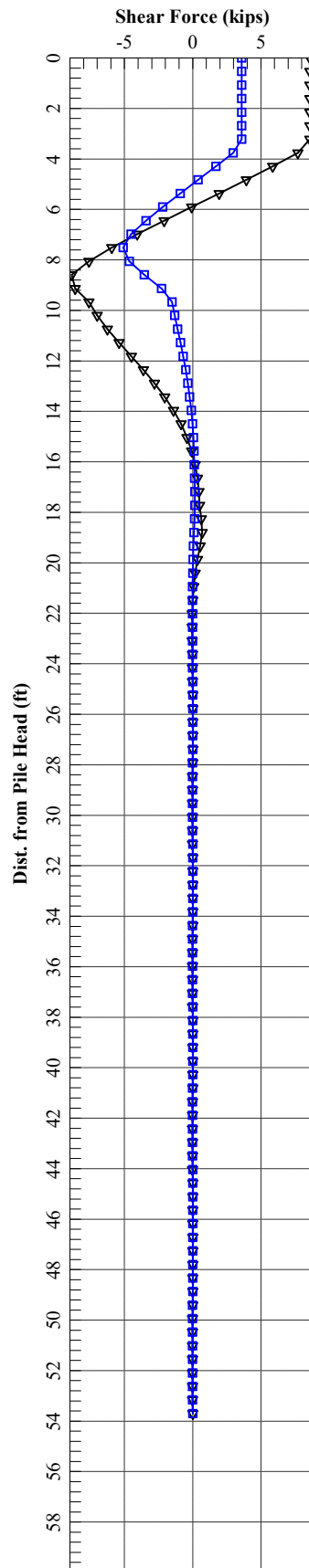
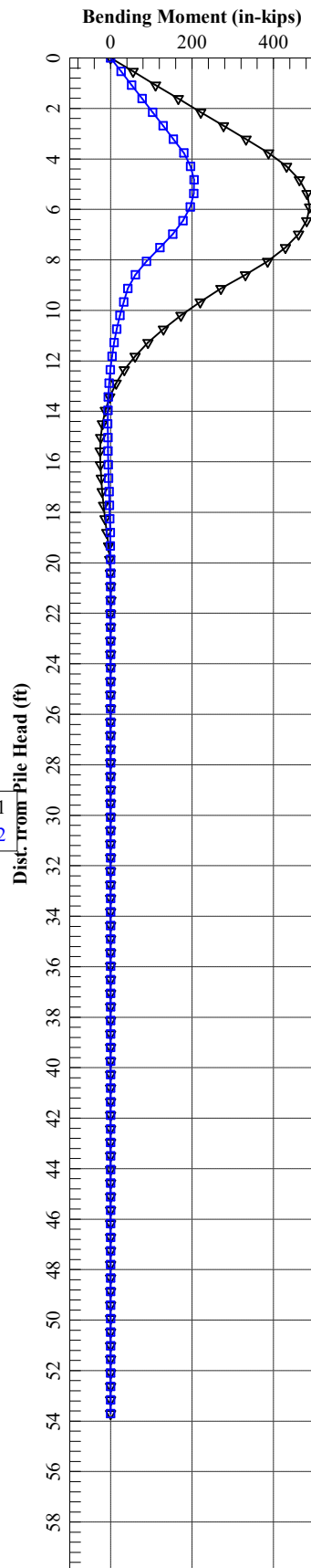
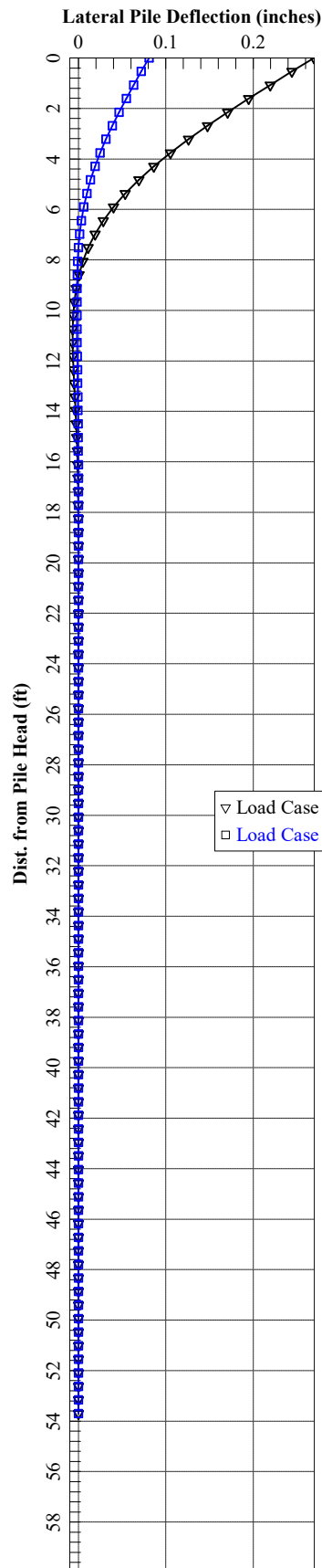
Depth ft	Unit Rs ksf	Unit Rt ksf	Qs in	Qt in	Js s/ft	Jt s/ft	Set. F. -	Limit D. ft	Set. T. Hours	EB Area in ²
0.0	0.0	3.7	0.10	0.12	0.05	0.15	1.0	6.0	1.0	12.4
1.0	0.1	8.4	0.10	0.12	0.05	0.15	1.0	6.0	1.0	12.4
2.0	0.2	17.4	0.10	0.12	0.05	0.15	1.0	6.0	1.0	12.4
3.0	0.3	22.1	0.10	0.11	0.15	0.15	1.5	6.0	168.0	12.4
4.0	1.0	24.0	0.10	0.11	0.15	0.15	1.5	6.0	168.0	12.4
5.0	1.8	23.6	0.10	0.11	0.15	0.15	1.5	6.0	168.0	12.4
6.0	1.8	23.6	0.10	0.11	0.15	0.15	1.5	6.0	168.0	12.4
7.0	1.8	23.6	0.10	0.11	0.15	0.15	1.5	6.0	168.0	12.4
8.0	1.8	23.6	0.10	0.11	0.15	0.15	1.5	6.0	168.0	12.4
9.0	1.8	38.8	0.10	0.11	0.15	0.15	1.5	6.0	168.0	12.4
10.0	2.6	66.3	0.10	0.10	0.05	0.15	1.0	6.0	1.0	12.4

11.0	2.1	95.9	0.10	0.10	0.05	0.15	1.0	6.0	1.0	12.4
12.0	1.8	116.1	0.10	0.10	0.05	0.15	1.0	6.0	1.0	12.4
13.0	1.9	122.0	0.10	0.10	0.05	0.15	1.0	6.0	1.0	12.4
14.0	2.0	127.7	0.10	0.10	0.05	0.15	1.0	6.0	1.0	12.4
15.0	2.0	133.6	0.10	0.10	0.05	0.15	1.0	6.0	1.0	12.4
16.0	2.2	139.4	0.10	0.10	0.05	0.15	1.0	6.0	1.0	12.4
17.0	2.2	145.3	0.10	0.10	0.05	0.15	1.0	6.0	1.0	12.4
18.0	2.3	126.9	0.10	0.10	0.05	0.15	1.0	6.0	1.0	12.4
19.0	1.6	89.1	0.10	0.10	0.15	0.15	1.5	6.0	168.0	12.4
20.0	1.2	49.5	0.10	0.10	0.15	0.15	1.5	6.0	168.0	12.4
21.0	0.7	25.9	0.10	0.10	0.15	0.15	1.5	6.0	168.0	12.4
22.0	0.7	25.9	0.10	0.10	0.15	0.15	1.5	6.0	168.0	12.4
23.0	0.7	30.4	0.10	0.10	0.15	0.15	1.5	6.0	168.0	12.4
24.0	0.7	38.0	0.10	0.09	0.15	0.15	1.5	6.0	168.0	12.4
25.0	0.9	45.7	0.10	0.09	0.15	0.15	1.5	6.0	168.0	12.4
26.0	1.0	50.1	0.10	0.09	0.15	0.15	1.5	6.0	168.0	12.4
27.0	1.0	50.1	0.10	0.09	0.15	0.15	1.5	6.0	168.0	12.4
28.0	1.0	50.1	0.10	0.09	0.15	0.15	1.5	6.0	168.0	12.4
29.0	1.0	50.1	0.10	0.09	0.15	0.15	1.5	6.0	168.0	12.4
30.0	1.0	50.1	0.10	0.09	0.15	0.15	1.5	6.0	168.0	12.4
31.0	0.9	50.1	0.10	0.09	0.15	0.15	1.5	6.0	168.0	12.4
32.0	1.0	50.1	0.10	0.09	0.15	0.15	1.5	6.0	168.0	12.4
33.0	1.0	51.6	0.10	0.09	0.15	0.15	1.5	6.0	168.0	12.4
34.0	1.0	54.1	0.10	0.09	0.15	0.15	1.5	6.0	168.0	12.4
35.0	1.2	56.7	0.10	0.09	0.15	0.15	1.5	6.0	168.0	12.4
36.0	1.2	58.2	0.10	0.09	0.15	0.15	1.5	6.0	168.0	12.4
37.0	1.2	58.2	0.10	0.09	0.15	0.15	1.5	6.0	168.0	12.4
38.0	1.2	58.2	0.10	0.09	0.15	0.15	1.5	6.0	168.0	12.4
39.0	1.2	58.2	0.10	0.09	0.15	0.15	1.5	6.0	168.0	12.4
40.0	1.2	58.2	0.10	0.09	0.15	0.15	1.5	6.0	168.0	12.4
41.0	1.2	58.2	0.10	0.09	0.15	0.15	1.5	6.0	168.0	12.4
42.0	1.2	58.2	0.10	0.09	0.15	0.15	1.5	6.0	168.0	12.4
43.0	1.2	58.2	0.10	0.09	0.15	0.15	1.5	6.0	168.0	12.4
44.0	1.2	90.3	0.10	0.09	0.15	0.15	1.5	6.0	168.0	12.4
45.0	1.6	146.3	0.10	0.09	0.10	0.15	1.2	6.0	24.0	12.4
46.0	2.8	202.3	0.10	0.09	0.10	0.15	1.2	6.0	24.0	12.4
47.0	4.0	234.6	0.10	0.09	0.10	0.15	1.2	6.0	24.0	12.4
48.0	4.1	234.6	0.10	0.09	0.10	0.15	1.2	6.0	24.0	12.4
49.0	4.2	234.6	0.10	0.09	0.10	0.15	1.2	6.0	24.0	12.4
50.0	4.2	234.6	0.10	0.09	0.10	0.15	1.2	6.0	24.0	12.4

51.0	4.3	234.6	0.10	0.09	0.10	0.15	1.2	6.0	24.0	12.4
52.0	4.4	234.6	0.10	0.09	0.10	0.15	1.2	6.0	24.0	12.4
53.0	4.4	206.0	0.10	0.09	0.10	0.15	1.2	6.0	24.0	12.4
54.0	5.4	156.2	0.10	0.08	0.20	0.15	1.4	6.0	24.0	12.4

APPENDIX F

▣ PILE LATERAL LOAD ANALYSES



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LPILE for Windows, Version 2022-12.007

Analysis of Individual Piles and Drilled Shafts
Subjected to Lateral Loading Using the p-y Method
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Files Used for Analysis

Path to file locations:

\PROJECT\2023\CLE-05\23050013CLE_Mott MacDonald _ CUY 71 10 07SW\Reports\LPILE\

Name of input data file:

24.6.3 B-004-0-24 Rear Abutment.lp12d

Name of output report file:

24.6.3 B-004-0-24 Rear Abutment.lp12o

Name of plot output file:

24.6.3 B-004-0-24 Rear Abutment.lp12p

Name of runtime message file:

24.6.3 B-004-0-24 Rear Abutment.lp12r

Date and Time of Analysis

Date: June 3, 2024

Time: 10:41:23

Problem Title

Project Name: CUY-71-10.07 SW

Job Number: 23050013CLE

Client: Ohio Department of Transportation

Engineer: CTL Engineering, Inc.

Description: Rear Abutment - Lateral Analysis

Program Options and Settings

Computational Options:

- Conventional Analysis

Engineering Units Used for Data Input and Computations:

- US Customary System Units (pounds, feet, inches)

Analysis Control Options:

- | | | |
|--|---|---------------|
| - Maximum number of iterations allowed | = | 500 |
| - Deflection tolerance for convergence | = | 1.0000E-05 in |
| - Maximum allowable deflection | = | 100.0000 in |
| - Number of pile increments | = | 100 |

Loading Type and Number of Cycles of Loading:

- Static loading specified
- Use of p-y modification factors for p-y curves not selected
- Analysis uses layering correction (Method of Georgiadis)
- Analysis includes loading by multiple distributed lateral loads acting on pile
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Computation of pile-head foundation stiffness matrix not selected
- Push-over analysis of pile not selected
- Buckling analysis of pile not selected

Output Options:

- Output files use decimal points to denote decimal symbols.
- Values of pile-head deflection, bending moment, shear force, and soil reaction are printed for full length of pile.
- Printing Increment (nodal spacing of output points) = 1

- No p-y curves to be computed and reported for user-specified depths
- Print using wide report formats

Pile Structural Properties and Geometry

Number of pile sections defined = 1
 Total length of pile = 53.700 ft
 Depth of ground surface below top of pile = 3.5000 ft

Pile diameters used for p-y curve computations are defined using 2 points.

p-y curves are computed using pile diameter values interpolated with depth over the length of the pile. A summary of values of pile diameter vs. depth follows.

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	10.1000
2	53.700	10.1000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is a H strong axis steel pile
 Length of section = 53.700000 ft
 Pile width = 10.100000 in

Soil and Rock Layering Information

The soil profile is modelled using 7 layers

Layer 1 is stiff clay without free water

Distance from top of pile to top of layer = 3.500000 ft
 Distance from top of pile to bottom of layer = 9.200000 ft
 Effective unit weight at top of layer = 125.000000 pcf
 Effective unit weight at bottom of layer = 125.000000 pcf
 Undrained cohesion at top of layer = 2625. psf
 Undrained cohesion at bottom of layer = 2625. psf
 Epsilon-50 at top of layer = 0.005000

Epsilon-50 at bottom of layer = 0.005000

Layer 2 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer	=	9.200000	ft
Distance from top of pile to bottom of layer	=	18.200000	ft
Effective unit weight at top of layer	=	132.000000	pcf
Effective unit weight at bottom of layer	=	132.000000	pcf
Friction angle at top of layer	=	38.200000	deg.
Friction angle at bottom of layer	=	38.200000	deg.
Subgrade k at top of layer	=	225.000000	pci
Subgrade k at bottom of layer	=	225.000000	pci

Layer 3 is stiff clay without free water

Distance from top of pile to top of layer	=	18.200000	ft
Distance from top of pile to bottom of layer	=	23.200000	ft
Effective unit weight at top of layer	=	125.000000	pcf
Effective unit weight at bottom of layer	=	125.000000	pcf
Undrained cohesion at top of layer	=	2875.	psf
Undrained cohesion at bottom of layer	=	2875.	psf
Epsilon-50 at top of layer	=	0.005000	
Epsilon-50 at bottom of layer	=	0.005000	

Layer 4 is stiff clay without free water

Distance from top of pile to top of layer	=	23.200000	ft
Distance from top of pile to bottom of layer	=	33.200000	ft
Effective unit weight at top of layer	=	135.000000	pcf
Effective unit weight at bottom of layer	=	135.000000	pcf
Undrained cohesion at top of layer	=	5563.	psf
Undrained cohesion at bottom of layer	=	5563.	psf
Epsilon-50 at top of layer	=	0.004000	
Epsilon-50 at bottom of layer	=	0.004000	

Layer 5 is stiff clay without free water

Distance from top of pile to top of layer	=	33.200000	ft
Distance from top of pile to bottom of layer	=	44.200000	ft
Effective unit weight at top of layer	=	140.000000	pcf
Effective unit weight at bottom of layer	=	140.000000	pcf
Undrained cohesion at top of layer	=	6460.	psf
Undrained cohesion at bottom of layer	=	6460.	psf
Epsilon-50 at top of layer	=	0.004000	
Epsilon-50 at bottom of layer	=	0.004000	

Layer 6 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer	=	44.200000 ft
Distance from top of pile to bottom of layer	=	53.700000 ft
Effective unit weight at top of layer	=	132.000000 pcf
Effective unit weight at bottom of layer	=	132.000000 pcf
Friction angle at top of layer	=	37.750000 deg.
Friction angle at bottom of layer	=	37.750000 deg.
Subgrade k at top of layer	=	225.000000 pci
Subgrade k at bottom of layer	=	225.000000 pci

Layer 7 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer	=	53.700000 ft
Distance from top of pile to bottom of layer	=	60.000000 ft
Effective unit weight at top of layer	=	155.000000 pcf
Effective unit weight at bottom of layer	=	155.000000 pcf
Uniaxial compressive strength at top of layer	=	120.280000 psi
Uniaxial compressive strength at bottom of layer	=	120.280000 psi
Initial modulus of rock at top of layer	=	10800. psi
Initial modulus of rock at bottom of layer	=	10800. psi
RQD of rock at top of layer	=	0.0000 %
RQD of rock at bottom of layer	=	0.0000 %
k _{rm} of rock at top of layer	=	0.0005000
k _{rm} of rock at bottom of layer	=	0.0005000

(Depth of the lowest soil layer extends 6.300 ft below the pile tip)

**** Warning - Possible Input Data Error ****

Values entered for effective unit weight of rock were outside the limits of 50 pcf to 150 pcf.

The maximum input value, in layer 1, for effective unit weight = 155.00 pcf

This data may be erroneous. Please check your data.

Summary of Input Soil Properties

Layer Num.	Soil Type Name (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Cohesion psf	Angle of Friction deg.	Uniaxial qu psi	RQD %	E50 or k _{rm}	k _{py} pci	Rock Mass Modulus psi
1	Stiff Clay	3.5000	125.0000	2625.	--	--	--	0.00500	--	--
	w/o Free Water	9.2000	125.0000	2625.	--	--	--	0.00500	--	--
2	Sand	9.2000	132.0000	--	38.2000	--	--	--	225.0000	--
	(Reese, et al.)	18.2000	132.0000	--	38.2000	--	--	--	225.0000	--
3	Stiff Clay	18.2000	125.0000	2875.	--	--	--	0.00500	--	--

	w/o Free Water	23.2000	125.0000	2875.	--	--	--	0.00500	--	--
4	Stiff Clay	23.2000	135.0000	5563.	--	--	--	0.00400	--	--
	w/o Free Water	33.2000	135.0000	5563.	--	--	--	0.00400	--	--
5	Stiff Clay	33.2000	140.0000	6460.	--	--	--	0.00400	--	--
	w/o Free Water	44.2000	140.0000	6460.	--	--	--	0.00400	--	--
6	Sand	44.2000	132.0000	--	37.7500	--	--	--	225.0000	--
	(Reese, et al.)	53.7000	132.0000	--	37.7500	--	--	--	225.0000	--
7	Weak	53.7000	155.0000	--	--	120.2800	0.00	5.00E-04	--	10800.
	Rock	60.0000	155.0000	--	--	120.2800	0.00	5.00E-04	--	10800.

Static Loading Type

Static loading criteria were used when computing p-y curves for all analyses.

Distributed Lateral Loading for Individual Load Cases

Distributed lateral load intensity for Load Case 1 defined using 2 points

Point No.	Depth X ft	Dist. Load lb/in
1	0.000	0.000
2	53.700	0.000

Distributed lateral load intensity for Load Case 2 defined using 2 points

Point No.	Depth X ft	Dist. Load lb/in
1	0.000	0.000
2	53.700	0.000

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 2

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length	Run Analysis
-----	----	-----	-----	-----	-----	-----

1	1	V =	8600. lbs	M =	0.0000 in-lbs	0.0000000	Yes	Yes
2	1	V =	3600. lbs	M =	0.0000 in-lbs	310000.	Yes	Yes

V = shear force applied normal to pile axis

M = bending moment applied to pile head

y = lateral deflection normal to pile axis

S = pile slope relative to original pile batter angle

R = rotational stiffness applied to pile head

Values of top y vs. pile lengths can be computed only for load types with specified shear loading (Load Types 1, 2, and 3).

Thrust force is assumed to be acting axially for all pile batter angles.

 Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 1

Pile Section No. 1:

 Dimensions and Properties of Steel H Strong Axis:

Length of Section	=	53.700000 ft
Flange Width	=	10.100000 in
Section Depth	=	12.400000 in
Flange Thickness	=	0.420000 in
Web Thickness	=	0.415000 in
Yield Stress of Pipe	=	50.000000 ksi
Elastic Modulus	=	29000. ksi
Cross-sectional Area	=	13.281400 sq. in.
Moment of Inertia	=	357.955969 in^4
Elastic Bending Stiffness	=	10380723. kip-in^2
Plastic Modulus, Z	=	64.683646in^3
Plastic Moment Capacity = Fy Z	=	3234.in-kip

Axial Structural Capacities:

Nom. Axial Structural Capacity = Fy As	=	664.070 kips
Nominal Axial Tensile Capacity	=	-664.070 kips

Number of Axial Thrust Force Values Determined from Pile-head Loadings = 2

Number	Axial Thrust Force
--------	--------------------

----- kips -----

1	0.000
2	310.000

Definition of Run Messages:

Y = part of pipe section has yielded.

Axial Thrust Force = 0.000 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Total Stress ksi	Run Msg
-----	-----	-----	-----	-----	----
0.00000726	75.2231455	10368404.	6.2000000	1.2914109	
0.00001451	150.4462911	10368404.	6.2000000	2.5828218	
0.00002177	225.6694366	10368404.	6.2000000	3.8742327	
0.00002902	300.8925822	10368404.	6.2000000	5.1656436	
0.00003628	376.1157277	10368404.	6.2000000	6.4570546	
0.00004353	451.3388733	10368404.	6.2000000	7.7484655	
0.00005079	526.5620188	10368404.	6.2000000	9.0398764	
0.00005804	601.7851644	10368404.	6.2000000	10.3312873	
0.00006530	677.0083099	10368404.	6.2000000	11.6226982	
0.00007255	752.2314555	10368404.	6.2000000	12.9141091	
0.00007981	827.4546010	10368404.	6.2000000	14.2055200	
0.00008706	902.6777466	10368404.	6.2000000	15.4969309	
0.00009432	977.9008921	10368404.	6.2000000	16.7883419	
0.0001016	1053.	10368404.	6.2000000	18.0797528	
0.0001088	1128.	10368404.	6.2000000	19.3711637	
0.0001161	1204.	10368404.	6.2000000	20.6625746	
0.0001233	1279.	10368404.	6.2000000	21.9539855	
0.0001306	1354.	10368404.	6.2000000	23.2453964	
0.0001378	1429.	10368404.	6.2000000	24.5368073	
0.0001451	1504.	10368404.	6.2000000	25.8282182	
0.0001524	1580.	10368404.	6.2000000	27.1196292	
0.0001596	1655.	10368404.	6.2000000	28.4110401	
0.0001669	1730.	10368404.	6.2000000	29.7024510	
0.0001741	1805.	10368404.	6.2000000	30.9938619	
0.0001814	1881.	10368404.	6.2000000	32.2852728	
0.0001886	1956.	10368404.	6.2000000	33.5766837	
0.0001959	2031.	10368404.	6.2000000	34.8680946	
0.0002031	2106.	10368404.	6.2000000	36.1595055	
0.0002104	2181.	10368404.	6.2000000	37.4509165	
0.0002177	2257.	10368404.	6.2000000	38.7423274	
0.0002249	2332.	10368404.	6.2000000	40.0337383	
0.0002322	2407.	10368404.	6.2000000	41.3251492	
0.0002394	2482.	10368404.	6.2000000	42.6165601	
0.0002467	2558.	10368404.	6.2000000	43.9079710	
0.0002539	2633.	10368404.	6.2000000	45.1993819	
0.0002612	2708.	10368404.	6.2000000	46.4907928	
0.0002684	2783.	10368404.	6.2000000	47.7822037	

0.0002757	2858.	10368404.	6.2000000	49.0736147
0.0002829	2928.	10348570.	6.2000000	50.0000000 Y
0.0002975	2999.	10080823.	6.2000000	50.0000000 Y
0.0003120	3021.	9684237.	6.2000000	50.0000000 Y
0.0003265	3040.	9310052.	6.2000000	50.0000000 Y
0.0003410	3056.	8960890.	6.2000000	50.0000000 Y
0.0003555	3070.	8634885.	6.2000000	50.0000000 Y
0.0003700	3082.	8330213.	6.2000000	50.0000000 Y
0.0003845	3093.	8044662.	6.2000000	50.0000000 Y
0.0003990	3103.	7777011.	6.2000000	50.0000000 Y
0.0004135	3112.	7525754.	6.2000000	50.0000000 Y
0.0004280	3120.	7289432.	6.2000000	50.0000000 Y
0.0004426	3127.	7066747.	6.2000000	50.0000000 Y
0.0004571	3134.	6856759.	6.2000000	50.0000000 Y
0.0004716	3140.	6658466.	6.2000000	50.0000000 Y
0.0004861	3145.	6470840.	6.2000000	50.0000000 Y
0.0005006	3150.	6293142.	6.2000000	50.0000000 Y
0.0005151	3155.	6124687.	6.2000000	50.0000000 Y
0.0005296	3159.	5964835.	6.2000000	50.0000000 Y
0.0005441	3163.	5812939.	6.2000000	50.0000000 Y
0.0005586	3166.	5668221.	6.2000000	50.0000000 Y
0.0005731	3170.	5530500.	6.2000000	50.0000000 Y
0.0005877	3173.	5399164.	6.2000000	50.0000000 Y
0.0006022	3176.	5273715.	6.2000000	50.0000000 Y
0.0006167	3178.	5154005.	6.2000000	50.0000000 Y
0.0006312	3181.	5039313.	6.2000000	50.0000000 Y
0.0006457	3183.	4929728.	6.2000000	50.0000000 Y
0.0006602	3185.	4824527.	6.2000000	50.0000000 Y
0.0006747	3187.	4723819.	6.2000000	50.0000000 Y
0.0006892	3189.	4627044.	6.2000000	50.0000000 Y
0.0007037	3191.	4534162.	6.2000000	50.0000000 Y
0.0007182	3193.	4444907.	6.2000000	50.0000000 Y
0.0007328	3194.	4358966.	6.2000000	50.0000000 Y
0.0007473	3196.	4276362.	6.2000000	50.0000000 Y
0.0007618	3197.	4196694.	6.2000000	50.0000000 Y
0.0007763	3198.	4119918.	6.2000000	50.0000000 Y
0.0007908	3200.	4045958.	6.2000000	50.0000000 Y
0.0008053	3201.	3974476.	6.2000000	50.0000000 Y
0.0008198	3202.	3905461.	6.2000000	50.0000000 Y
0.0008343	3203.	3838846.	6.2000000	50.0000000 Y
0.0008488	3204.	3774417.	6.2000000	50.0000000 Y
0.0008633	3205.	3712034.	6.2000000	50.0000000 Y
0.0009214	3208.	3481857.	6.2000000	50.0000000 Y
0.0009794	3211.	3278379.	6.2000000	50.0000000 Y
0.0010375	3213.	3097258.	6.2000000	50.0000000 Y
0.0010955	3215.	2934942.	6.2000000	50.0000000 Y
0.0011536	3217.	2788705.	6.2000000	50.0000000 Y
0.0012116	3218.	2656366.	6.2000000	50.0000000 Y
0.0012696	3220.	2535861.	6.2000000	50.0000000 Y
0.0013277	3221.	2425878.	6.2000000	50.0000000 Y
0.0013857	3222.	2324910.	6.2000000	50.0000000 Y
0.0014438	3223.	2232060.	6.2000000	50.0000000 Y

Axial Thrust Force = 310.000 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Total Stress ksi	Run Msg
0.00000526	54.5669469	10368404.	159.1333182	24.2777037	
0.00001053	109.1338938	10368404.	82.6666591	25.2144945	
0.00001579	163.7008407	10368404.	57.1777727	26.1512853	
0.00002105	218.2677876	10368404.	44.4333295	27.0880761	
0.00002631	272.8347345	10368404.	36.7866636	28.0248669	
0.00003158	327.4016814	10368404.	31.6888864	28.9616577	
0.00003684	381.9686283	10368404.	28.0476169	29.8984485	
0.00004210	436.5355752	10368404.	25.3166648	30.8352393	
0.00004737	491.1025221	10368404.	23.1925909	31.7720301	
0.00005263	545.6694690	10368404.	21.4933318	32.7088206	
0.00005789	600.2364159	10368404.	20.1030289	33.6456114	
0.00006315	654.8033628	10368404.	18.9444432	34.5824022	
0.00006842	709.3703097	10368404.	17.9641014	35.5191931	
0.00007368	763.9372566	10368404.	17.1238084	36.4559841	
0.00007894	818.5042035	10368404.	16.3955545	37.3927749	
0.00008420	873.0711504	10368404.	15.7583324	38.3295655	
0.00008947	927.6380973	10368404.	15.1960775	39.2663563	
0.00009473	982.2050442	10368404.	14.6962955	40.2031471	
0.00009999	1037.	10368404.	14.2491220	41.1399381	
0.0001053	1091.	10368404.	13.8466659	42.0767288	
0.0001105	1146.	10368404.	13.4825390	43.0135196	
0.0001158	1200.	10368404.	13.1515145	43.9503102	
0.0001210	1255.	10368404.	12.8492747	44.8871012	
0.0001263	1310.	10368404.	12.5722216	45.8238920	
0.0001316	1364.	10368404.	12.3173327	46.7606828	
0.0001368	1419.	10368404.	12.0820507	47.6974736	
0.0001421	1473.	10368404.	11.8641970	48.6342644	
0.0001474	1528.	10368404.	11.6619042	49.5710553	
0.0001526	1578.	10339437.	11.4858212	50.0000000	Y
0.0001579	1609.	10189827.	11.3744214	50.0000000	Y
0.0001631	1628.	9981616.	11.3003681	50.0000000	Y
0.0001684	1647.	9779296.	11.2342250	50.0000000	Y
0.0001737	1664.	9582867.	11.1751191	50.0000000	Y
0.0001789	1681.	9392316.	11.1222732	50.0000000	Y
0.0001842	1696.	9207617.	11.0749914	50.0000000	Y
0.0001895	1711.	9028731.	11.0326475	50.0000000	Y
0.0001947	1724.	8855278.	10.9948578	50.0000000	Y
0.0002000	1737.	8687331.	10.9610513	50.0000000	Y
0.0002052	1750.	8524828.	10.9307656	50.0000000	Y
0.0002158	1773.	8214830.	10.8797500	50.0000000	Y
0.0002263	1793.	7924030.	10.8393514	50.0000000	Y
0.0002368	1812.	7651243.	10.8075432	50.0000000	Y
0.0002474	1829.	7394765.	10.7830580	50.0000000	Y
0.0002579	1845.	7153603.	10.7644971	50.0000000	Y
0.0002684	1859.	6926571.	10.7508748	50.0000000	Y
0.0002789	1872.	6712583.	10.7413783	50.0000000	Y

0.0002895	1885.	6510691.	10.7352991	50.0000000	Y
0.0003000	1896.	6319738.	10.7322832	50.0000000	Y
0.0003105	1906.	6139179.	10.7316369	50.0000000	Y
0.0003210	1916.	5968144.	10.7330606	50.0000000	Y
0.0003316	1925.	5805978.	10.7361977	50.0000000	Y
0.0003421	1933.	5651924.	10.7408902	50.0000000	Y
0.0003526	1941.	5505583.	10.7467357	50.0000000	Y
0.0003631	1949.	5366377.	10.7535835	50.0000000	Y
0.0003737	1956.	5233721.	10.7613688	50.0000000	Y
0.0003842	1962.	5107210.	10.7699143	50.0000000	Y
0.0003947	1968.	4986484.	10.7790477	50.0000000	Y
0.0004052	1974.	4871166.	10.7886708	50.0000000	Y
0.0004158	1979.	4760910.	10.7986937	50.0000000	Y
0.0004263	1985.	4655406.	10.8090336	50.0000000	Y
0.0004368	1989.	4554308.	10.8196903	50.0000000	Y
0.0004473	1994.	4457353.	10.8306065	50.0000000	Y
0.0004579	1998.	4364349.	10.8416630	50.0000000	Y
0.0004684	2002.	4275081.	10.8527969	50.0000000	Y
0.0004789	2006.	4189351.	10.8639488	50.0000000	Y
0.0004894	2010.	4106823.	10.8752763	50.0000000	Y
0.0005000	2014.	4027410.	10.8866277	50.0000000	Y
0.0005105	2017.	3951016.	10.8978707	50.0000000	Y
0.0005210	2020.	3877348.	10.9091786	50.0000000	Y
0.0005315	2023.	3806306.	10.9204692	50.0000000	Y
0.0005421	2026.	3737874.	10.9315424	50.0000000	Y
0.0005526	2029.	3671653.	10.9428003	50.0000000	Y
0.0005631	2032.	3607809.	10.9537927	50.0000000	Y
0.0005736	2034.	3546037.	10.9648111	50.0000000	Y
0.0005842	2037.	3486351.	10.9756605	50.0000000	Y
0.0005947	2039.	3428578.	10.9864537	50.0000000	Y
0.0006052	2041.	3372679.	10.9971025	50.0000000	Y
0.0006157	2043.	3318515.	11.0076839	50.0000000	Y
0.0006263	2045.	3266077.	11.0180783	50.0000000	Y
0.0006684	2053.	3071588.	11.0586177	50.0000000	Y
0.0007105	2059.	2898615.	11.0972480	50.0000000	Y

Summary of Results for Nominal Moment Capacity for Section 1

Load No.	Axial Thrust kips	Nominal Moment Capacity in-kips
1	0.00000000	3223.
2	310.0000000000	2059.

Note that the values in the above table are not factored by a strength reduction factor for LRFD.

The value of the strength reduction factor depends on the provisions of the

LRFD code being followed.

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to the LRFD structural design standard being followed.

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	3.5000	0.00	N.A.	No	0.00	60811.
2	9.2000	6.9911	No	No	60811.	592330.
3	18.2000	33.1204	No	No	653141.	109060.
4	23.2000	21.3284	Yes	No	762201.	421171.
5	33.2000	27.4387	Yes	No	1183372.	538155.
6	44.2000	22.2324	No	No	1721527.	3040701.
7	53.7000	50.2000	No	Yes	N.A.	N.A.

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals for Layer n. Layering correction equivalent depths are computed only for soil types with both shallow-depth and deep-depth expressions for peak lateral load transfer. These soil types are soft and stiff clays, non-liquefied sands, and cemented c-phi soil.

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 1

Pile-head conditions are Shear and Moment (Loading Type 1)

Shear force at pile head = 8600.0 lbs
Applied moment at pile head = 0.0 in-lbs
Axial thrust load on pile head = 0.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	0.2696	-5.54E-08	8600.	-0.00392	7.82E-10	1.04E+10	0.00	0.00	0.00

0.5370	0.2444	55418.	8600.	-0.00390	781.8362	1.04E+10	0.00	0.00	0.00
1.0740	0.2194	110837.	8600.	-0.00385	1564.	1.04E+10	0.00	0.00	0.00
1.6110	0.1948	166255.	8600.	-0.00376	2346.	1.04E+10	0.00	0.00	0.00
2.1480	0.1709	221674.	8600.	-0.00364	3127.	1.04E+10	0.00	0.00	0.00
2.6850	0.1479	277092.	8600.	-0.00349	3909.	1.04E+10	0.00	0.00	0.00
3.2220	0.1260	332510.	8600.	-0.00330	4691.	1.04E+10	0.00	0.00	0.00
3.7590	0.1054	387929.	7702.	-0.00307	5473.	1.04E+10	-278.602	17038.	0.00
4.2960	0.08634	431778.	5858.	-0.00282	6091.	1.04E+10	-293.919	21936.	0.00
4.8330	0.06904	463423.	3927.	-0.00254	6538.	1.04E+10	-305.222	28487.	0.00
5.3700	0.05360	482393.	1938.	-0.00225	6806.	1.04E+10	-312.111	37523.	0.00
5.9070	0.04009	488402.	-79.352	-0.00194	6890.	1.04E+10	-314.068	50485.	0.00
6.4440	0.02853	481370.	-2091.	-0.00164	6791.	1.04E+10	-310.352	70091.	0.00
6.9810	0.01891	461450.	-4057.	-0.00135	6510.	1.04E+10	-299.749	102169.	0.00
7.5180	0.01113	429084.	-5924.	-0.00107	6053.	1.04E+10	-279.842	162077.	0.00
8.0550	0.00507	385096.	-7613.	-8.21E-04	5433.	1.04E+10	-244.106	310548.	0.00
8.5920	5.47E-04	330973.	-8877.	-5.98E-04	4669.	1.04E+10	-148.397	1749325.	0.00
9.1290	-0.00265	270687.	-8609.	-4.11E-04	3819.	1.04E+10	231.5008	563692.	0.00
9.6660	-0.00476	220014.	-7608.	-2.59E-04	3104.	1.04E+10	79.1703	107281.	0.00
10.2030	-0.00598	172628.	-7004.	-1.37E-04	2435.	1.04E+10	108.2875	116624.	0.00
10.7400	-0.00652	129740.	-6245.	-4.29E-05	1830.	1.04E+10	127.4503	125967.	0.00
11.2770	-0.00654	92143.	-5392.	2.60E-05	1300.	1.04E+10	137.2583	135310.	0.00
11.8140	-0.00618	60247.	-4502.	7.34E-05	849.9560	1.04E+10	138.8314	144654.	0.00
12.3510	-0.00559	34115.	-3625.	1.03E-04	481.2946	1.04E+10	133.6172	153997.	0.00
12.8880	-0.00486	13532.	-2797.	1.17E-04	190.9103	1.04E+10	123.2189	163340.	0.00
13.4250	-0.00408	-1934.	-2048.	1.21E-04	27.2885	1.04E+10	109.2512	172683.	0.00
13.9620	-0.00330	-12864.	-1396.	1.17E-04	181.4844	1.04E+10	93.2283	182026.	0.00
14.4990	-0.00258	-19923.	-848.923	1.06E-04	281.0643	1.04E+10	76.4837	191369.	0.00
15.0360	-0.00193	-23805.	-408.780	9.27E-05	335.8376	1.04E+10	60.1219	200713.	0.00
15.5730	-0.00138	-25191.	-70.086	7.75E-05	355.3895	1.04E+10	44.9970	210056.	0.00
16.1100	-9.31E-04	-24708.	177.0722	6.20E-05	348.5808	1.04E+10	31.7126	219399.	0.00
16.6470	-5.81E-04	-22909.	345.7491	4.72E-05	323.1938	1.04E+10	20.6390	228742.	0.00
17.1840	-3.23E-04	-20252.	450.7189	3.38E-05	285.7159	1.04E+10	11.9401	238085.	0.00
17.7210	-1.46E-04	-17100.	507.2551	2.22E-05	241.2431	1.04E+10	5.6068	247428.	0.00
18.2580	-3.74E-05	-13715.	633.4622	1.26E-05	193.4856	1.04E+10	33.5636	5789531.	0.00
18.7950	1.64E-05	-8936.	694.1889	5.56E-06	126.0655	1.04E+10	-14.716	5789531.	0.00
19.3320	3.43E-05	-4768.	547.3978	1.30E-06	67.2665	1.04E+10	-30.843	5789531.	0.00
19.8690	3.32E-05	-1881.	351.9635	-7.62E-07	26.5363	1.04E+10	-29.813	5789531.	0.00
20.4060	2.45E-05	-231.905	184.9703	-1.42E-06	3.2717	1.04E+10	-22.016	5789531.	0.00
20.9430	1.49E-05	502.9406	70.9137	-1.33E-06	7.0954	1.04E+10	-13.384	5789531.	0.00
21.4800	7.30E-06	682.0300	6.6514	-9.66E-07	9.6220	1.04E+10	-6.561	5789531.	0.00
22.0170	2.44E-06	588.6636	-21.555	-5.72E-07	8.3048	1.04E+10	-2.193	5789531.	0.00
22.5540	-6.37E-08	404.2356	-28.436	-2.63E-07	5.7029	1.04E+10	0.05724	5789531.	0.00
23.0910	-9.49E-07	222.1846	-25.503	-6.84E-08	3.1346	1.04E+10	0.8529	5789531.	0.00
23.6280	-9.45E-07	75.5495	-17.158	2.41E-08	1.0658	1.04E+10	1.7371	1.18E+07	0.00
24.1650	-6.38E-07	1.0490	-7.781	4.79E-08	0.01480	1.04E+10	1.1731	1.18E+07	0.00
24.7020	-3.27E-07	-24.738	-2.064	4.06E-08	0.3490	1.04E+10	0.6014	1.18E+07	0.00
25.2390	-1.15E-07	-25.552	0.5559	2.50E-08	0.3605	1.04E+10	0.2118	1.18E+07	0.00
25.7760	-5.57E-09	-17.573	1.2712	1.16E-08	0.2479	1.04E+10	0.01024	1.18E+07	0.00
26.3130	3.37E-08	-9.169	1.1047	3.24E-09	0.1294	1.04E+10	-0.06190	1.18E+07	0.00
26.8500	3.62E-08	-3.336	0.6909	-6.45E-10	0.04706	1.04E+10	-0.06654	1.18E+07	0.00
27.3870	2.54E-08	-0.265	0.3263	-1.76E-09	0.00374	1.04E+10	-0.04662	1.18E+07	0.00
27.9240	1.35E-08	0.8694	0.09630	-1.58E-09	0.01226	1.04E+10	-0.02475	1.18E+07	0.00
28.4610	5.05E-09	0.9760	-0.01337	-1.00E-09	0.01377	1.04E+10	-0.00928	1.18E+07	0.00

28.9980	5.44E-10	0.6970	-0.04651	-4.83E-10	0.00983	1.04E+10	-0.00100	1.18E+07	0.00
29.5350	-1.17E-09	0.3765	-0.04280	-1.49E-10	0.00531	1.04E+10	0.00215	1.18E+07	0.00
30.0720	-1.38E-09	0.1453	-0.02771	1.30E-11	0.00205	1.04E+10	0.00253	1.18E+07	0.00
30.6090	-1.00E-09	0.01939	-0.01360	6.41E-11	2.74E-04	1.04E+10	0.00185	1.18E+07	0.00
31.1460	-5.52E-10	-0.02993	-0.00439	6.09E-11	4.22E-04	1.04E+10	0.00101	1.18E+07	0.00
31.6830	-2.19E-10	-0.03715	1.78E-04	4.00E-11	5.24E-04	1.04E+10	4.03E-04	1.18E+07	0.00
32.2200	-3.57E-11	-0.02764	0.00169	1.99E-11	3.90E-04	1.04E+10	6.56E-05	1.18E+07	0.00
32.7570	3.71E-11	-0.01540	0.00168	6.52E-12	2.17E-04	1.04E+10	-6.83E-05	1.18E+07	0.00
33.2940	4.83E-11	-0.00599	0.00113	0.00	8.45E-05	1.04E+10	-1.03E-04	1.38E+07	0.00
33.8310	3.55E-11	-8.71E-04	5.50E-04	-2.26E-12	1.23E-05	1.04E+10	-7.58E-05	1.38E+07	0.00
34.3680	1.92E-11	0.00110	1.74E-04	-2.19E-12	1.56E-05	1.04E+10	-4.10E-05	1.38E+07	0.00
34.9050	7.33E-12	0.00137	-8.48E-06	-1.42E-12	1.94E-05	1.04E+10	-1.56E-05	1.38E+07	0.00
35.4420	0.00	9.93E-04	-6.53E-05	0.00	1.40E-05	1.04E+10	-2.01E-06	1.38E+07	0.00
35.9790	-1.47E-12	5.30E-04	-6.17E-05	0.00	7.48E-06	1.04E+10	3.14E-06	1.38E+07	0.00
36.5160	-1.76E-12	1.98E-04	-3.95E-05	0.00	2.79E-06	1.04E+10	3.76E-06	1.38E+07	0.00
37.0530	-1.25E-12	2.18E-05	-1.87E-05	0.00	3.08E-07	1.04E+10	2.68E-06	1.38E+07	0.00
37.5900	0.00	-4.33E-05	-5.56E-06	0.00	6.11E-07	1.04E+10	1.41E-06	1.38E+07	0.00
38.1270	0.00	-4.99E-05	6.45E-07	0.00	7.04E-07	1.04E+10	5.16E-07	1.38E+07	0.00
38.6640	0.00	-3.50E-05	2.46E-06	0.00	4.94E-07	1.04E+10	4.68E-08	1.38E+07	0.00
39.2010	0.00	-1.82E-05	2.21E-06	0.00	2.57E-07	1.04E+10	-1.23E-07	1.38E+07	0.00
39.7380	0.00	-6.51E-06	1.38E-06	0.00	9.18E-08	1.04E+10	-1.36E-07	1.38E+07	0.00
40.2750	0.00	-4.56E-07	6.35E-07	0.00	6.43E-09	1.04E+10	-9.43E-08	1.38E+07	0.00
40.8120	0.00	1.68E-06	1.76E-07	0.00	2.37E-08	1.04E+10	-4.84E-08	1.38E+07	0.00
41.3490	0.00	1.81E-06	-3.48E-08	0.00	2.55E-08	1.04E+10	-1.69E-08	1.38E+07	0.00
41.8860	0.00	1.23E-06	-9.18E-08	0.00	1.74E-08	1.04E+10	-8.06E-10	1.38E+07	0.00
42.4230	0.00	6.23E-07	-7.91E-08	0.00	8.79E-09	1.04E+10	4.75E-09	1.38E+07	0.00
42.9600	0.00	2.12E-07	-4.78E-08	0.00	2.98E-09	1.04E+10	4.98E-09	1.38E+07	0.00
43.4970	0.00	6.78E-09	-2.08E-08	0.00	9.56E-11	1.04E+10	3.39E-09	1.38E+07	0.00
44.0340	0.00	-5.70E-08	-4.24E-09	0.00	8.05E-10	1.04E+10	1.76E-09	1.38E+07	0.00
44.5710	0.00	-4.79E-08	1.52E-09	0.00	6.76E-10	1.04E+10	3.14E-11	714586.	0.00
45.1080	0.00	-3.75E-08	1.60E-09	0.00	5.29E-10	1.04E+10	-7.17E-12	723929.	0.00
45.6450	0.00	-2.73E-08	1.48E-09	0.00	3.86E-10	1.04E+10	-2.97E-11	733272.	0.00
46.1820	0.00	-1.84E-08	1.25E-09	0.00	2.60E-10	1.04E+10	-4.02E-11	742616.	0.00
46.7190	0.00	-1.12E-08	9.85E-10	0.00	1.58E-10	1.04E+10	-4.23E-11	751959.	0.00
47.2560	0.00	-5.75E-09	7.22E-10	0.00	8.11E-11	1.04E+10	-3.92E-11	761302.	0.00
47.7930	0.00	-1.91E-09	4.89E-10	0.00	2.69E-11	1.04E+10	-3.32E-11	770645.	0.00
48.3300	0.00	5.54E-10	2.97E-10	0.00	7.82E-12	1.04E+10	-2.62E-11	779988.	0.00
48.8670	0.00	1.93E-09	1.51E-10	0.00	2.72E-11	1.04E+10	-1.92E-11	789331.	0.00
49.4040	0.00	2.50E-09	4.71E-11	0.00	3.53E-11	1.04E+10	-1.30E-11	798675.	0.00
49.9410	0.00	2.53E-09	-2.07E-11	0.00	3.57E-11	1.04E+10	-7.98E-12	808018.	0.00
50.4780	0.00	2.24E-09	-5.95E-11	0.00	3.15E-11	1.04E+10	-4.07E-12	817361.	0.00
51.0150	0.00	1.77E-09	-7.65E-11	0.00	2.49E-11	1.04E+10	-1.22E-12	826704.	0.00
51.5520	0.00	1.25E-09	-7.80E-11	0.00	1.76E-11	1.04E+10	0.00	836047.	0.00
52.0890	0.00	7.62E-10	-6.86E-11	0.00	1.08E-11	1.04E+10	2.16E-12	845390.	0.00
52.6260	0.00	3.65E-10	-5.14E-11	0.00	5.15E-12	1.04E+10	3.16E-12	854733.	0.00
53.1630	0.00	9.96E-11	-2.83E-11	0.00	1.41E-12	1.04E+10	4.00E-12	864077.	0.00
53.7000	0.00	0.00	0.00	0.00	0.00	1.04E+10	4.80E-12	436710.	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the

magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 1:

Pile-head deflection = 0.26964462 inches
Computed slope at pile head = -0.0039173 radians
Maximum bending moment = 488402. inch-lbs
Maximum shear force = -8877. lbs
Depth of maximum bending moment = 5.90700000 feet below pile head
Depth of maximum shear force = 8.59200000 feet below pile head
Number of iterations = 24
Number of zero deflection points = 11
Pile deflection at ground = 0.11529836 inches

Pile-head Deflection vs. Pile Length for Load Case 1

Boundary Condition Type 1, Shear and Moment

Shear = 8600. lbs
Moment = 0. in-lbs
Axial Load = 0. lbs

Pile Length feet	Pile Head Deflection inches	Maximum Moment ln-lbs	Maximum Shear lbs
53.70000	0.26964462	488402.	-8877.
51.01500	0.25749629	473387.	-8758.
48.33000	0.28012244	498369.	-9078.
45.64500	0.26503661	482254.	-8860.
42.96000	0.28241765	500903.	-8932.
40.27500	0.26430667	481593.	-8641.
37.59000	0.27556231	494120.	-8959.
34.90500	0.28303034	501712.	-9104.
32.22000	0.26200213	478676.	-8792.
29.53500	0.26237273	479690.	-8953.
26.85000	0.28048487	497974.	-9121.
24.16500	0.27068827	488069.	-9103.
21.48000	0.27363255	491313.	-8985.
18.79500	0.26845208	486002.	-8977.
16.11000	0.26830161	484644.	-9026.
13.42500	0.28016849	491425.	-9560.
10.74000	0.44387112	467671.	-13063.

Computed Values of Pile Loading and Deflection

for Lateral Loading for Load Case Number 2

Pile-head conditions are Shear and Moment (Loading Type 1)

Shear force at pile head = 3600.0 lbs
 Applied moment at pile head = 0.0 in-lbs
 Axial thrust load on pile head = 310000.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	0.08072	-6.93E-09	3600.	-0.00137	23341.	1.04E+10	0.00	0.00	0.00
0.5370	0.07192	25927.	3600.	-0.00136	23707.	1.04E+10	0.00	0.00	0.00
1.0740	0.06323	51821.	3600.	-0.00133	24072.	1.04E+10	0.00	0.00	0.00
1.6110	0.05474	77652.	3600.	-0.00129	24436.	1.04E+10	0.00	0.00	0.00
2.1480	0.04656	103386.	3600.	-0.00124	24799.	1.04E+10	0.00	0.00	0.00
2.6850	0.03879	128991.	3600.	-0.00116	25161.	1.04E+10	0.00	0.00	0.00
3.2220	0.03154	154437.	3600.	-0.00108	25520.	1.04E+10	0.00	0.00	0.00
3.7590	0.02491	179690.	2974.	-9.73E-04	25876.	1.04E+10	-194.284	50252.	0.00
4.2960	0.01900	196653.	1699.	-8.56E-04	26115.	1.04E+10	-201.329	68269.	0.00
4.8330	0.01388	205012.	392.1111	-7.31E-04	26233.	1.04E+10	-204.395	94886.	0.00
5.3700	0.00958	204628.	-920.352	-6.04E-04	26228.	1.04E+10	-202.949	136521.	0.00
5.9070	0.00610	195563.	-2206.	-4.80E-04	26100.	1.04E+10	-196.154	207299.	0.00
6.4440	0.00340	178110.	-3426.	-3.63E-04	25854.	1.04E+10	-182.348	345725.	0.00
6.9810	0.00141	152863.	-4518.	-2.61E-04	25497.	1.04E+10	-156.769	714761.	0.00
7.5180	4.01E-05	120917.	-5089.	-1.76E-04	25047.	1.04E+10	-20.410	3276359.	0.00
8.0550	-8.49E-04	87974.	-4652.	-1.11E-04	24582.	1.04E+10	156.1175	1185220.	0.00
8.5920	-0.00139	61404.	-3547.	-6.42E-05	24207.	1.04E+10	186.7477	868618.	0.00
9.1290	-0.00168	42512.	-2280.	-3.19E-05	23941.	1.04E+10	206.6326	794420.	0.00
9.6660	-0.00180	32148.	-1518.	-8.70E-06	23794.	1.04E+10	29.9094	107281.	0.00
10.2030	-0.00179	22987.	-1317.	8.43E-06	23665.	1.04E+10	32.3636	116624.	0.00
10.7400	-0.00169	15140.	-1107.	2.03E-05	23555.	1.04E+10	32.9942	125967.	0.00
11.2770	-0.00153	8645.	-896.894	2.77E-05	23463.	1.04E+10	32.0605	135310.	0.00
11.8140	-0.00133	3470.	-697.313	3.14E-05	23390.	1.04E+10	29.8826	144654.	0.00
12.3510	-0.00112	-467.624	-514.665	3.24E-05	23348.	1.04E+10	26.8053	153997.	0.00
12.8880	-9.14E-04	-3292.	-353.651	3.12E-05	23387.	1.04E+10	23.1679	163340.	0.00
13.4250	-7.20E-04	-5150.	-216.879	2.86E-05	23414.	1.04E+10	19.2816	172683.	0.00
13.9620	-5.46E-04	-6201.	-105.090	2.51E-05	23428.	1.04E+10	15.4139	182026.	0.00
14.4990	-3.97E-04	-6605.	-17.472	2.11E-05	23434.	1.04E+10	11.7797	191369.	0.00
15.0360	-2.74E-04	-6511.	47.9894	1.70E-05	23433.	1.04E+10	8.5373	200713.	0.00
15.5730	-1.78E-04	-6054.	94.1498	1.31E-05	23426.	1.04E+10	5.7894	210056.	0.00
16.1100	-1.05E-04	-5350.	124.3611	9.55E-06	23416.	1.04E+10	3.5872	219399.	0.00
16.6470	-5.45E-05	-4489.	142.1569	6.49E-06	23404.	1.04E+10	1.9360	228742.	0.00
17.1840	-2.17E-05	-3543.	150.9782	3.99E-06	23391.	1.04E+10	0.8018	238085.	0.00
17.7210	-3.05E-06	-2560.	153.9394	2.10E-06	23377.	1.04E+10	0.1172	247428.	0.00
18.2580	5.34E-06	-1568.	138.8479	8.16E-07	23363.	1.04E+10	-4.801	5789531.	0.00
18.7950	7.46E-06	-773.373	101.7777	8.84E-08	23352.	1.04E+10	-6.704	5789531.	0.00
19.3320	6.48E-06	-256.412	61.4097	-2.32E-07	23345.	1.04E+10	-5.825	5789531.	0.00
19.8690	4.48E-06	18.9999	29.6826	-3.05E-07	23341.	1.04E+10	-4.022	5789531.	0.00
20.4060	2.55E-06	127.3580	9.3490	-2.60E-07	23343.	1.04E+10	-2.288	5789531.	0.00
20.9430	1.13E-06	140.5277	-1.288	-1.77E-07	23343.	1.04E+10	-1.013	5789531.	0.00

21.4800	2.70E-07	111.4629	-5.334	-9.84E-08	23342.	1.04E+10	-0.243	5789531.	0.00
22.0170	-1.40E-07	72.1728	-5.711	-4.13E-08	23342.	1.04E+10	0.1260	5789531.	0.00
22.5540	-2.62E-07	38.0249	-4.547	-7.05E-09	23341.	1.04E+10	0.2352	5789531.	0.00
23.0910	-2.31E-07	13.5966	-3.121	8.99E-09	23341.	1.04E+10	0.2076	5789531.	0.00
23.6280	-1.46E-07	-2.228	-1.588	1.25E-08	23341.	1.04E+10	0.2681	1.18E+07	0.00
24.1650	-6.96E-08	-6.917	-0.312	9.69E-09	23341.	1.04E+10	0.1279	1.18E+07	0.00
24.7020	-2.10E-08	-6.283	0.2253	5.58E-09	23341.	1.04E+10	0.03868	1.18E+07	0.00
25.2390	2.36E-09	-4.036	0.3359	2.38E-09	23341.	1.04E+10	-0.00433	1.18E+07	0.00
25.7760	9.59E-09	-1.963	0.2652	5.13E-10	23341.	1.04E+10	-0.01763	1.18E+07	0.00
26.3130	8.96E-09	-0.620	0.1553	-2.90E-10	23341.	1.04E+10	-0.01648	1.18E+07	0.00
26.8500	5.85E-09	0.03914	0.06753	-4.71E-10	23341.	1.04E+10	-0.01076	1.18E+07	0.00
27.3870	2.90E-09	0.2519	0.01571	-3.80E-10	23341.	1.04E+10	-0.00533	1.18E+07	0.00
27.9240	9.51E-10	0.2432	-0.00708	-2.26E-10	23341.	1.04E+10	-0.00175	1.18E+07	0.00
28.4610	-2.18E-11	0.1616	-0.01258	-1.01E-10	23341.	1.04E+10	4.01E-05	1.18E+07	0.00
28.9980	-3.47E-10	0.08148	-0.01039	-2.52E-11	23341.	1.04E+10	6.38E-04	1.18E+07	0.00
29.5350	-3.46E-10	0.02776	-0.00629	8.79E-12	23341.	1.04E+10	6.36E-04	1.18E+07	0.00
30.0720	-2.34E-10	4.30E-04	-0.00285	1.75E-11	23341.	1.04E+10	4.30E-04	1.18E+07	0.00
30.6090	-1.20E-10	-0.00905	-7.56E-04	1.49E-11	23341.	1.04E+10	2.20E-04	1.18E+07	0.00
31.1460	-4.22E-11	-0.00937	2.04E-04	9.14E-12	23341.	1.04E+10	7.76E-05	1.18E+07	0.00
31.6830	-2.09E-12	-0.00646	4.67E-04	4.22E-12	23341.	1.04E+10	3.85E-06	1.18E+07	0.00
32.2200	1.22E-11	-0.00338	4.07E-04	1.16E-12	23341.	1.04E+10	-2.24E-05	1.18E+07	0.00
32.7570	1.29E-11	-0.00122	2.58E-04	0.00	23341.	1.04E+10	-2.37E-05	1.18E+07	0.00
33.2940	8.74E-12	-4.57E-05	1.22E-04	0.00	23341.	1.04E+10	-1.87E-05	1.38E+07	0.00
33.8310	4.40E-12	3.55E-04	3.17E-05	0.00	23341.	1.04E+10	-9.39E-06	1.38E+07	0.00
34.3680	1.48E-12	3.65E-04	-8.71E-06	0.00	23341.	1.04E+10	-3.15E-06	1.38E+07	0.00
34.9050	0.00	2.44E-04	-1.90E-05	0.00	23341.	1.04E+10	-3.39E-08	1.38E+07	0.00
35.4420	0.00	1.21E-04	-1.59E-05	0.00	23341.	1.04E+10	9.98E-07	1.38E+07	0.00
35.9790	0.00	3.95E-05	-9.43E-06	0.00	23341.	1.04E+10	9.96E-07	1.38E+07	0.00
36.5160	0.00	-6.26E-07	-4.11E-06	0.00	23341.	1.04E+10	6.56E-07	1.38E+07	0.00
37.0530	0.00	-1.36E-05	-9.68E-07	0.00	23341.	1.04E+10	3.21E-07	1.38E+07	0.00
37.5900	0.00	-1.32E-05	3.92E-07	0.00	23341.	1.04E+10	1.02E-07	1.38E+07	0.00
38.1270	0.00	-8.56E-06	7.04E-07	0.00	23341.	1.04E+10	-4.81E-09	1.38E+07	0.00
38.6640	0.00	-4.13E-06	5.66E-07	0.00	23341.	1.04E+10	-3.80E-08	1.38E+07	0.00
39.2010	0.00	-1.27E-06	3.28E-07	0.00	23341.	1.04E+10	-3.59E-08	1.38E+07	0.00
39.7380	0.00	1.00E-07	1.38E-07	0.00	23341.	1.04E+10	-2.30E-08	1.38E+07	0.00
40.2750	0.00	5.14E-07	2.88E-08	0.00	23341.	1.04E+10	-1.09E-08	1.38E+07	0.00
40.8120	0.00	4.74E-07	-1.68E-08	0.00	23341.	1.04E+10	-3.24E-09	1.38E+07	0.00
41.3490	0.00	3.00E-07	-2.60E-08	0.00	23341.	1.04E+10	3.84E-10	1.38E+07	0.00
41.8860	0.00	1.41E-07	-2.01E-08	0.00	23341.	1.04E+10	1.44E-09	1.38E+07	0.00
42.4230	0.00	4.11E-08	-1.13E-08	0.00	23341.	1.04E+10	1.30E-09	1.38E+07	0.00
42.9600	0.00	-4.53E-09	-4.48E-09	0.00	23341.	1.04E+10	8.03E-10	1.38E+07	0.00
43.4970	0.00	-1.68E-08	-7.72E-10	0.00	23341.	1.04E+10	3.47E-10	1.38E+07	0.00
44.0340	0.00	-1.46E-08	4.56E-10	0.00	23341.	1.04E+10	3.42E-11	1.38E+07	0.00
44.5710	0.00	-1.10E-08	5.41E-10	0.00	23341.	1.04E+10	-8.00E-12	714586.	0.00
45.1080	0.00	-7.66E-09	4.73E-10	0.00	23341.	1.04E+10	-1.31E-11	723929.	0.00
45.6450	0.00	-4.89E-09	3.83E-10	0.00	23341.	1.04E+10	-1.48E-11	733272.	0.00
46.1820	0.00	-2.72E-09	2.89E-10	0.00	23341.	1.04E+10	-1.43E-11	742616.	0.00
46.7190	0.00	-1.15E-09	2.03E-10	0.00	23341.	1.04E+10	-1.25E-11	751959.	0.00
47.2560	0.00	-9.92E-11	1.30E-10	0.00	23341.	1.04E+10	-1.01E-11	761302.	0.00
47.7930	0.00	5.33E-10	7.25E-11	0.00	23341.	1.04E+10	-7.64E-12	770645.	0.00
48.3300	0.00	8.48E-10	3.06E-11	0.00	23341.	1.04E+10	-5.35E-12	779988.	0.00
48.8670	0.00	9.39E-10	2.39E-12	0.00	23341.	1.04E+10	-3.41E-12	789331.	0.00
49.4040	0.00	8.87E-10	-1.47E-11	0.00	23341.	1.04E+10	-1.89E-12	798675.	0.00

49.9410	0.00	7.56E-10	-2.33E-11	0.00	23341.	1.04E+10	0.00	808018.	0.00
50.4780	0.00	5.92E-10	-2.59E-11	0.00	23341.	1.04E+10	0.00	817361.	0.00
51.0150	0.00	4.25E-10	-2.46E-11	0.00	23341.	1.04E+10	0.00	826704.	0.00
51.5520	0.00	2.77E-10	-2.09E-11	0.00	23341.	1.04E+10	0.00	836047.	0.00
52.0890	0.00	1.56E-10	-1.61E-11	0.00	23341.	1.04E+10	0.00	845390.	0.00
52.6260	0.00	6.93E-11	-1.08E-11	0.00	23341.	1.04E+10	0.00	854733.	0.00
53.1630	0.00	1.72E-11	-5.38E-12	0.00	23341.	1.04E+10	0.00	864077.	0.00
53.7000	0.00	0.00	0.00	0.00	23341.	1.04E+10	0.00	436710.	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 2:

Pile-head deflection	=	0.08072474 inches
Computed slope at pile head	=	-0.0013658 radians
Maximum bending moment	=	205012. inch-lbs
Maximum shear force	=	-5089. lbs
Depth of maximum bending moment	=	4.83300000 feet below pile head
Depth of maximum shear force	=	7.51800000 feet below pile head
Number of iterations	=	18
Number of zero deflection points	=	11
Pile deflection at ground	=	0.02811140 inches

Pile-head Deflection vs. Pile Length for Load Case 2

Boundary Condition Type 1, Shear and Moment

Shear	=	3600. lbs
Moment	=	0. in-lbs
Axial Load	=	310000. lbs

Pile Length feet	Pile Head Deflection inches	Maximum Moment ln-lbs	Maximum Shear lbs
53.70000	0.08072474	205012.	-5089.
51.01500	0.07497141	197638.	-4960.
48.33000	0.08528638	211483.	-5213.
45.64500	0.07835002	202609.	-5053.
42.96000	0.08659122	212907.	-5182.
40.27500	0.07896682	201933.	-4972.
37.59000	0.08363677	208843.	-5178.

34.90500	0.08687048	213300.	-5267.
32.22000	0.07741895	200115.	-5077.
29.53500	0.07751441	200976.	-5143.
26.85000	0.08523104	211208.	-5302.
24.16500	0.08104469	205694.	-5255.
21.48000	0.08277791	207505.	-5228.
18.79500	0.08054176	204446.	-5192.
16.11000	0.07993318	203715.	-5237.
13.42500	0.08339769	208024.	-5324.
10.74000	0.09164860	205316.	-6086.

Summary of Pile-head Responses for Conventional Analyses

Definitions of Pile-head Loading Conditions:

Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians

Load Case No.	Load Type 1	Pile-head Load 1	Load Type 2	Pile-head Load 2	Axial Loading lbs	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
1	V, lb	8600.	M, in-lb	0.00	0.00	0.2696	-0.00392	-8877.	488402.
2	V, lb	3600.	M, in-lb	0.00	310000.	0.08072	-0.00137	-5089.	205012.

Maximum pile-head deflection = 0.2696446206 inches

Maximum pile-head rotation = -0.0039173188 radians = -0.224446 deg.

The analysis ended normally.

Project: CUY-71-10.07 SW
Project No: 23050013CLE
June 10, 2024

L-PILE Soil Parameters (Boring B-004-0-23 Rear Abutment)

General Comments:

- No groundwater encountered in test boring
- Bottom of pile cap (top of pile in LPILE analysis) at elevation 800.0 feet
- Pile driven to refusal on underlying bedrock (depth of 53.7 feet)
- - The upper 3.5 feet of passive soil resistance is ignored

From 796.5 to 790.8' (3.5' to 9.2')

Soil Classification – A-6a

Use soil type – *Stiff Clay without Free Water (Reese)*

Effective Unit Weight (pcf) = 125 pcf

Undrained Cohesion (psf) = 2,625 psf

Use Strain Factor $K_{rm} = 0.005$ (From L-pile Technical Manual Table 3-4, stiff clay)

From 790.8' to 781.8' (9.2' to 18.2')

Soil Classification – A-3a

Use soil type – *Sand (Reese)*

Effective Unit Weight (pcf) = 132 pcf

Friction Angle = 38.2 degrees

Use Non-Default k (lb/in³) = 225 pci (From L-pile Technical Manual Table 3.7, Dense above Water Table)

From 781.8' to 776.8' (18.2' to 23.2')

Soil Classification – A-4a (cohesive)

Use soil type – *Stiff Clay without Free Water (Reese)*

Effective Unit Weight (pcf) = 125 pcf

Undrained Cohesion (psf) = 2,875 psf

Use Strain Factor $K_{rm} = 0.005$ (From L-pile Technical Manual Table 3-4, stiff clay)

From 776.8' to 766.8' (23.2' to 33.2')

Soil Classification – A-4a (cohesive)

Use soil type – *Stiff Clay without Free Water (Reese)*

Effective Unit Weight (pcf) = 135 pcf

Undrained Cohesion (psf) = 5,563 psf

Use Strain Factor $K_{rm} = 0.004$ (From L-pile Technical Manual Table 3-4, hard clay)

From 766.8' to 755.8' (33.2' to 44.2')

Soil Classification – A-4a (cohesive)

Project: CUY-71-10.07 SW

Project No: 23050013CLE

June 10, 2024

Use soil type – *Stiff Clay without Free Water (Reese)*

Effective Unit Weight (pcf) = 140 pcf

Undrained Cohesion (psf) = 6,460 psf

Use Strain Factor $K_{rm} = 0.004$ (From L-pile Technical Manual Table 3-4, hard clay)

From 755.8' to 746.3' (44.2' to 53.7')

Soil Classification – A-2-4

Use soil type – *Sand (Reese)*

Effective Unit Weight (pcf) = 132 pcf

Friction Angle = 37.75 degrees

Use Non-Default k (lb/in³) = 225 pci (From L-pile Technical Manual Table 3.7, Dense above Water Table)

Below 746.3' (53.7')

Use soil type – *Weak Rock (Reese)*

Effective Unit Weight (pcf) = 155 pcf

Compressive strength (q_u) = 120.28 psi (17.32 ksf)

Initial Rock Modulus (E_r) = 10,800 psi (Per ODOT OGE, interpolated from Very Weak)

RQD = 0%

Use Strain Factor $K_{rm} = 0.0005$ (From L-pile Technical Manual Equation 3-136)

P-y Modification Factors

No P-y factors applied, center-to-center spacing of piles greater than 3.75 times the width of the pile.

Width of HP10x42 pile = 10.1 inches (0.84 feet)

Pile center-to-center spacing in plan view = 5.0 feet

Pile center-to-center spacing in profile view = 4.75 feet