Technical Design Memo

Client:	Ohio Department of Transportation, District 10		
Project:	**ATH-144-6.04 (Task Order 10-Z)** **PID 117974**		
HDR Project No:	10361044	Rev:	0
Calculation No:	1	Page:	1 of 117
Title:	Landslide Remediation Analyses and Design		
Purpose:	Prepare slope stability analyses and wall calculations for the design of a landslide repair along the northbound travel lane of State Route 144 (SR 144) in Athens County, Ohio.		
Originator:	AKB	Date:	3/6/2023
Checked by:	DCM	Date:	3/8/2023
QC Review by:	DMV	Date:	3/10/2023

Summary

1. A landslide has occurred on the slope below SR 144 near mile marker 6.04 in Athens County, Ohio. The project location is shown on the attached Site Vicinity and Topographic Map, near the base of the valley wall above the floodplain of the Hocking River. Based on observations gathered during the site reconnaissance performed on December 1, 2022, coupled with the findings from the geotechnical explorations performed from January 19 to 24 and February 6, 2023, a soldier pile and lagging retaining wall is recommended to stabilize the landslide and repair SR 144. Presented herein are the discussion and evaluation of a soldier pile and lagging wall for landslide mitigation. This design assumes that the topography and slope geometry as presented in the surveyed cross sections are representative of the current field conditions.

2. The geotechnical exploration program consisted of a series of 3 test borings (designated as Borings B-001-0-23, B-002-0-23, and B-003-0-23) and 3 dynamic cone penetrometer soundings (designated as D-001-1-23, where 2 tests were performed, and D-002-1-23) to characterize the subsurface profile in the vicinity of the existing landslide and develop a repair. The second test at the D-001-1-23 location was performed to confirm the relatively shallow refusal depth encountered in the initial test. The 3 test borings were drilled within the northbound lane of SR

144 and the 3 DCPs were performed on a mid-slope bench below the roadway at the locations shown on the attached Boring Location Plan. Typed boring logs and the DCP test logs are also included. The soil profile, as encountered in the borings, generally consisted of an upper layer of stiff to very stiff colluvium, underlain by a granular layer of medium dense to dense colluvium. This granular layer was not encountered in Boring B-002-0-23, but a limestone boulder was encountered at a similar depth. The colluvium was underlain by hard residuum. The overburden soils were underlain by interbedded limestone, claystone, sandstone, and shale bedrock. Free water was encountered in all three test borings (Borings B-001-0-23, B-002-0-23, and B-003-0-23) at depths of 15.0 feet (El. 616.5), 20.0 feet (El. 611.2) and 21.0 feet (El 612.2), respectively, during drilling. As the borings were backfilled upon completion given their locations within the roadway, delayed water level readings were not obtained.

The generalized soil profile developed for the design section is primarily based on the findings from Boring B-002-0-23 and DCP D-002-1-23, located near the design section at Sta. 319+25. The soil profile is assumed to be depicted as shown graphically on the attached Slope/W output plots based on the generalized soil conditions as encountered in the explorations, as well as field observations gathered during the course of our site reconnaissance.

3. Eastern Athens County is located within the Marietta Plateau region of the Allegheny (Kanawha) Plateaus section of the unglaciated and dissected Appalachian Plateaus province, described as dissected, high-relief terrain prone to landslide activity and mainly composed of fine-grained rocks, red shales, and red residual soils. Soils in the Marietta Plateau region are identified as Pleistocene (Teays)-age Minford clays and/or red and brown colluvial silty-clay loam landslide deposits. The southeastern portion of Athens County is drained by tributaries of the Hocking River, which in turn flows into the Ohio River at the southeastern corner of the county. The project site is drained directly by the Hocking River, located adjacent to the toe of the slope. Soils in the area are comprised primarily of residuum and colluvium derived from the underlying sedimentary bedrock. The bedrock at the project site is mapped within the Pennsylvanian-age Monongahela Group, with the overlying Permian-Pennsylvanian-age Dunkard Group on the hillsides above the project site, near El. 660 to 680. The Monongahela Group consists of shale, siltstone, and mudstone, with minor amounts of limestone and coal. The Dunkard Group consists of mudstone, shale, and siltstone, with minor amounts of sandstone, limestone, and coal.

4. The main coal seams of note within the Monongahela Group include the Pittsburgh No. 8, Pomeroy (Redstone) No. 8a, Meigs Creek (Sewickley) No. 9, Uniontown No. 10, and Waynesburg No. 11 coals, and the notable seam within the Dunkard Group is the Washington No. 12 coal. Most of the mining in Athens County occurred in the northwestern portion of the county; no significant mining activity is mapped at the project site according to information from the Ohio Department of Natural Resources. All mining is mapped further than 2 miles from the project site.

5. No base flood elevation has been established based on review of FEMA flood maps for the area in order to determine the high water elevation along the slope located below the roadway. The project site is mapped in an area designated without a base flood elevation (Zone A). The mapped extents generally range partway up the slope east of the roadway, about El. 600.

6. HDR is unaware of any prior geotechnical explorations at the ATH-144-6.04 project site. A search of the available records on ODOT's Transportation Information Mapping System (TIMS) reveals only the geographical locations of known landslide activity in the project area. The nearest borings from prior studies were performed approximately 0.5 mile south of the project site.

7. In accordance with ODOT Geotechnical Design Manual (GDM) recommendations, an initial set of soil strength parameters were selected based on the boring logs, laboratory tests, and published correlations of soil strength with SPT N_{60} values. A statistical basis for selecting the initial soil parameters was performed and is in the attached printed spreadsheets entitled "Soil Strength Parameter Determination". Following development of the soil strength parameters, cross-sections perpendicular to the roadway centerline were reviewed, and the section at Station 319+25 was selected for design.

The developed soil parameters and subsurface profile were then entered into the Slope/W slope stability modeling software to re-create the landslide observed in the field by simulating a series of trial searches to determine the critical mode of failure based on a Morgenstern-Price stability model. In addition, the Slope/W optimization feature was utilized, which generates a hybrid circular and translational failure shape. Recognizing that a landslide had already occurred, strength parameters within the existing soil layers were adjusted in order to generate a reasonable slip surface (FS < 1.0) that is consistent with the field observations and engineering judgment. Based on the topographic survey, apparent toe bulges are located below the existing SR 144 alignment. As such, the existing slope was reconstructed based on geometry from Station 320+25 for comparison. The reconstructed slope resulted in a higher factor of safety than the current survey, so the current survey was carried forward in design. Both Slope/W analyses are included in the attachments.

Limited groundwater information was available from the borings and published sources. However, slightly elevated moisture contents were noted approximately 4 feet below existing grade in B-002-0-23, which may be a result of run-off infiltration and/or perched water conditions. Based on the available information and on-site observations, groundwater was modeled from the existing drainage ditch to the left of the existing roadway to the level of elevated moistures and extending to the approximate level of the Hocking River near El. 585.

Bedrock depths along the slope below SR 144 were estimated based on the slope of the existing terrain, exposed bedrock outcrops on the west side of the roadway, limited data available on published bedrock topography maps, overburden soil thicknesses encountered in the soil borings and refusal depths of the DCP tests. Analyses were performed with a 2-foot thick "Weak Rock" layer along the interface of the colluvial and hard residual soils. Once the soil parameters and failure surface were established, they were entered into the UA Slope Version 2.3 software program and a model was developed based on the current slope configuration (See attached UA Slope screen shot).

8. After the soil profile and parameters between Slope/W and UA Slope were confirmed and finalized, a preliminary wall location was plotted with the centerline of the proposed drilled shafts a distance of 21 feet from the centerline of the roadway. This offset allows for, at a minimum, a 10-foot travel lane and 2-foot paved shoulder, as well as continuity of the existing guardrail located to the north and south of the project site, which is currently offset 15 feet right of centerline, and 5 feet of clearance from the face of the guardrail to the face of the retaining wall. This offset should also provide sufficient space for construction of the wall while maintaining a single lane of traffic on SR 144, as well as avoid the remnant of an existing sandstone block foundation located 24.5 feet right of centerline at approximate Sta. 320.45. A 4-foot maintenance bench was included in front of the wall for design, with the existing grade elevation used as the proposed bench elevation. However, the existing sandstone-block foundation may encroach on the bench. Elevations along this preliminary wall profile were reviewed to establish the tallest exposed wall height (considering the elevation at the centerline of SR 144 to the proposed bench elevation), which was about 8.5 feet at Station 320+12 (see attached). Downslope stability was analyzed in Slope/W based on the actual geometry at the section, but the elevation of the bench was lowered to match the maximum exposed wall height for the UA Slope, wall loading, and LPile analyses (see attached).

Once the wall location was established, the "Manually Determined Load Transfer Factor" was selected in the UA Slope program and the load transfer factor (η) was set to zero in order to determine the horizontal forces acting on the wall. The computed unfactored force per shaft is **Ps = 164,602** pounds based on 48-inch diameter drilled shafts spaced at approximate 6-foot centers. (See attached UA Slope computer screen shots of the post-construction condition of these calculations.) The numbering of soil layers for the UA Slope profile is listed as follows:

a. Layer 1 = Surcharge Load
b. Layer 2 = Item 203 Embankment Fill
c. Layer 3 = Stiff to Very Stiff Cohesive
d. Layer 4 = Weak Residuum
e. Layer 5 = Hard Cohesive
f. Layer 6 = Bedrock

9. In accordance with ODOT design requirements, LPILE software was used to determine the pile response to the applied lateral loading from the failure wedge determined by the Slope/W and UA Slope analyses performed at the design section. At Sta. 319+25 for a 9-foot exposed wall height, the following were considered relative to LPILE analyses:

(a) <u>Factored Distributed Load (per GDM Section 903.1, pgs. 9-12 and 9-13)</u>

- Convert concentrated load from <u>UA Slope</u> to distributed load
  - ½(D_L)(H_T) = 164,602 lbs.
    D_L = distributed load
    H_T = 25.3 feet (top/wall to slip surface, see attached)
  - D_L = [(164,602 lbs)(2)]/[(25.3')(12"/ft)] = Resolution of Triangular Area
    D_L = **<u>1,084 lbs/in</u>** (Service Load)

- (1,084 lbs/in)(γ_{EH}) = (1,084 lbs/in)(1.5) = **1,627 lbs/in** (Strength Load for Moment/Shear Analysis).

Loading due to conventional earth pressures were performed for comparison purposes.

- Calculate conventional earth pressure wall loading.
  - Equivalent Fluid Weight (G_H) = (γ_m) * (K) = **48 pcf**
    Ym = soil moist unit weight (see attached calculations)
    Ka = active earth pressure (see attached calculations)
  - Lateral Thrust (P) = 1/2 * G_H * H^2 = P = **3,088 lbs/ft**
    H = Wall Height
  - Horizontal Force Per Shaft (P_{SH}) = P*(S_{cc}) = **18,531 lbs/shaft**
    S_{cc} = Center-to-Center Shaft Spacing = 6 ft
  - Resolve Horizontal Earth Pressure to Distributed Triangular Load
    (2* P_{SH}/H) / (12 in/ft)
    = **273 lbs/in per shaft (Service Load)**
    (273 lbs/in) (γ_{EH}) = (273 lbs/in) (1.5)
    = **410 lbs/in per shaft (Strength Load)**

Based on a comparison of the two loading methods, landslide loading from UA Slope was applied to the proposed wall.

(b) Traffic Surcharge (per GDM Section 903.7, pg. 9-16)

As loading traffic may be present up to the front edge of the guardrail, traffic surcharge loading was included in the distributed load acting on the shaft (see attached calculations).

(c) Modification of p-y curves

Since the center-to-center spacing is < 3.5 shaft diameters, a reduction in soil resistance (p) should be applied from the ground surface to the bottom of shaft or bedrock (whichever is shallower).

- $\beta_a = 0.64(S/D)^{0.34} = \beta_a = 0.64(6/4)^{0.34}$
- β_a = **0.73**

The downslope stability exhibited a Factor of Safety less than 1.3. (See the Slope/W output plot included in the attached calculations.) As such, the GDM recommendation of artificially lowering the ground surface in the LPILE analysis was included.

- Top of Wall El. 629.9 ft
  - Assumes approximately 3.3 feet of fill placement to re-establish grade.

- Maintenance Bench GS El. = 621.4 ft (Based on Max. Wall Height at Sta. 320+12)
- Wall Height = 629.9 ft – 621.4 ft = 8.5 ft.
- Artificially lowered surface = 2.8 feet (See attached)
- GS for LPILE analysis = 621.4 ft – 2.8 ft = 618.6 ft
  - Wall Height for LPILE Analysis = 8.5 ft + 2.8 ft = **11.3 ft**

(d) Pile Head Deflection

As noted in the ODOT GDM (Section 903.8, pgs. 9-16 and 9-17), for the unfactored Service Limit State analysis, pile head deflection shall be limited 1% or less of the drilled shaft length above bedrock (or the total shaft length when bedrock is not encountered). If the drilled shafts are within 10 feet of the edge of pavement, the deflection must be limited to 2 inches. The centerline of the drilled shafts is anticipated to be located less than 10 feet from the edge of pavement. As such, a limited pile head deflection of 2 inches or less was adopted.

Computed Pile Head Deflection (W 40 x 167) = **1.99 inches** < 2.00 inches OK
(See attached calculations)

(e) Pile Length (per GDM Section 903.4, pg. 9-14)

*Minimum 10 feet below slip plane
*Slip Plane = 25.3 ft below top of wall
+10.0 ft
35.3 ft minimum pile length

- **Bottom of Drilled Shaft = 41.0 ft ≥ 35.3 ft** **OK**

The ODOT GDM requires embedding a drilled shaft a minimum of 10 feet below the failure surface and into a solid stratum such that the calculated deflection at the top of the wall is constrained to the appropriate serviceability limits. (See Section 9(d) above.) The "Top Deflection Versus Length" plot produced by the LPILE software was reviewed to determine the recommended rock socket length. Based on the encountered bedrock and our experience with such local bedrock types, **a minimum rock socket length of 10 feet** is recommended.

(f) Steel Reinforcement and Pile Cross Section Character

Use W 40 x 167 shaft reinforcement

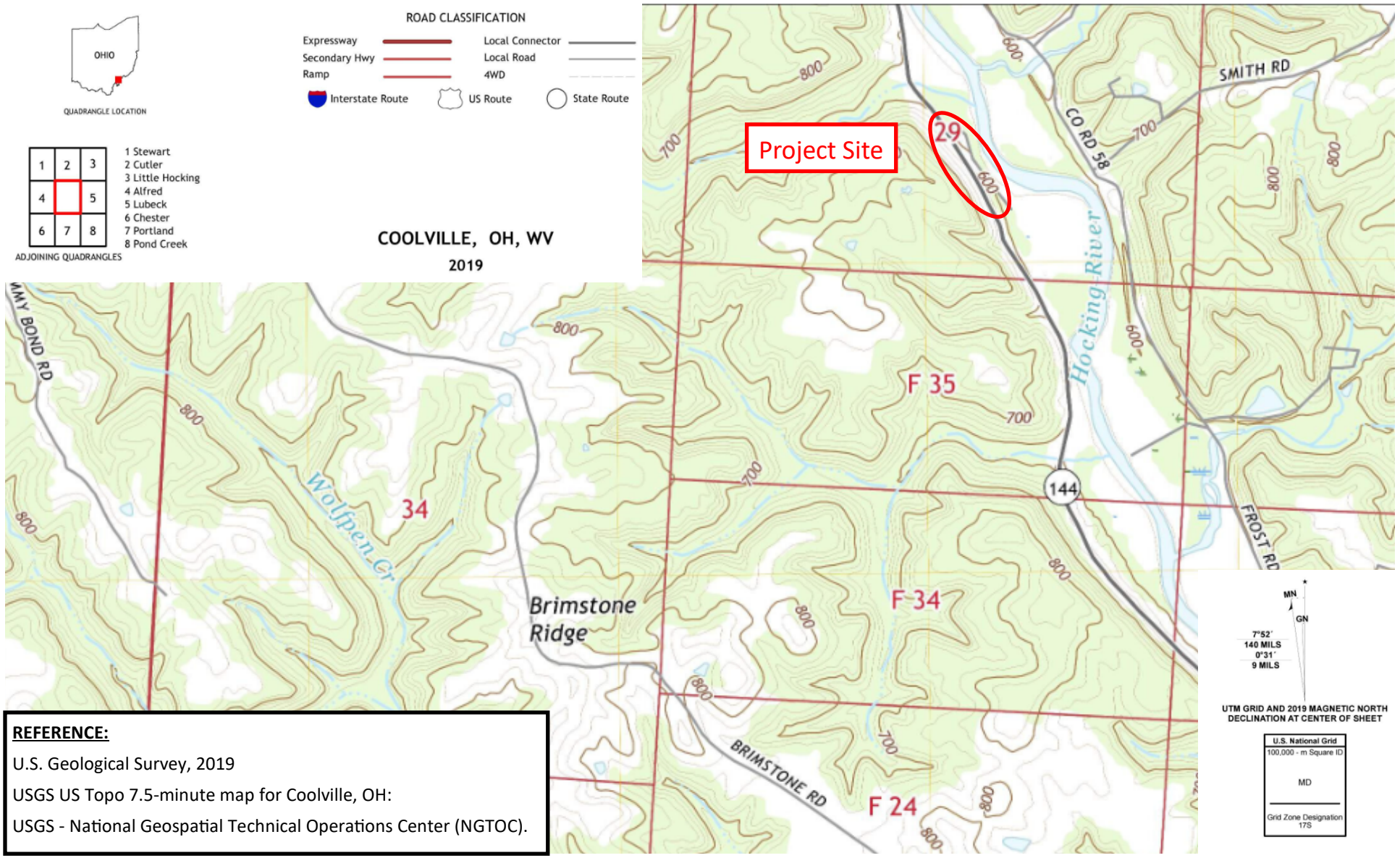
A_s = Area of Steel = 49.2 in^2
I_x = Moment of Inertia around strong axis = 11,600 in^4
T_w = web thickness = 0.65 in
E = Modulus of Elasticity of Steel = 29,000,000 psi
F_y = yield strength of steel = 50,000 psi

B_f = Flange Width = 11.8 in

8. It is recommended that plug piles be utilized to prevent loss of material and undermining of the concrete lagging. Please refer to the attached "Soldier Pile and Lagging Wall Details" sheet for details on the plug piles as well as further details on the wall itself.

Site Vicinity and Topographic Map

Site Vicinity and Topographic Map



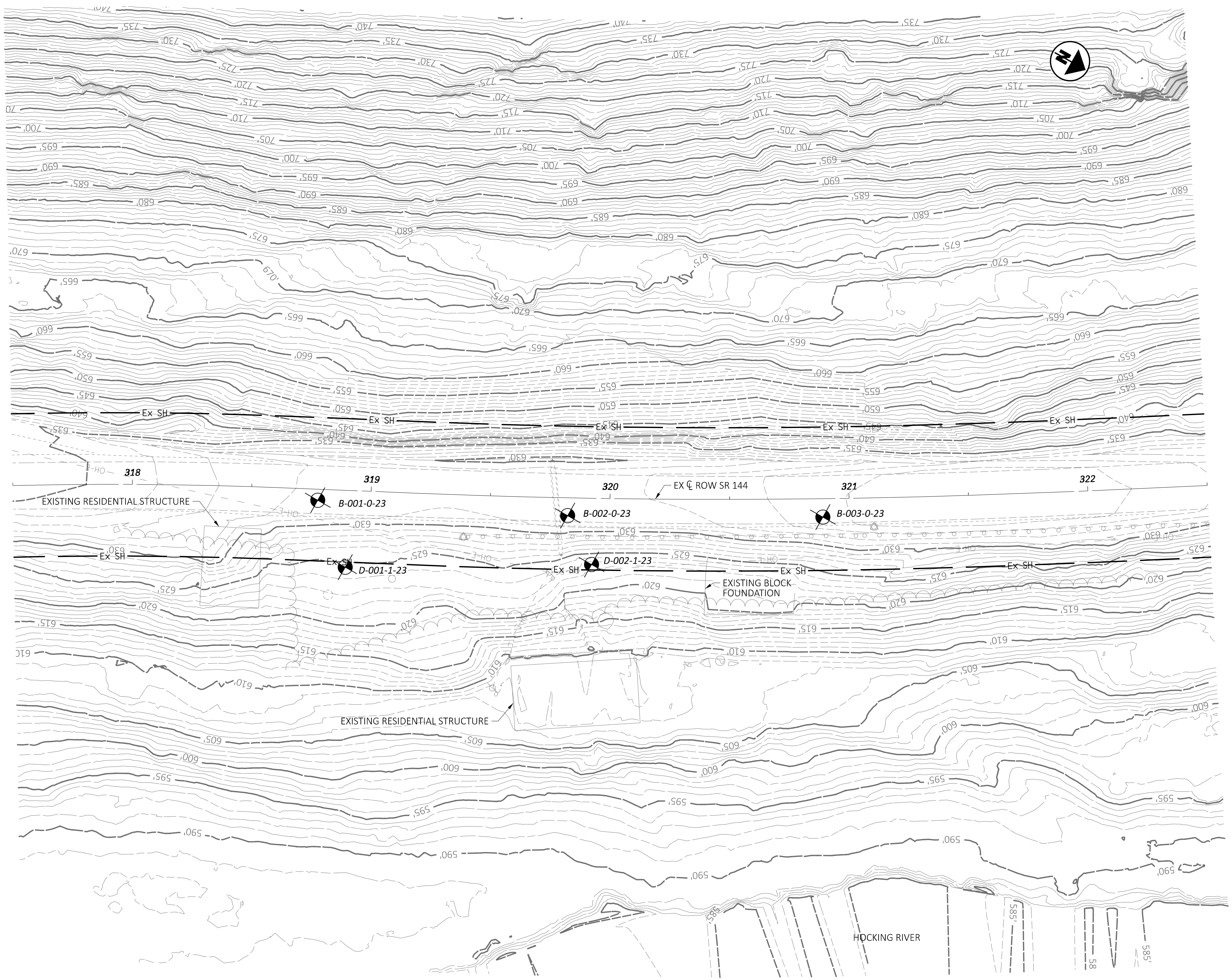
REFERENCE:

U.S. Geological Survey, 2019

USGS US Topo 7.5-minute map for Coolville, OH:

USGS - National Geospatial Technical Operations Center (NGTOC).

Boring Location Plan



HORIZONTAL SCALE IN FEET
0 20 40

BORING LOCATION PLAN

DESIGN AGENCY

DESIGNER
AKB
REVIEWER
DMV 03-10-23
PROJECT ID
117974
SHEET TOTAL

ATH-144-6.04

MODEL: CLX_RW_SR145 - Plan 1 [Sheet] PAPERSIZE: 17x11 (in.) DATE: 3/9/2023 TIME: 9:11:21 AM USER: ABARATTA
pw:\\ohiodot-pw.bentley.com:ohiodot-pw-02\Documents\01 Active Projects\District 10\Athens\117974\402-Engineering_HDR\Geotechnical\Sheets\117974_YP903.dgn

Boring Logs
and
Rock Core Photos

PROJECT: ATH-144-06.04	DRILLING FIRM / OPERATOR: CENTRAL STAR / TS	DRILL RIG: DIEDRICH D-50 (SN311)	STATION / OFFSET: 318+78, 5' RT.	EXPLORATION ID B-001-0-23
TYPE: LANDSLIDE	SAMPLING FIRM / LOGGER: HDR / DM	HAMMER: AUTOMATIC HAMMER	ALIGNMENT: SR 144	
PID: 117974 SFN:	DRILLING METHOD: 2.25 HSA / NQ2	CALIBRATION DATE: 3/7/22	ELEVATION: 631.5 (MSL) EOB: 40.8 ft.	PAGE 1 OF 2
START: 1/24/23 END: 1/24/23	SAMPLING METHOD: SPT / NQ2	ENERGY RATIO (%): 84.9	LAT / LONG: 39.244460, -81.808967	

MATERIAL DESCRIPTION AND NOTES	ELEV. 631.5	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
18 inches of Asphalt	630.0	1																
VERY STIFF TO HARD, RED-BROWN AND LIGHT BROWN, **SILTY CLAY**, SOME SAND, LITTLE GRAVEL, DAMP		2	12 12 10	31	67	SS-1	2.00	-	-	-	-	-	-	-	-	8	A-6b (V)	
		3																
		4																
		5																
		6	6 9 13	31	78	SS-2	4.00	17	7	22	24	30	37	18	19	13	A-6b (7)	
		7																
		8	10 9 9	25	78	SS-3	3.00	-	-	-	-	-	-	-	-	11	A-6b (V)	
		9																
		10																
	620.0	11	6 5 6	16	67	SS-4	2.00	-	-	-	-	-	-	-	-	18	A-6b (V)	
STIFF TO VERY STIFF, RED-BROWN AND LIGHT BROWN, **SILT AND CLAY**, "AND" SAND, LITTLE STONE FRAGMENTS, DAMP		12																
@ 13.5' - 14.0' : Light Brown Coarse and Fine Sand, Trace Stone Fragments		13	2 3 13	23	78	SS-5	1.50	16	17	24	29	14	28	17	11	14	A-6a (2)	
	616.5	14																
MEDIUM DENSE, GRAY-BROWN, **STONE FRAGMENTS WITH SAND, SILT, AND CLAY**, DAMP	W 616.5	15	1 3 6	13	78	SS-6	-	-	-	-	-	-	-	-	-	19	A-2-6 (V)	
@ 16.5' - 17.0' : Auger Grinding		16																
		17																
		18	12 14 5	27	44	SS-7	-	51	11	8	14	16	33	18	15	11	A-2-6 (1)	
@ 19.0' - 20.0' : Auger Grinding		19																
@ 20.5' : Auger Refusal	611.0	20	50/5"	-	100	SS-8	3.00	-	-	-	-	-	-	-	-	20	A-2-6 (V)	
LIMESTONE, GRAY, MODERATELY WEATHERED, STRONG, VERY THIN TO THIN BEDDED, CRYSTALLINE, JOINT AND BEDDING DISCONTINUITIES WITH STAINING, FRACTURED, OPEN APERTURE, VERY ROUGH, VERY BLOCKY GOOD SURFACE CONDITIONS; RQD 0%, REC 63%.	TR	21	0		75	NQ2-1											CORE	
		22																
		23	0		50	NQ2-2											CORE	
	607.0	24																
CLAYSTONE, GRAY TRACE BROWN, MODERATELY WEATHERED, WEAK, THIN TO MEDIUM BEDDED, JOINT AND BEDDING DISCONTINUITIES, MODERATELY FRACTURED, NARROW APERTURE, SLICKENSIDED, VERY BLOCKY, POOR SURFACE CONDITIONS; RQD 44%, REC 100%.		25	67		100	NQ2-3											CORE	
		26																
		27																
	602.5	28																
		29																

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 3/6/23 15:11 - C:\PWWORKING\EAST01\D3052821\20230124_ATH-144-6.04_10-Z_BORING LOGS WITH LAB.GPJ

PID: 117974	SFN:	PROJECT: ATH-144-06.04	STATION / OFFSET: 318+78, 5' RT.	START: 1/24/23	END: 1/24/23	PG 2 OF 2	B-001-0-23

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
CLAYSTONE, RED-BROWN AND GRAY, MODERATELY TO HIGHLY WEATHERED, VERY WEAK, LAMINATED TO VERY THIN BEDDED, FRIABLE, JOINT AND BEDDING DISCONTINUITIES, HIGHLY FRACTURED, OPEN APERTURE, SLICKENSIDED, LAMINATED, VERY POOR SURFACE CONDITIONS; RQD 0%, REC 100%. *(continued)*	601.5	31	0		100	NQ2-4											CORE	
CLAYSTONE, GRAY TRACE BROWN, MODERATELY WEATHERED, WEAK, THIN TO MEDIUM BEDDED, JOINT AND BEDDING DISCONTINUITIES, MODERATELY FRACTURED, NARROW APERTURE, SLICKENSIDED, VERY BLOCKY, POOR SURFACE CONDITIONS; RQD 52%, REC 100%.	599.0	32																
SANDSTONE, GRAY, SLIGHTLY WEATHERED, MODERATELY STRONG, FINE TO MEDIUM GRAINED, THICK TO VERY THICK BEDDED, JOINT AND BEDDING DISCONTINUITIES, SLIGHTLY FRACTURED TO INTACT, TIGHT APERTURE, SLIGHTLY ROUGH, INTACT, GOOD SURFACE CONDITIONS; RQD 83%, REC 99%. @ 34.2' - 35.4' : Gray-Brown to olive-gray, moderately fractured with staining, open aperture @ 36.0' - 36.4' : Qu = 4943 psi	597.3	33 34 35 36 37 38 39 40	41		100	NQ2-5											CORE	
	590.7	EOB	90		99	NQ2-6											CORE	

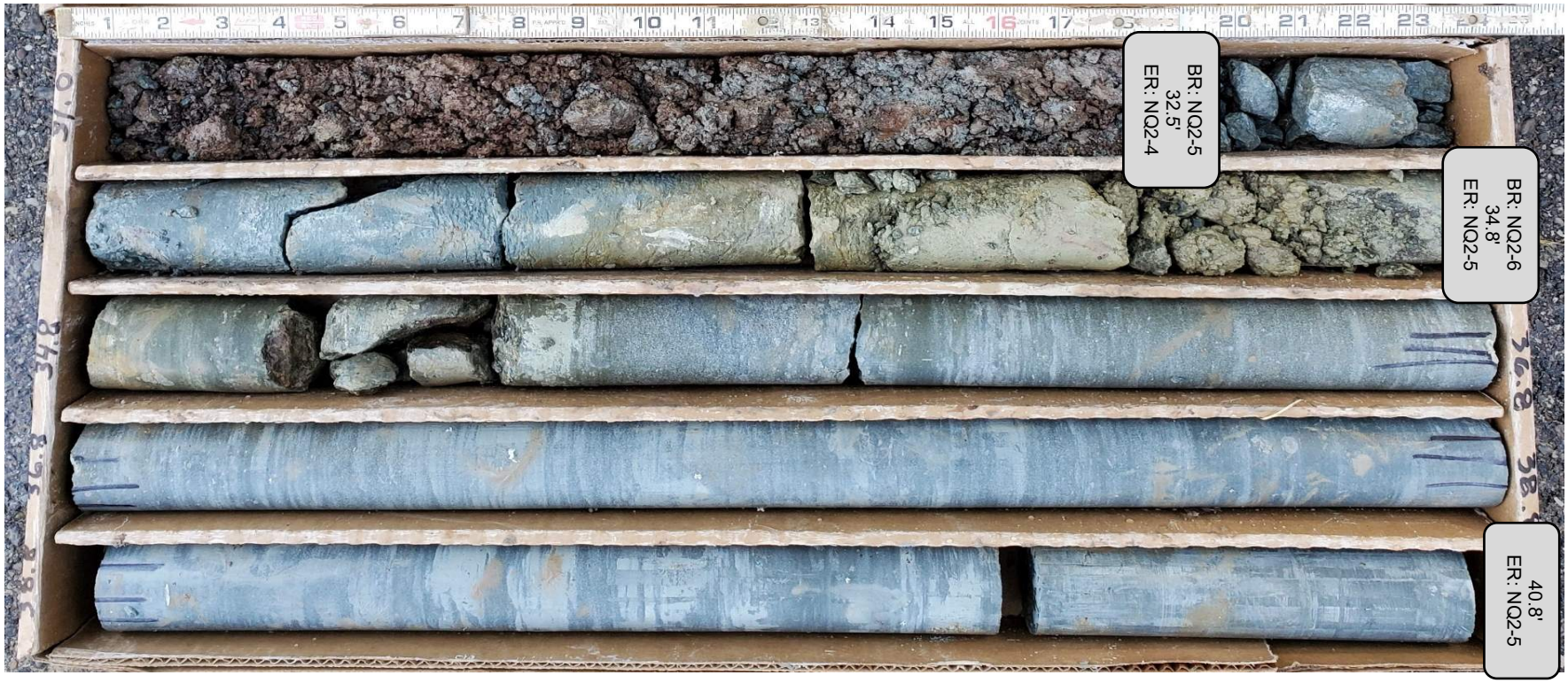
NOTES: BOREHOLE CAPPED WITH QUICK-CRETE CONCRETE PATCH; NQ2-1 AND NQ2-2 CORED WITH IMPREGNATED BIT; NQ2-3 THROUGH NQ2-6 CORED WITH SURFACE SET BIT

ABANDONMENT METHODS, MATERIALS, QUANTITIES: TREMIED 20 LB. BENTONITE POWDER; 94 LB. CEMENT; 50 GAL. WATER

B-001-0-23

Run #	Depth (ft)		Recovery		RQD	
NQ2-1	20.5	22.5	18 in. / 24 in.	75%	0 in. / 24 in.	0%
NQ2-2	22.5	24.5	12 in. / 24 in.	50%	0 in. / 24 in.	0%
NQ2-3	24.5	27.5	36 in. / 36 in.	100%	24 in. / 36 in.	67%
NQ2-4	27.5	32.5	60 in. / 60 in.	100%	0 in. / 60 in.	0%
ATH-144-6.04 PID 117974						

B-001-0-23



Run #	Depth (ft)		Recovery		RQD	
NQ2-4	27.5	32.5	60 in. / 60 in.	100%	0 in. / 60 in.	0%
NQ2-5	32.5	34.8	27 in. / 27 in.	100%	11 in. / 27 in.	41%
NQ2-6	34.8	40.8	71 in. / 72 in.	99%	65 in. / 72 in.	90%

ATH-144-6.04 PID 117974

PROJECT: ATH-144-06.04	DRILLING FIRM / OPERATOR: CENTRAL STAR / TS	DRILL RIG: DIEDRICH D-50 (SN311)	STATION / OFFSET: 319+82, 7' RT.	EXPLORATION ID B-002-0-23
TYPE: LANDSLIDE	SAMPLING FIRM / LOGGER: HDR / DM	HAMMER: AUTOMATIC HAMMER	ALIGNMENT: SR 144	
PID: 117974 SFN:	DRILLING METHOD: 2.25 HSA / NQ2	CALIBRATION DATE: 3/7/22	ELEVATION: 631.2 (MSL) EOB: 48.5 ft.	PAGE 1 OF 2
START: 1/19/23 END: 1/20/23	SAMPLING METHOD: SPT / ST / NQ2	ENERGY RATIO (%): 84.9	LAT / LONG: 39.244719, -81.809127	

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
19 inches of Asphalt	631.2																	
	629.6																	
STIFF TO VERY STIFF, RED-BROWN AND BROWN, **CLAY**, "AND" SAND, SOME SILT, TRACE STONE FRAGMENTS, DAMP (FILL)		1																
		2																
		3	6 5 4	13	78	SS-1	3.50	-	-	-	-	-	-	-	-	19	A-7-6 (V)	
		4																
		5	3 3 5	11	67	SS-2	3.00	7	13	28	24	28	43	20	23	20	A-7-6 (8)	
		6	6 6 5	16	78	SS-3	2.00	-	-	-	-	-	-	-	-	15	A-7-6 (V)	
		7																
		8	5 6 8	20	83	SS-4	2.50	-	-	-	-	-	-	-	-	17	A-7-6 (V)	
	622.2	9																
STIFF TO VERY STIFF, RED-BROWN AND BROWN, **SANDY SILT**, LITTLE CLAY, TRACE STONE FRAGMENTS, DAMP			10 21 15	51	89	SS-5	2.00	-	-	-	-	-	-	-	-	17	A-4a (V)	
@ 9.5' - 10.5' : Brown and Dark Brown Highly Weathered Sandstone Fragments		10																
		11	8 6 9	21	67	SS-6	1.50	-	-	-	-	-	-	-	-	13	A-4a (V)	
		12	13 11 9	28	89	SS-7A	2.00	-	-	-	-	-	-	-	-	20	A-4a (V)	
@ 12.5' - 13.0' : Brown Coarse and Fine Sand, Little Silt, Trace Gravel, Trace Clay Layer		13				SS-7B	-	2	30	49	14	5	NP	NP	NP	9	A-3a (0)	
		14	3 7 9	23	89	SS-8	1.00	8	13	35	27	17	27	17	10	13	A-4a (2)	
		15	5 8 6	20	50	SS-9	2.00	-	-	-	-	-	-	-	-	13	A-4a (V)	
		16																
		17	3 4 5	13	56	SS-10	3.50	-	-	-	-	-	-	-	-	13	A-4a (V)	
	613.2	18																
STIFF TO VERY STIFF, LIGHT BROWN TO OLIVE, **SILT AND CLAY**, "AND" SAND, LITTLE STONE FRAGMENTS, DAMP		19			100	ST-11	4.00	20	22	14	22	22	36	21	15	14	A-6a (3)	
@ 18.6' - 19.1' : Qu = 2337 psf																		
@ 20.5' : Anvil Hammer Issues. Stopped SPT sampler at 12 inches and pulled sample.		W 611.2 20	5 6/6"	-	100	SS-12	4.00	-	-	-	-	-	-	-	-	17	A-6a (V)	
	610.7		50/0"	-		SS-13	-	-	-	-	-	-	-	-	-	-		
@ 20.5' Auger Grinding		21	46		58	NQ2-1											CORE	
LIMESTONE, GRAY, SLIGHTLY TO MODERATELY WEATHERED, VERY STRONG, CRYSTALLINE. (BOULDER)	608.7	22																
HARD, GRAY AND LIGHT BROWN, **SILT AND CLAY**, LITTLE SAND, LITTLE GRAVEL, DAMP		23	0		0	NQ2-2											CORE	
		24																
		25																
		26	8 23 34	81	78	SS-14	4.50	-	-	-	-	-	-	-	-	15	A-6a (V)	
		27	18 23 47	99	78	SS-15	4.50	-	-	-	-	-	-	-	-	14	A-6a (V)	
	603.2																	
CLAYSTONE, RED-BROWN WITH BROWN, MODERATELY TO HIGHLY WEATHERED, VERY WEAK.	602.7	TR 28	50/5"	-	100	SS-16	-	-	-	-	-	-	-	-	-	-	Rock (V)	
		29	75		75	NQ2-3											CORE	

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 3/6/23 15:11 - C:\PWWORKING\EAST01\D30528211\20230124_ATH-144-6.04_10-Z_BORING LOGS WITH LAB.GPJ

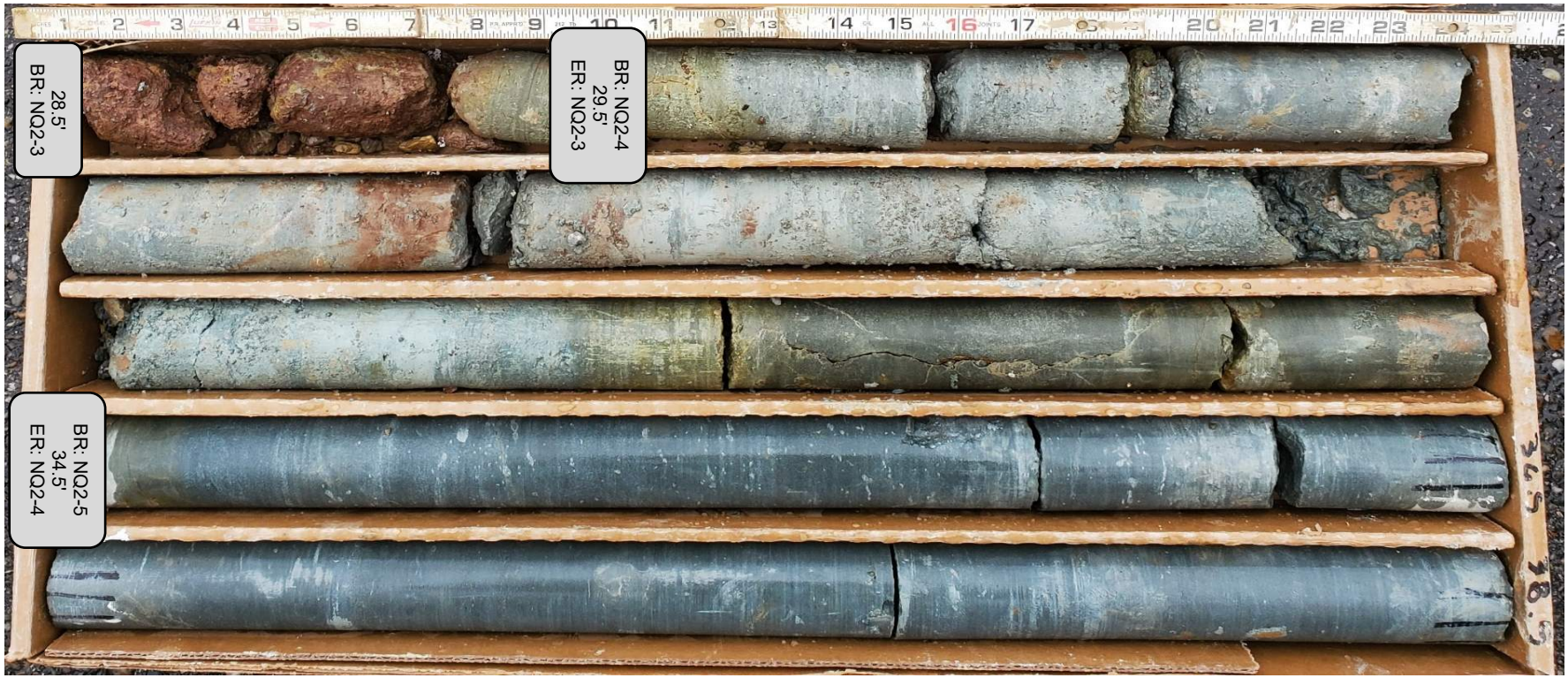
PID: 117974	SFN:	PROJECT: ATH-144-06.04	STATION / OFFSET: 319+82, 7' RT.	START: 1/19/23	END: 1/20/23	PG 2 OF 2	B-002-0-23

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
CLAYSTONE, RED-BROWN WITH BROWN, MODERATELY TO HIGHLY WEATHERED, VERY WEAK, THIN BEDDED, ARENACEOUS, CALCAREOUS, JOINT AND BEDDING DISCONTINUITIES, MODERATELY FRACTURED, NARROW APERTURE, SLICKENSIDED, VERY BLOCKY, POOR SURFACE CONDITIONS; RQD 82%, REC 95%. *(continued)*	601.2	31																
@ 30.8' - 31.2' : Qu = 51 psi	597.7	32	87		100	NQ2-4											CORE	
SANDSTONE, GRAY, SLIGHTLY WEATHERED, MODERATELY STRONG, FINE GRAINED, MEDIUM TO THICK BEDDED, CALCAREOUS, JOINT AND BEDDING DISCONTINUITIES, SLIGHTLY FRACTURED, TIGHT APERTURE, SLIGHTLY ROUGH, INTACT TO BLOCKY, GOOD SURFACE CONDITIONS; RQD 100%, REC 100%.	591.2	33 34 35 36 37 38 39	89		100	NQ2-5											CORE	
CLAYSTONE, RED-BROWN AND GRAY, SLIGHTLY TO MODERATELY WEATHERED, WEAK TO SLIGHTLY STRONG, THIN BEDDED, ARENACEOUS, CALCAREOUS, JOINT AND BEDDING DISCONTINUITIES, NARROW TO OPEN APERTURE, SLICKENSIDED TO SLIGHTLY ROUGH, FAIR SURFACE CONDITIONS; RQD 66%, REC 100%. @ 40.0' - 41.9' : Olive-Gray @ 41.9' - 42.5' : Limestone @ 44.5' - 45.5' : Calcareous with Limestone Nodules @ 46.5' - 48.0' : Calcareous with Limestone Nodules @ 47.4' - 47.8' : Qu = 2388 psi @ 48.0' - 48.5' : Limestone	582.7	40 41 42 43 44 45 46 47 48 EOB	63		100	NQ2-6											CORE	

NOTES: BOREHOLE CAPPED WITH QUICK-CRETE CONCRETE PATCH;

ABANDONMENT METHODS, MATERIALS, QUANTITIES: TREMIED 20 LB. BENTONITE POWDER; 94 LB. CEMENT; 50 GAL. WATER

B-002-0-23



Run #	Depth (ft)		Recovery		RQD	
NQ2-3	28.5	29.5	9 in. / 12 in.	75%	9 in. / 12 in.	75%
NQ2-4	29.5	34.5	60 in. / 60 in.	100%	52 in. / 60 in.	87%
NQ2-5	34.5	43.3	106 in. / 106 in.	100%	94 in. / 106 in.	89%

ATH-144-6.04 PID 117974

B-002-0-23

Run #	Depth (ft)		Recovery		RQD	
NQ2-5	34.5	43.3	106 in. / 106 in.	100%	94 in. / 106 in.	89%
NQ2-6	43.3	48.5	62 in. / 62 in.	100%	36 in. / 62 in.	58%

ATH-144-6.04 PID 117974

PROJECT: ATH-144-06.04	DRILLING FIRM / OPERATOR: CENTRAL STAR / TS	DRILL RIG: DIEDRICH D-50 (SN311)	STATION / OFFSET: 320+89, 8' RT.	EXPLORATION ID B-003-0-23
TYPE: LANDSLIDE	SAMPLING FIRM / LOGGER: HDR / DM	HAMMER: AUTOMATIC HAMMER	ALIGNMENT: SR 144	
PID: 117974 SFN:	DRILLING METHOD: 2.25 HSA / NQ2	CALIBRATION DATE: 3/7/22	ELEVATION: 633.2 (MSL) EOB: 52.5 ft.	PAGE 1 OF 2
START: 1/23/23 END: 1/23/23	SAMPLING METHOD: SPT / ST / NQ2	ENERGY RATIO (%): 84.9	LAT / LONG: 39.244977, -81.809307	

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
15 inches of Asphalt	633.2																	
	631.9																	
STIFF TO VERY STIFF, BROWN AND ORANGE-BROWN, **SILT AND CLAY**, "AND" SAND, TRACE SANDSTONE FRAGMENTS, DAMP (FILL)		1																
		2	5 5 5	14	67	SS-1	3.00	3	10	47	22	18	28	16	12	14	A-6a (2)	
		3																
		4																
		5	5 4 5	13	44	SS-2	2.50	-	-	-	-	-	-	-	-	12	A-6a (V)	
		6																
		7																
	624.7	8	10 9 8	24	56	SS-3	3.00	-	-	-	-	-	-	-	-	15	A-6a (V)	
VERY DENSE, LIGHT BROWN, **COARSE AND FINE SAND**, LITTLE SILT, TRACE CLAY, DAMP		9																
	620.7	10																
		11	74 30 13	61	78	SS-4	-	0	47	35	13	5	NP	NP	NP	7	A-3a (0)	
MEDIUM DENSE, BROWN AND ORANGE-BROWN, **STONE FRAGMENTS WITH SAND AND SILT**, LITTLE CLAY, DAMP		12																
		13	6 8 8	23	67	SS-5	-	-	-	-	-	-	-	-	-	12	A-2-4 (V)	
		14																
		15																
		16	6 7 8	21	67	SS-6	-	7	14	44	21	14	25	18	7	11	A-2-4 (0)	
		17																
		18	2 7 5	17	56	SS-7	-	-	-	-	-	-	-	-	-	16	A-2-4 (V)	
		19																
		20																
	612.2	21			54	ST-8	-	34	15	27	15	9	25	17	8	11	A-2-4 (0)	
	W 612.2	22																
DENSE, GRAY AND GRAY-BROWN, **STONE FRAGMENTS WITH SAND AND SILT**, TRACE CLAY, DAMP		23	13 9 13	31	56	SS-9	-	-	-	-	-	-	-	-	-	17	A-2-4 (V)	
		24																
	608.2	25																
		26	18 35 50/5"	-	94	SS-10	4.50	1	2	10	49	38	35	20	15	14	A-6a (10)	
HARD, RED-BROWN, BROWN AND GRAY, **SILT AND CLAY**, LITTLE SAND, TRACE STONE FRAGMENTS, DAMP (RESIDUUM)		27																
		28	50/5"	-	100	SS-11	4.50	-	-	-	-	-	-	-	-	10	A-6a (V)	
	603.2	29																

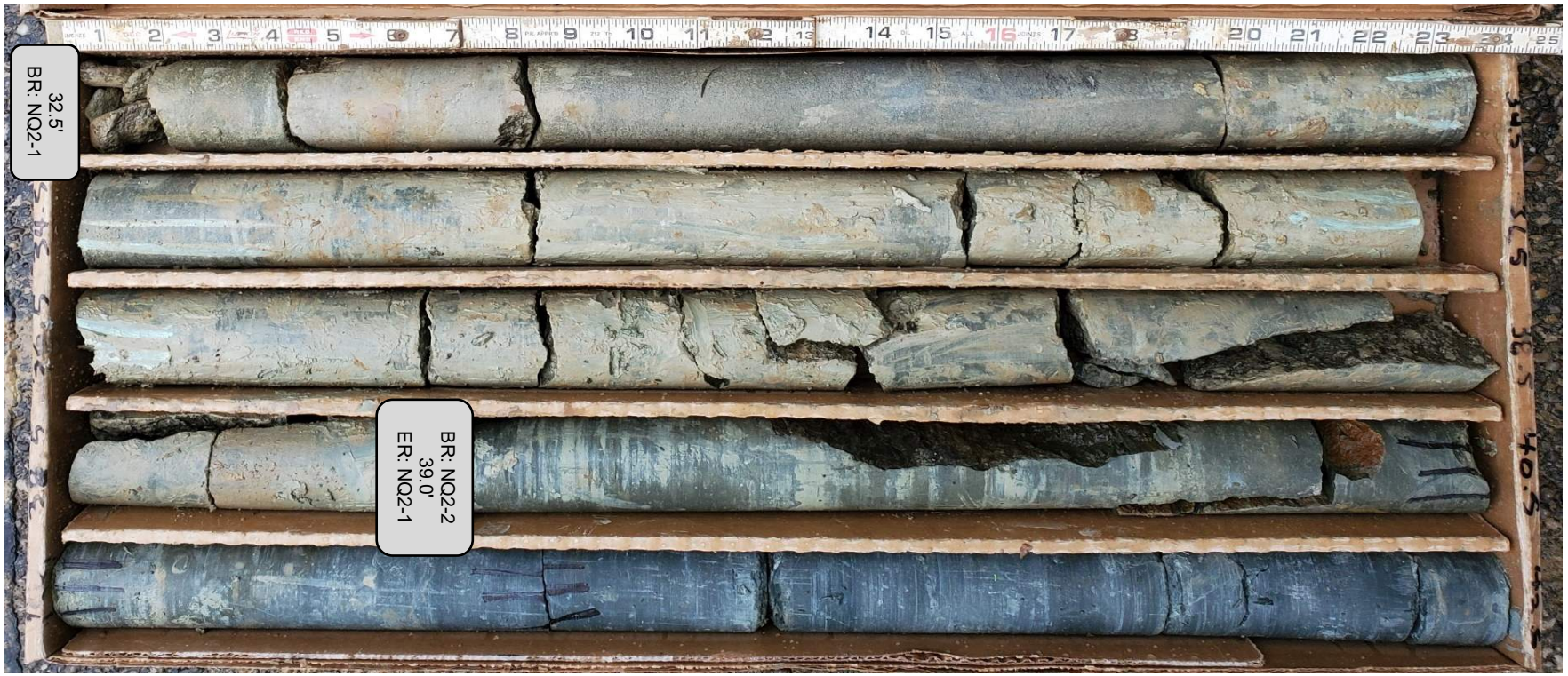
PID: 117974	SFN:	PROJECT: ATH-144-06.04	STATION / OFFSET: 320+89, 8' RT.	START: 1/23/23	END: 1/23/23	PG 2 OF 2	B-003-0-23

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
CLAYSTONE, RED-BROWN TRACE BROWN, HIGHLY WEATHERED, VERY WEAK.	603.2	TR	40 50/4"	-	100	SS-12	-	-	-	-	-	-	-	-	-	-	Rock (V)	
	600.7	31 32																
SANDSTONE, GRAY, MODERATELY WEATHERED, MODERATELY STRONG, VERY FINE TO FINE GRAINED, THIN TO MEDIUM BEDDED, JOINT AND BEDDING DISCONTINUITIES, SLIGHTLY TO MODERATELY FRACTURED, NARROW TO OPEN APERTURE, SLIGHTLY ROUGH, BLOCKY, FAIR SURFACE CONDITIONS; RQD 69%, REC 100%. @ 37.5' - 37.7' : Vertical Fracture with Staining @ 37.9' - 38.9' : Vertical Fracture with Staining @ 39.5' - 40.3' : Vertical Fracture with Staining	592.7	33 34 35 36 37 38 39	62		100	NQ2-1											CORE	
SHALE, DARK GRAY, SLIGHTLY WEATHERED, WEAK, THIN TO MEDIUM BEDDED, JOINT AND BEDDING DISCONTINUITIES, MODERATELY TO SLIGHTLY FRACTURED, TIGHT APERTURE, SLIGHTLY ROUGH TO SLICKENSIDED, BLOCKY, FAIR TO POOR SURFACE CONDITIONS; RQD 60%, REC 100%. @ 41.5' - 41.9' : Qu = 753 psi	590.2	40 41 42 43 44	83		100	NQ2-2											CORE	
CLAYSTONE, RED-BROWN AND GRAY, SLIGHTLY TO MODERATELY WEATHERED, SLIGHTLY STRONG, THIN TO MEDIUM BEDDED, CALCAREOUS, JOINT AND BEDDING DISCONTINUITIES, MODERATELY TO SLIGHTLY FRACTURED, SLIGHTLY ROUGH TO SLICKENSIDED, VERY BLOCKY, FAIR TO POOR SURFACE CONDITIONS; RQD 95%, REC 100%. @ 43.0' - 45.0' : Limestone Laminations and Calcareous Nodules @ 44.9' - 45.8' : Red-Brown @ 47.0' - 49.0' : Limestone Laminations and Calcareous Nodules Below 49.5' : Red-Brown, Friable @ 51.6' - 52.0' : Qu = 1224 psi	580.7	45 46 47 48 49 50 51 52 EOB	93		100	NQ2-3											CORE	

NOTES: BOREHOLE CAPPED WITH QUICK-CRETE CONCRETE PATCH;

ABANDONMENT METHODS, MATERIALS, QUANTITIES: TREMIED 20 LB. BENTONITE POWDER; 94 LB. CEMENT; 50 GAL. WATER

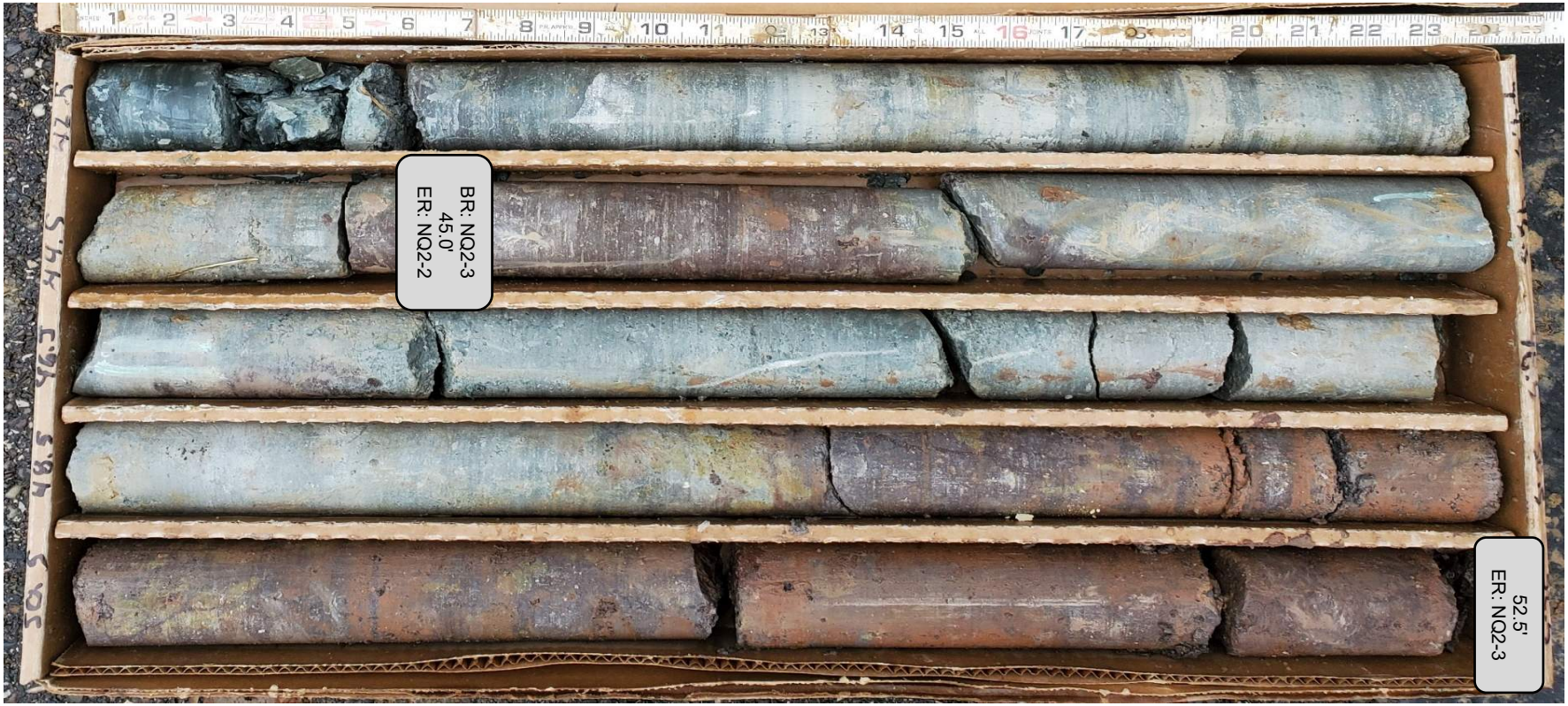
B-003-0-23



Run #	Depth (ft)		Recovery		RQD	
NQ2-1	32.5	39	78 in. / 78 in.	100%	48 in. / 78 in.	62%
NQ2-2	39	45	72 in. / 72 in.	100%	60 in. / 72 in.	83%

ATH-144-6.04 PID 117974

B-003-0-23



Run #	Depth (ft)		Recovery		RQD	
NQ2-2	39	45.0	72 in. / 72 in.	100%	60 in. / 72 in.	83%
NQ2-3	45	52.5	90 in. / 90 in.	100%	84 in. / 90 in.	93%

ATH-144-6.04 PID 117974

DCP Logs

Dynamic Cone Penetration Test Log

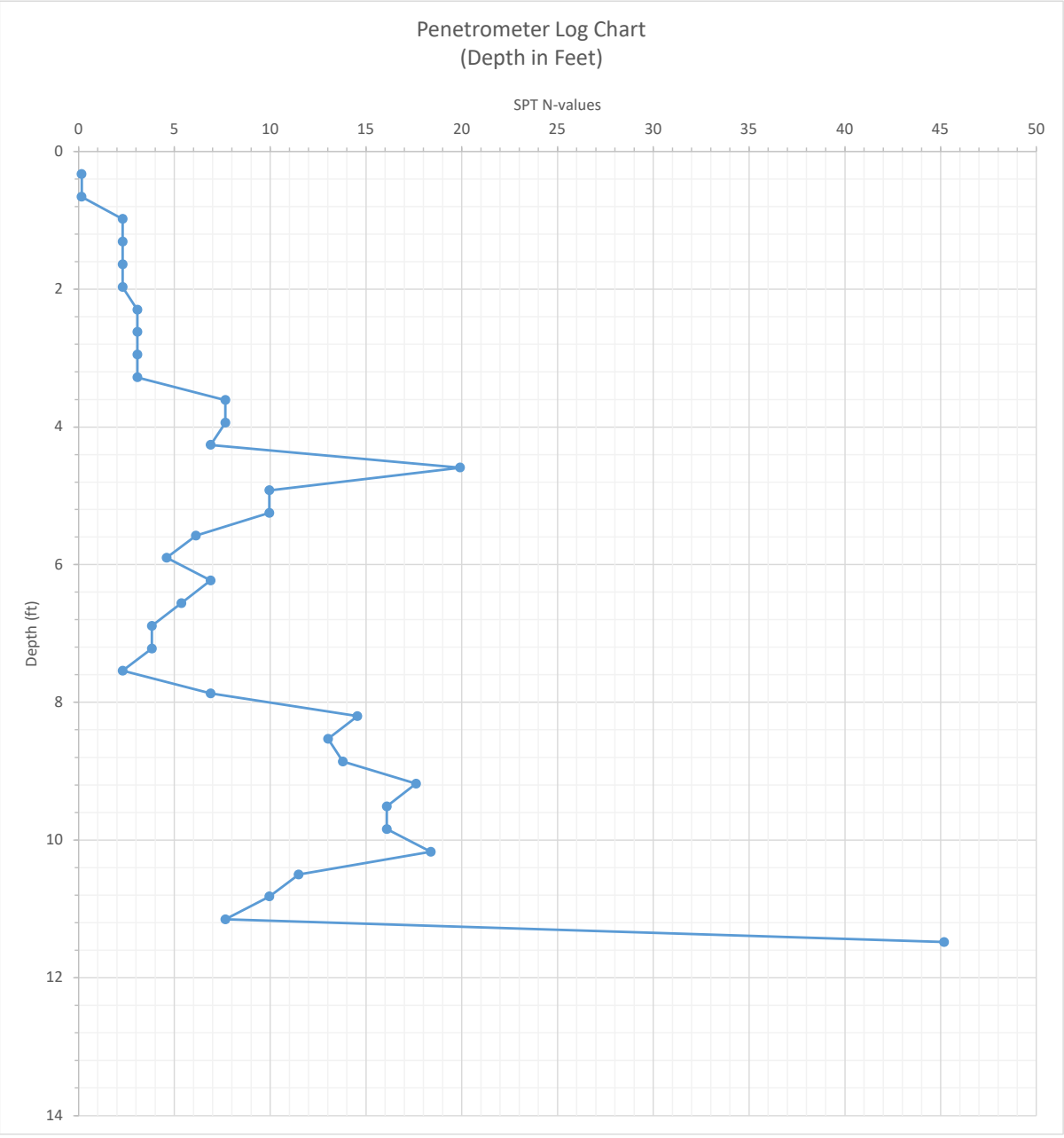
Client:	ODOT - District 10	**Operator Name / Company:**	JK / Advanced Materials, LLC
Project Name:	ATH-144-6.04	**Lat / Long:**	39.244524 -81.808901
Location:	D-001-1-23	**North / East:**	454023.9 2164223.4
Station, Offset:	318+90, 32' RT	**Date:**	2/6/2023
Elevation:	624.5	**Sheet:**	1 of 2
Notes:	Staked Location		

Depth (in)	Depth (ft)	Depth (cm)	Pre Blows	SPT N-Value
3.94	0.33	10	0.2	0.1532
7.87	0.66	20	0.2	0.1532
11.81	0.98	30	3	2.298
15.75	1.31	40	3	2.298
19.69	1.64	50	3	2.298
23.62	1.97	60	3	2.298
27.56	2.3	70	4	3.064
31.5	2.62	80	4	3.064
35.43	2.95	90	4	3.064
39.37	3.28	100	4	3.064
43.31	3.61	110	10	7.66
47.24	3.94	120	10	7.66
51.18	4.26	130	9	6.894
55.12	4.59	140	26	19.916
59.06	4.92	150	13	9.958
62.99	5.25	160	13	9.958
66.93	5.58	170	8	6.128
70.87	5.9	180	6	4.596
74.8	6.23	190	9	6.894
78.74	6.56	200	7	5.362
82.68	6.89	210	5	3.83
86.61	7.22	220	5	3.83
90.55	7.54	230	3	2.298
94.49	7.87	240	9	6.894
98.43	8.2	250	19	14.554
102.36	8.53	260	17	13.022
106.3	8.86	270	18	13.788
110.24	9.18	280	23	17.618
114.17	9.51	290	21	16.086
118.11	9.84	300	21	16.086
122.05	10.17	310	24	18.384
125.98	10.5	320	15	11.49
129.92	10.82	330	13	9.958
133.86	11.15	340	10	7.66
137.8	11.48	350	59	45.194

Depth (in)	Depth (ft)	Depth (cm)	Pre Blows	SPT N-Value

Dynamic Cone Penetration Test Log

Client:	ODOT - District 10	**Operator Name / Company:**	JK / Advanced Materials, LLC
Project Name:	ATH-144-6.04	**Lat / Long:**	39.244524 -81.808901
Location:	D-001-1-23	**North / East:**	454023.9 2164223.4
Station, Offset:	318+90, 32' RT	**Date:**	2/6/2023
Elevation:	624.5	**Sheet:**	2 of 2
Notes:	Staked Location		



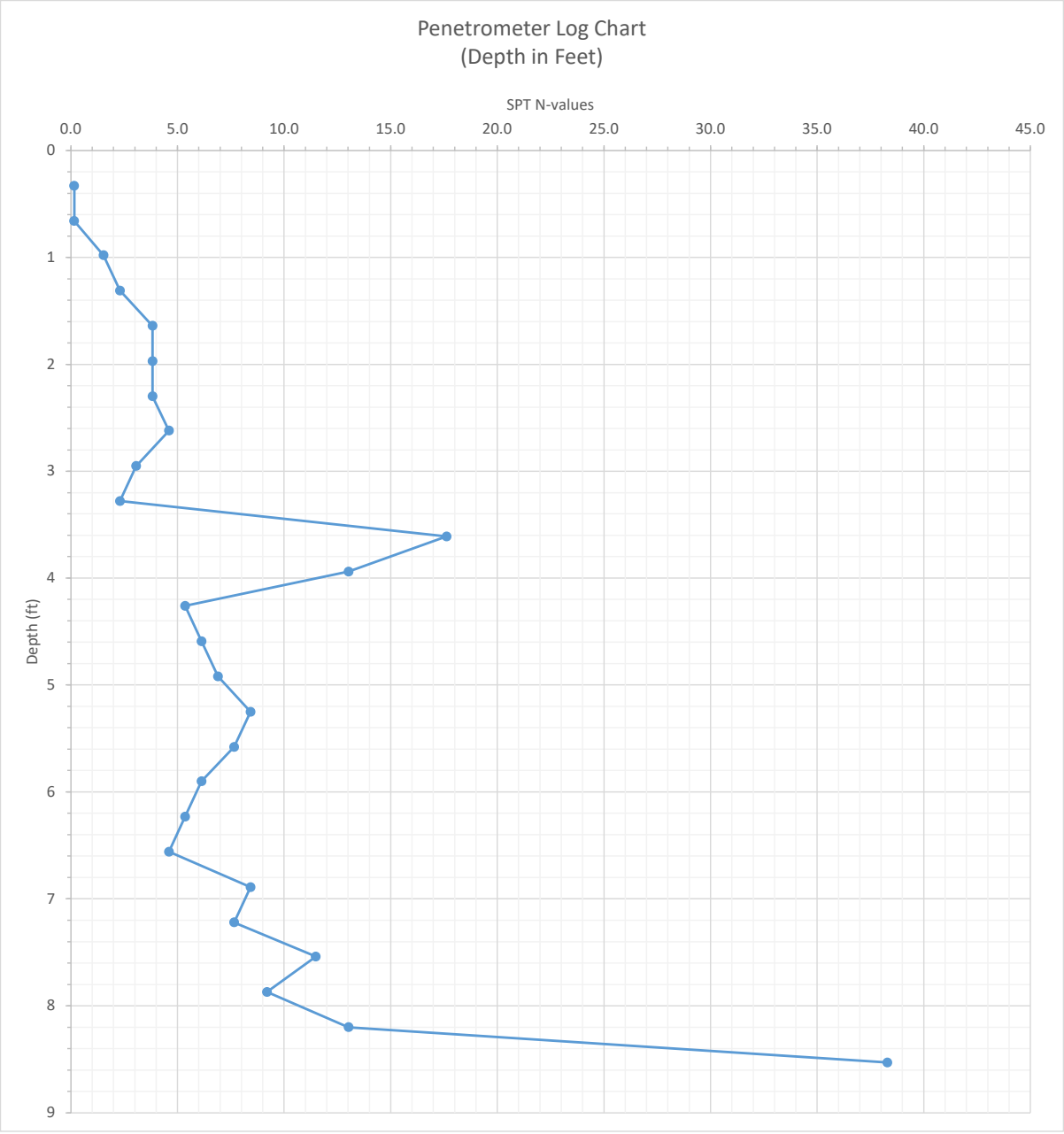
Dynamic Cone Penetration Test Log

Client:	ODOT - District 10	**Operator Name / Company:**	JK / Advanced Materials, LLC
Project Name:	ATH-144-6.04	**Lat / Long:**	39.244529 -81.808904
Location:	D-001-1-23	**North / East:**	454025.6 2164222.4
Station, Offset:	318+93, 32' RT	**Date:**	2/6/2023
Elevation:	624.5	**Sheet:**	1 of 2
Notes:	2nd Test 3 ft. upstation to confirm shallow refusal		

Depth (in)	Depth (ft)	Depth (cm)	Pre Blows	SPT N-Value	Depth (in)	Depth (ft)	Depth (cm)	Pre Blows	SPT N-Value
3.94	0.33	10	0.2	0.2					
7.87	0.66	20	0.2	0.2					
11.81	0.98	30	2	1.5					
15.75	1.31	40	3	2.3					
19.69	1.64	50	5	3.8					
23.62	1.97	60	5	3.8					
27.56	2.3	70	5	3.8					
31.5	2.62	80	6	4.6					
35.43	2.95	90	4	3.1					
39.37	3.28	100	3	2.3					
43.31	3.61	110	23	17.6					
47.24	3.94	120	17	13.0					
51.18	4.26	130	7	5.4					
55.12	4.59	140	8	6.1					
59.06	4.92	150	9	6.9					
62.99	5.25	160	11	8.4					
66.93	5.58	170	10	7.7					
70.87	5.9	180	8	6.1					
74.8	6.23	190	7	5.4					
78.74	6.56	200	6	4.6					
82.68	6.89	210	11	8.4					
86.61	7.22	220	10	7.7					
90.55	7.54	230	15	11.5					
94.49	7.87	240	12	9.2					
98.43	8.2	250	17	13.0					
102.36	8.53	260	50	38.3					

Dynamic Cone Penetration Test Log

Client:	ODOT - District 10	**Operator Name / Company:**	JK / Advanced Materials, LLC
Project Name:	ATH-144-6.04	**Lat / Long:**	39.244529 -81.808904
Location:	D-001-1-23	**North / East:**	454025.6 2164222.4
Station, Offset:	318+93, 32' RT	**Date:**	2/6/2023
Elevation:	624.5	**Sheet:**	2 of 2
Notes:	2nd Test 3 ft. upstation to confirm shallow refusal		



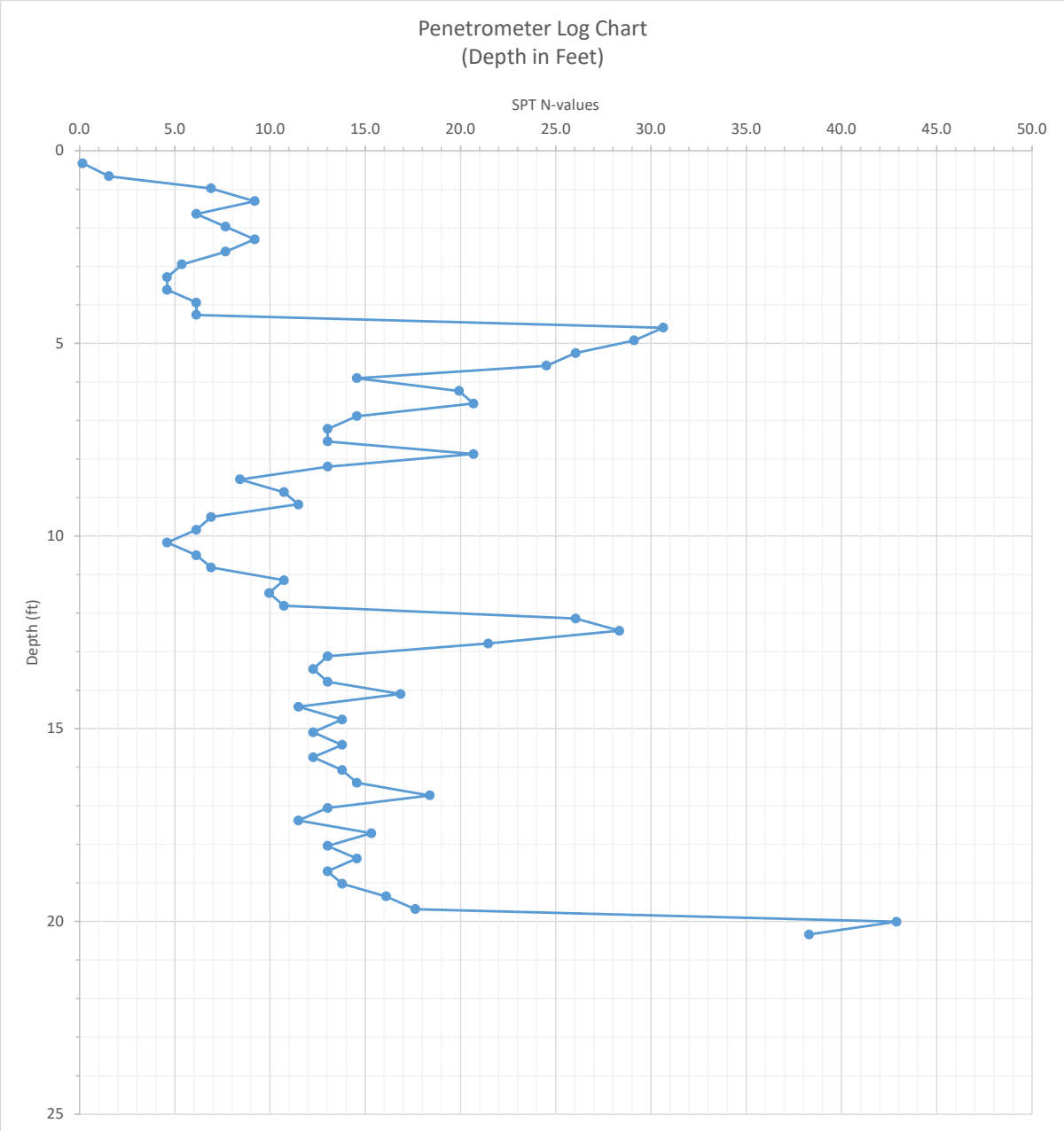
Dynamic Cone Penetration Test Log

Client:	ODOT - District 10	**Operator Name / Company:**	JK / Advanced Materials, LLC
Project Name:	ATH-144-6.04	**Lat / Long:**	39.244771 -81.809081
Location:	D-002-1-23	**North / East:**	454113.2 2164171.8
Station, Offset:	319+93, 28' RT	**Date:**	2/6/2023
Elevation:	622.2	**Sheet:**	1 of 2
Notes:	Staked Location		

Depth (in)	Depth (ft)	Depth (cm)	Pre Blows	SPT N-Value
3.94	0.33	10	0.2	0.2
7.87	0.66	20	2	1.5
11.81	0.98	30	9	6.9
15.75	1.31	40	12	9.2
19.69	1.64	50	8	6.1
23.62	1.97	60	10	7.7
27.56	2.3	70	12	9.2
31.5	2.62	80	10	7.7
35.43	2.95	90	7	5.4
39.37	3.28	100	6	4.6
43.31	3.61	110	6	4.6
47.24	3.94	120	8	6.1
51.18	4.26	130	8	6.1
55.12	4.59	140	40	30.6
59.06	4.92	150	38	29.1
62.99	5.25	160	34	26.0
66.93	5.58	170	32	24.5
70.87	5.9	180	19	14.6
74.8	6.23	190	26	19.9
78.74	6.56	200	27	20.7
82.68	6.89	210	19	14.6
86.61	7.22	220	17	13.0
90.55	7.54	230	17	13.0
94.49	7.87	240	27	20.7
98.43	8.2	250	17	13.0
102.36	8.53	260	11	8.4
106.3	8.86	270	14	10.7
110.24	9.18	280	15	11.5
114.17	9.51	290	9	6.9
118.11	9.84	300	8	6.1
122.05	10.17	310	6	4.6
125.98	10.5	320	8	6.1
129.92	10.82	330	9	6.9
133.86	11.15	340	14	10.7
137.8	11.48	350	13	10.0
141.73	11.81	360	14	10.7
145.67	12.14	370	34	26.0
149.61	12.46	380	37	28.3
153.54	12.79	390	28	21.4
157.48	13.12	400	17	13.0
161.42	13.45	410	16	12.3
165.35	13.78	420	17	13.0
169.29	14.1	430	22	16.9
173.23	14.43	440	15	11.5
177.17	14.76	450	18	13.8
181.1	15.09	460	16	12.3
185.04	15.42	470	18	13.8
188.98	15.74	480	16	12.3
192.91	16.07	490	18	13.8
196.85	16.4	500	19	14.6
200.79	16.73	510	24	18.4
204.72	17.06	520	17	13.0
208.66	17.38	530	15	11.5
212.6	17.71	540	20	15.3
216.54	18.04	550	17	13.0
220.47	18.37	560	19	14.6
224.41	18.7	570	17	13.0
228.35	19.02	580	18	13.8
232.28	19.35	590	21	16.1
236.22	19.68	600	23	17.6
240.16	20.01	610	56	42.9
244.09	20.34	620	50	38.3

Dynamic Cone Penetration Test Log

Client:	ODOT - District 10	**Operator Name / Company:**	JK / Advanced Materials, LLC
Project Name:	ATH-144-6.04	**Lat / Long:**	39.244771 -81.809081
Location:	D-002-1-23	**North / East:**	454113.2 2164171.8
Station, Offset:	319+93, 28' RT	**Date:**	2/6/2023
Elevation:	622.2	**Sheet:**	2 of 2
Notes:	Staked Location		



Bedrock Geology and Topography Maps

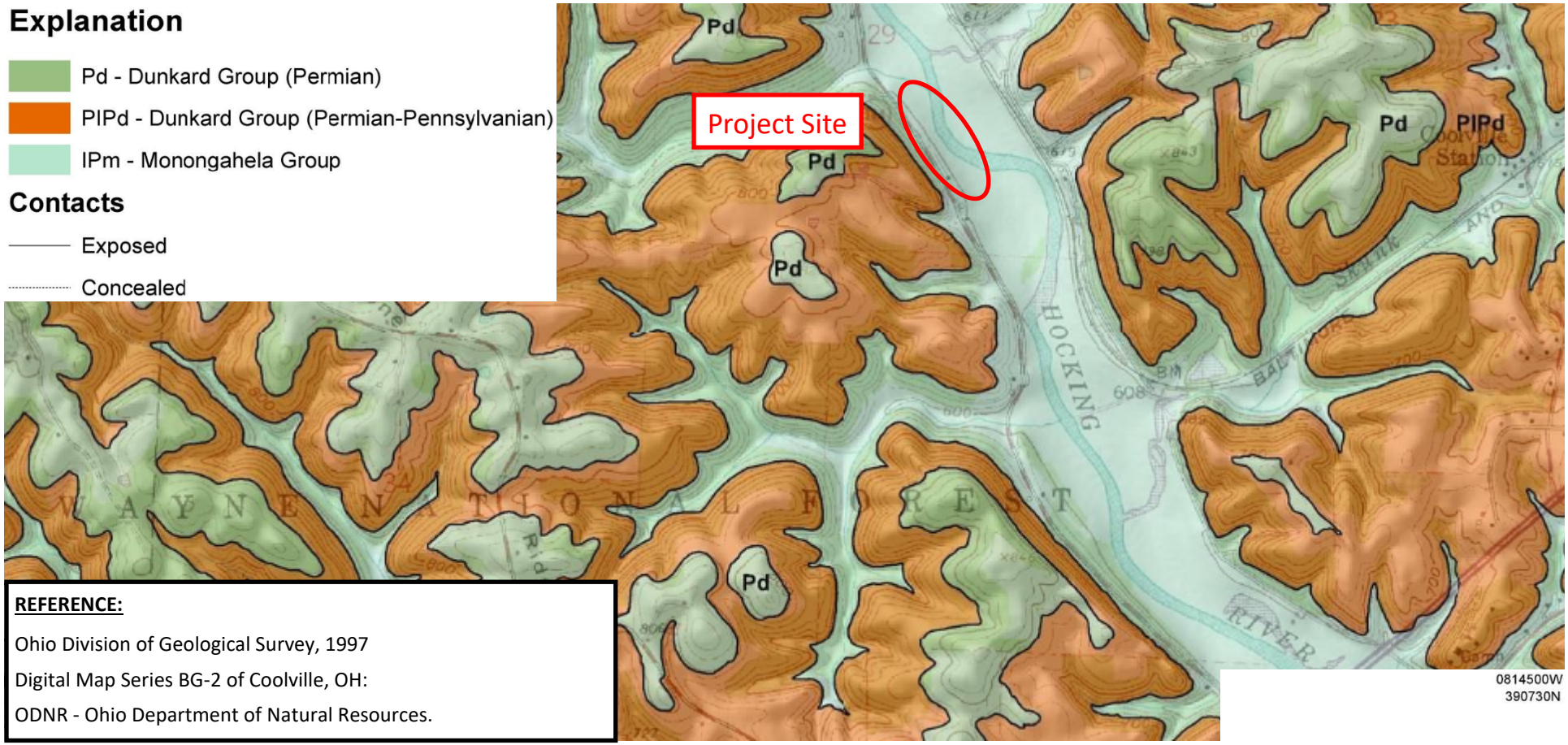
Bedrock Geology Map

Explanation

- Pd - Dunkard Group (Permian)
- PIPd - Dunkard Group (Permian-Pennsylvanian)
- IPm - Monongahela Group

Contacts

- Exposed
- Concealed



REFERENCE:

Ohio Division of Geological Survey, 1997

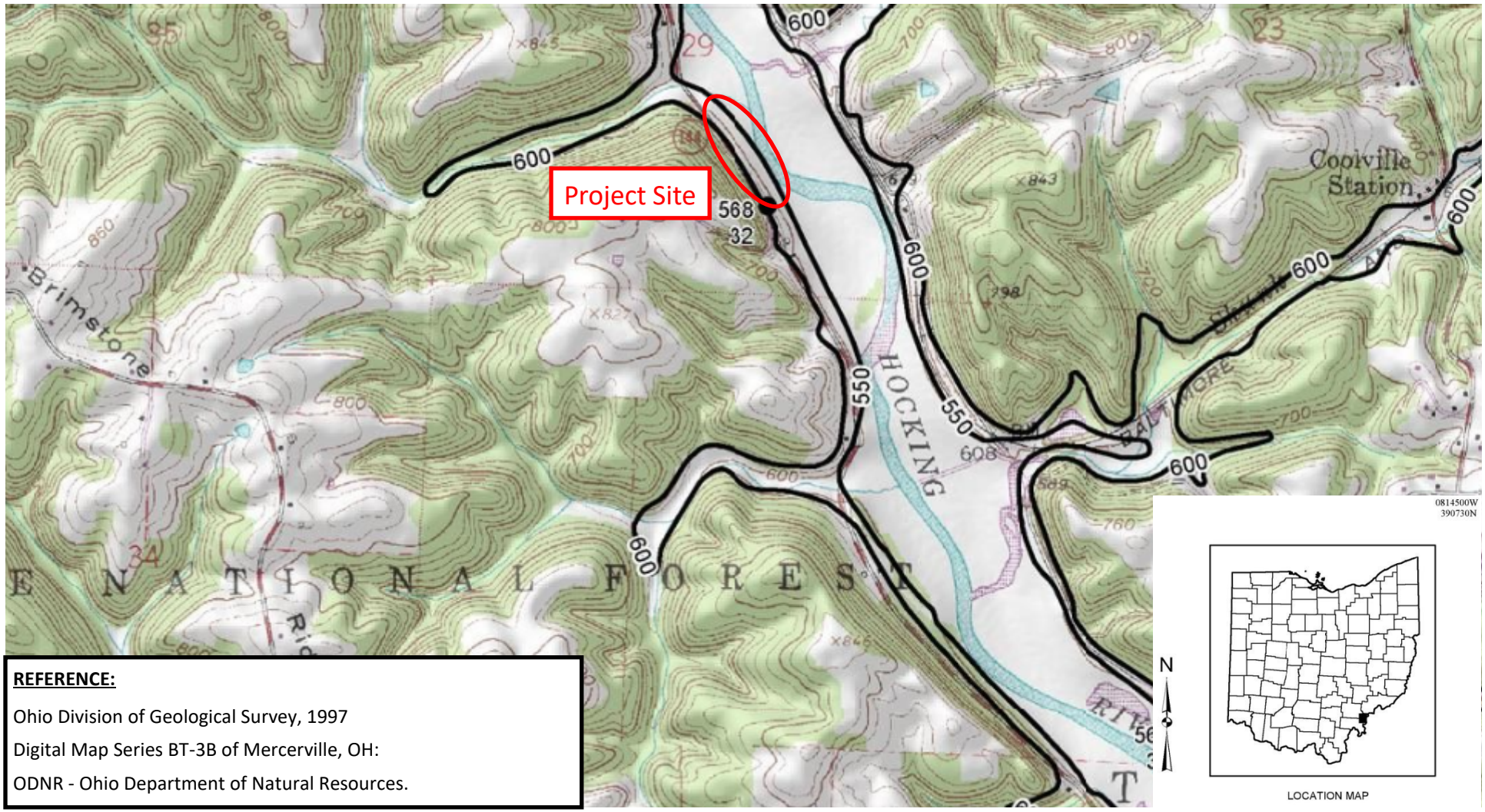
Digital Map Series BG-2 of Coolville, OH:

ODNR - Ohio Department of Natural Resources.

1,000 0 1,000 2,000 3,000 4,000 5,000 6,000 7,000 Feet

LOCATION MAP

Bedrock Topography Map



REFERENCE:

Ohio Division of Geological Survey, 1997

Digital Map Series BT-3B of Mercerville, OH:

ODNR - Ohio Department of Natural Resources.

1,000 0 1,000 2,000 3,000 4,000 5,000 6,000 7,000

Feet

Mine Map

ATH-144-6.04 Mine Map

March 1, 2023

1:18,056

0 0.1 0.2 0.4 mi

0 0.17 0.35 0.7 km

- Quadrangle 24K (7.5 min)
- Abandoned before 1977
- Past
- Current
- Proposed
- Original Application
- Adjacent Area Application
- Historic - From Geology Maps
- Past
- Current
- Proposed
- Original Application

VITA, West Virginia GIS, Esri, HERE, Garmin, INCREMENT P, USGS, METI/ NASA, EPA, USDA

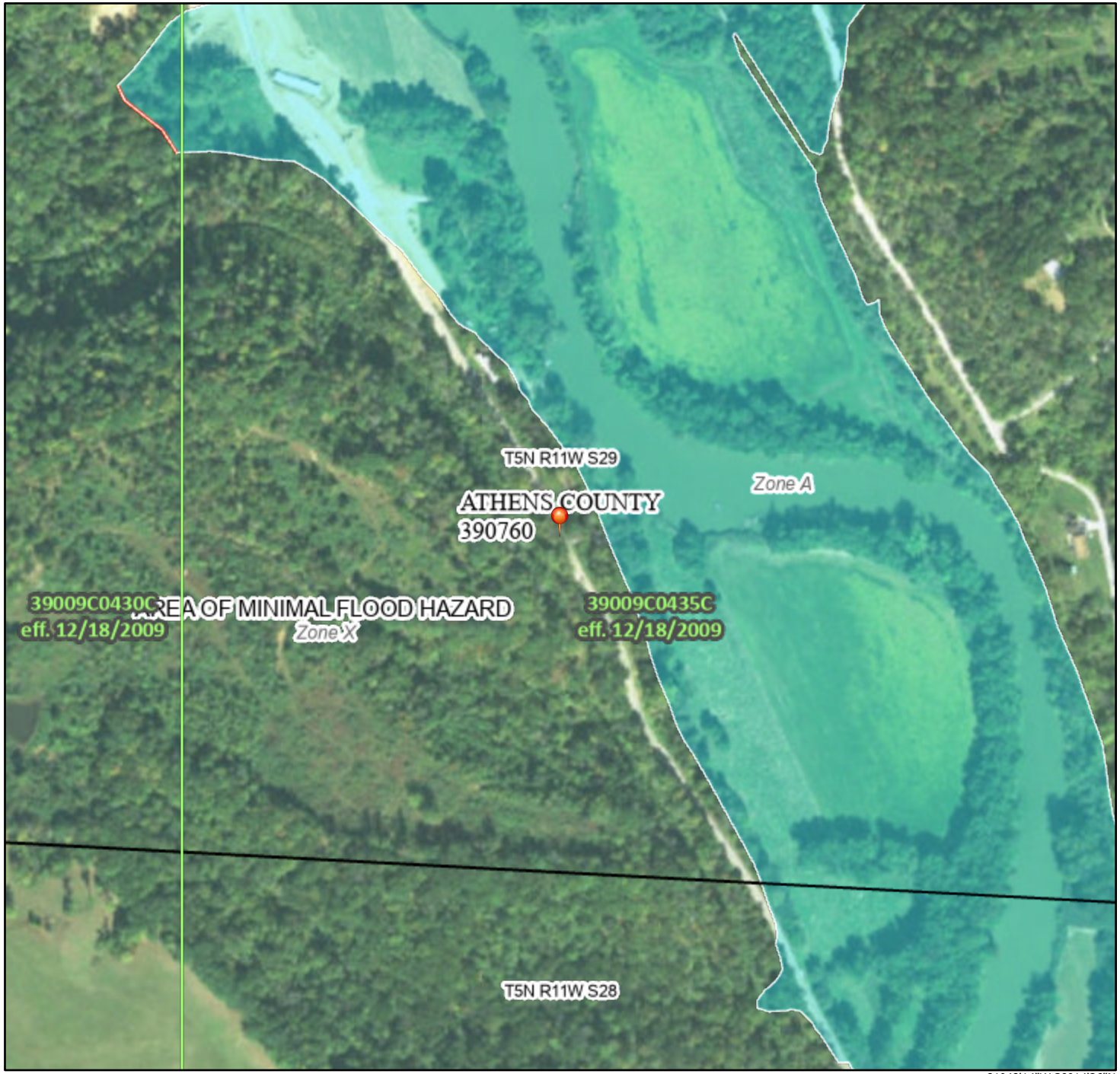
Ohio Dept. of Natural Resources

FEMA Flood Map

National Flood Hazard Layer FIRMette

FEMA

81°48'51"W 39°14'54"N



81°48'14"W 39°14'26"N

0 250 500 1,000 1,500 2,000 Feet

1:6,000

Basemap: USGS National Map: Orthoimagery: Data refreshed October, 2020

Legend

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

SPECIAL FLOOD HAZARD AREAS
- Without Base Flood Elevation (BFE) *Zone A, V, A99*
- With BFE or Depth *Zone AE, AO, AH, VE, AR*
- Regulatory Floodway

OTHER AREAS OF FLOOD HAZARD
- 0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile *Zone X*
- Future Conditions 1% Annual Chance Flood Hazard *Zone X*
- Area with Reduced Flood Risk due to Levee. See Notes. *Zone X*
- Area with Flood Risk due to Levee *Zone D*

OTHER AREAS
- NO SCREEN Area of Minimal Flood Hazard *Zone X*
- Effective LOMRs
- Area of Undetermined Flood Hazard *Zone D*

GENERAL STRUCTURES
- Channel, Culvert, or Storm Sewer
- Levee, Dike, or Floodwall

OTHER FEATURES
- 20.2 / 17.5 Cross Sections with 1% Annual Chance / Water Surface Elevation
- Coastal Transect
- Base Flood Elevation Line (BFE)
- Limit of Study
- Jurisdiction Boundary
- Coastal Transect Baseline
- Profile Baseline
- Hydrographic Feature

MAP PANELS
- Digital Data Available
- No Digital Data Available
- Unmapped

N

The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location.

This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on 2/28/2023 at 2:30 PM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date. Map images for unmapped and unmodernized areas cannot be used for regulatory purposes.

Soil Strength Parameter Determination

9999 Carver Road, Suite 210, Cincinnati, OH 45242-5583 **hdrinc.com**
(513) 984-7500

ODOT District 10
ATH-144-6.08

Soil Strength Parameter Determination

Computed By = AKB
Checked By = DCM

Layer		Undrained Shear Strength (Su) (psf)				Dry Unit Weight (pcf)		Moist Unit Wt. (pcf)		Adopted Short Term Parameters		Long-Term Strength Values					Adopted Long Term Strength Parameters (Back-Calculated from SlopeW)	
		PPR	N-values		Tested	Correlation	Tested	Correlation	Tested				N_{60} Value	ODOT GB-7 Correlations		Tested		
			Sowers	T and P	Values									Cohesion (psf)	phi (deg)	Cohesion (psf)	phi (deg)	
Layer 1 STIFF TO VERY STIFF COHESIVE	Max	4000	4000	4000	1169	120	124	130	142			Max	31	200	26			
	Min	1000	975	1463	1169	100	124	120	142	S_u=	1200 psf	Min	11	121	23		c' =	140 psf
	Average	2556	2906	2661	1169	111	124	126	142	Φ =	0 deg	Average	20	164	25		Φ' =	24 deg
	Std Dev	873	1080	830		6		4				Std Dev	6	24	1			
										Y_{dry} =	125 pcf						Y_{dry} =	125 pcf
	Avg + Std	3428	3986	3491		117		130		Y_{moist} =	140 pcf	Avg + Std	27	188	26		Y_{moist} =	140 pcf
	Avg - Std	1683	1826	1831		104		122				Avg - Std	14	140	24			
Layer 2 MEDIUM DENSE TO DENSE GRANULAR	Max	N/A	N/A	N/A		125		140				Max	61	N/A	40			
	Min	N/A	N/A	N/A		110		130		S_u =	0 psf	Min	13	N/A	31		c' =	0 psf
	Average	N/A	N/A	N/A		114		133		Φ =	34 deg	Average	28	N/A	34		Φ' =	34 deg
	Std Dev	N/A	N/A	N/A		6		5				Std Dev	16	N/A	4			
										Y_{dry} =	115 pcf						Y_{dry} =	115 pcf
	Avg + Std	N/A	N/A	N/A		120		138		Y_{moist} =	135 pcf	Avg + Std	43	N/A	38		Y_{moist} =	135 pcf
	Avg - Std	N/A	N/A	N/A		107		128				Avg - Std	12	N/A	31			
Layer 3 HARD COHESIVE	Max	4500	4000	4000		130		140				Max	99	250	28			
	Min	4500	4000	4000		130		140		S_u =	4000 psf	Min	81	250	28		c' =	250 psf
	Average	4500	4000	4000		130		140		Φ =	0 deg	Average	90	250	28		Φ' =	28 deg
	Std Dev	0	0	0		0		0				Std Dev	13	0	0			
										Y_{dry} =	130 pcf						Y_{dry} =	130 pcf
	Avg + Std	4500	4000	4000		130		140		Y_{moist} =	140 pcf	Avg + Std	103	250	28		Y_{moist} =	140 pcf
	Avg - Std	4500	4000	4000		130		140				Avg - Std	77	250	28			

Values for Soil Strength Correlation	
Reference	Value
HI PI (Sowers)	0.25
MD PI (Sowers)	0.175
LO PI (Sowers)	0.075
T&P	0.133

Layer 1

	N_{60}	% Rec	HP	% Gr	% CS	% FS	% Silt	% Clay	LL	PL	PI	% WC	Short-Term Cohesion (psf) N-values PPR	Sowers	T & P	Correlated LT Cohesion (psf) per GB-7	phi (deg)	Midpoint Sample Depth (ft.)	Midpoint Sample Elevation (ft.)	Correlated Dry Unit Wt. (pcf) per GB-7	Correlated Moist Unit Wt. (pcf) per GB-7	Correlated C_c	Assumed Specific Gravity (G_s)	Computed Void Ratio (e)	Strength Testing Dry Unit Wt (pcf)	Moist Unit Wt (pcf)	Qu/UU Su (psf)
Max	31	100	4.0	20	22	47	29	30	43	21	23	20	4000	4000	4000	200	26	19.0	630.2	120	130	0.297	2.72	0.697	124	142	1169
Min	11	44	1.0	3	7	14	22	14	27	16	10	8	1000	975	1463	121	23	2.0	612.2	100	120	0.153	2.65	0.404	124	142	1169
Average	20	72	2.6	12	14	28	25	22	33	18	15	15	2556	2906	2661	164	25	9.3	622.3	111	126	0.209	2.70	0.527	124	142	1169
Std Dev	6	14	0.9	7	5	11	3	6	6	2	5	3	873	1080	830	24	1	5.0	5.3	6	4	0.058	0.03	0.082	N/A	N/A	N/A
Avg + Std	27	86	3.4	19	19	40	27	28	40	20	20	18	3428	3986	3491	188	26	14.3	627.7	117	130	0.267	2.73	0.609	N/A	N/A	N/A
Avg - Std	14	57	1.7	5	8	17	22	15	27	16	10	11	1683	1826	1831	140	24	4.3	617.0	104	122	0.150	2.67	0.445	N/A	N/A	N/A

Alignment	Surface Elevation	Exploration ID	From		To	Sample ID	N_{60}	% Rec	HP	% Gr	% CS	% FS	% Silt	% Clay	LL	PL	PI	% WC	ODOT Class.	Soil Type	Layer	Short-Term Cohesion (psf) N-values PPR	Sowers	T & P	Correlated LT Cohesion (psf) per GB-7	phi (deg)	Midpoint Sample Depth (ft.)	Midpoint Sample Elevation (ft.)	Correlated Dry Unit Wt. (pcf) per GB-7	Correlated Moist Unit Wt. (pcf) per GB-7	Correlated C_c	Assumed Specific Gravity (G_s)	Computed Void Ratio (e)	Strength Testing Dry Unit Wt (pcf)	Moist Unit Wt (pcf)	Qu/UU Su (psf)
SR 144	631.5	B-001-0-23	1.5	-	3	SS-1	31	67	2	-	-	-	-	-	-	-	-	8	A-6b	Cohesive	1	2000	4000	4000	200	26	2.0	629.5	115	125		2.70	0.465			
SR 144	631.5	B-001-0-23	5	-	6.5	SS-2	31	78	4	17	7	22	24	30	37	18	19	13	A-6b	Cohesive	1	4000	4000	4000	200	26	6.0	625.5	120	130	0.243	2.70	0.404			
SR 144	631.5	B-001-0-23	7.5	-	9	SS-3	25	78	3	-	-	-	-	-	-	-	-	11	A-6b	Cohesive	1	3000	4000	3325	183	25	8.0	623.5	110	125		2.70	0.532			
SR 144	631.5	B-001-0-23	10	-	11.5	SS-4	16	67	2	-	-	-	-	-	-	-	-	18	A-6b	Cohesive	1	2000	2800	2128	153	24	11.0	620.5	115	130		2.70	0.465			
SR 144	631.5	B-001-0-23	12.5	-	14	SS-5	23	78	1.5	16	17	24	29	14	28	17	11	14	A-6a	Cohesive	1	1500	4000	3059	177	25	13.0	618.5	115	130	0.162	2.72	0.476			
SR 144	631.2	B-002-0-23	2.5	-	4	SS-1	13	78	3.5	-	-	-	-	-	-	-	-	19	A-7-6	Cohesive	1	3500	3250	1729	136	23	3.0	628.2	100	120		2.65	0.654			
SR 144	631.2	B-002-0-23	4	-	5.5	SS-2	11	67	3	7	13	28	24	28	43	20	23	20	A-7-6	Cohesive	1	3000	2750	1463	121	23	5.0	626.2	100	120	0.297	2.65	0.654			
SR 144	631.2	B-002-0-23	5.5	-	7	SS-3	16	78	2	-	-	-	-	-	-	-	-	15	A-7-6	Cohesive	1	2000	4000	2128	153	24	6.0	625.2	110	125		2.65	0.503			
SR 144	631.2	B-002-0-23	7	-	8.5	SS-4	20	83	2.5	-	-	-	-	-	-	-	-	17	A-7-6	Cohesive	1	2500	4000	2660	167	25	8.0	623.2	110	125		2.65	0.503			
SR 144	631.2	B-002-0-23	10	-	11.5	SS-6	21	67	1.5	-	-	-	-	-	-	-	-	13	A-4a	Cohesive	1	1500	1575	2793	170	25	11.0	620.2	115	130		2.72	0.476			
SR 144	631.2	B-002-0-23	11.5	-	12.5	SS-7A	28	89	2	-	-	-	-	-	-	-	-	20	A-4a	Cohesive	1	2000	2100	3724	193	26	12.0	619.2	115	130		2.72	0.476			
SR 144	631.2	B-002-0-23	13	-	14.5	SS-8	23	89	1	8	13	35	27	17	27	17	10	13	A-4a	Cohesive	1	1000	1725	3059	177	25	14.0	617.2	115	130	0.153	2.72	0.476			
SR 144	631.2	B-002-0-23	14.5	-	16	SS-9	20	50	2	-	-	-	-	-	-	-	-	13	A-4a	Cohesive	1	2000	1500	2660	167	25	15.0	616.2	115	130		2.72	0.476			
SR 144	631.2	B-002-0-23	16	-	17.5	SS-10	13	56	3.5	-	-	-	-	-	-	-	-	13	A-4a	Cohesive	1	3500	975	1729	136	23	17.0	614.2	110	125		2.72	0.543			
SR 144	631.2	B-002-0-23	17.5	-	19.5	ST-11	ST	100	4	20	22	14	22	22	36	21	15	14	A-6a	Cohesive	1	4000	N/A	N/A			19.0	612.2			0.234	2.72		124.4	141.8	1168.5
SR 144	633.2	B-003-0-23	2	-	3.5	SS-1	14	67	3	3	10	47	22	18	28	16	12	14	A-6a	Cohesive	1	3000	2450	1862	143	24	3.0	630.2	100	120	0.162	2.72	0.697			
SR 144	633.2	B-003-0-23	5	-	6.5	SS-2	13	44	2.5	-	-	-	-	-	-	-	-	12	A-6a	Cohesive	1	2500	2275	1729	136	23	6.0	627.2	105	125		2.72	0.616			
SR 144	633.2	B-003-0-23	7.5	-	9	SS-3	24	56	3	-	-	-	-	-	-	-	-	15	A-6a	Cohesive	1	3000	4000	3192	180	25	8.0	625.2	110	125		2.72	0.543			

Omitted B-002-0-23, SS-5 as outlier.

ODOT District 10
ATH-144-6.08

Soil Strength Parameter Determination

Computed By = AKB
Checked By = DCM

Values for Soil Strength Correlation	
Reference	Value
HI PI (Sowers)	0.25
MD PI (Sowers)	0.175
LO PI (Sowers)	0.075
T&P	0.133

Layer 2

	N_{60}	% Rec	HP	% Gr	% CS	% FS	% Silt	% Clay	LL	PL	PI	% WC		Short-Term Cohesion (psf) PPR	N-values Sowers	N-values T & P	Correlated LT Cohesion (psf) per GB-7	phi (deg)	Midpoint Sample Depth (ft.)	Midpoint Sample Elevation (ft.)	Correlated Dry Unit Wt. (pcf) per GB-7	Correlated Moist Unit Wt. (pcf) per GB-7	Correlated C_c	Assumed Specific Gravity (G_s)	Computed Void Ratio (e)
Max	61	100	N/A	51	47	44	21	16	33	18	15	20	Max	N/A	N/A	N/A	N/A	40	23.0	622.2	125	140	0.207	2.71	0.537
Min	13	44	N/A	0	11	8	13	5	25	17	7	7	Min	N/A	N/A	N/A	N/A	31	11.0	610.2	110	130	0.135	2.65	0.323
Average	28	67	N/A	23	22	29	16	11	28	18	10	14	Average	N/A	N/A	N/A	N/A	34	17.3	615.3	114	133	0.159	2.70	0.488
Std Dev	16	17	N/A	24	17	15	4	5	5	1	4	4	Std Dev	N/A	N/A	N/A	N/A	4	3.8	4.0	6	5	0.042	0.02	0.087
Avg + Std	43	84	N/A	47	39	44	19	16	32	18	14	18	Avg + Std	N/A	N/A	N/A	N/A	38	21.1	619.3	120	138	0.201	2.72	0.576
Avg - Std	12	50	N/A	-1	5	13	12	6	23	17	6	9	Avg - Std	N/A	N/A	N/A	N/A	31	13.5	611.3	107	128	0.117	2.68	0.401

Alignment	Surface Elevation	Exploration ID	From		To	Sample ID	N_{60}	% Rec	HP	% Gr	% CS	% FS	% Silt	% Clay	LL	PL	PI	% WC	ODOT Class.	Soil Type	Layer	Short-Term Cohesion (psf) PPR	N-values Sowers	N-values T & P	Correlated LT Cohesion (psf) per GB-7	phi (deg)	Midpoint Sample Depth (ft.)	Midpoint Sample Elevation (ft.)	Correlated Dry Unit Wt. (pcf) per GB-7	Correlated Moist Unit Wt. (pcf) per GB-7	Correlated C_c	Assumed Specific Gravity (G_s)	Computed Void Ratio (e)
SR 144	631.5	B-001-0-23	15	-	16.5	SS-6	13	78	-	-	-	-	-	-	-	-	-	19	A-2-6	Granular	2	N/A				31	16.0	615.5	110	130		2.71	0.537
SR 144	631.5	B-001-0-23	17.5	-	19	SS-7	27	44	-	51	11	8	14	16	33	18	15	11	A-2-6	Granular	2	N/A				33	18.0	613.5	110	130	0.207	2.71	0.537
SR 144	631.5	B-001-0-23	20	-	20.42	SS-8	Refusal	100	-	-	-	-	-	-	-	-	-	20	A-2-6	Granular	2	N/A				40	20.0	611.5				2.71	
SR 144	633.2	B-003-0-23	10	-	11.5	SS-4	61	78	-	0	47	35	13	5	NP	NP	NP	7	A-3a	Granular	2	N/A				40	11.0	622.2	125	140	N/A	2.65	0.323
SR 144	633.2	B-003-0-23	12.5	-	14	SS-5	23	67	-	-	-	-	-	-	-	-	-	12	A-2-4	Granular	2	N/A				33	13.0	620.2	110	130		2.71	0.537
SR 144	633.2	B-003-0-23	15	-	16.5	SS-6	21	67	-	7	14	44	21	14	25	18	7	11	A-2-4	Granular	2	N/A				32	16.0	617.2	110	130	0.135	2.71	0.537
SR 144	633.2	B-003-0-23	17.5	-	19	SS-7	17	56	-	-	-	-	-	-	-	-	-	16	A-2-4	Granular	2	N/A				31	18.0	615.2	110	130		2.71	0.537
SR 144	633.2	B-003-0-23	20	-	22	ST-8	ST	54	-	34	15	27	15	9	25	17	8	11	A-2-4	Granular	2	N/A					21.0	612.2			0.135	2.71	
SR 144	633.2	B-003-0-23	22	-	23.5	SS-9	31	56	-	-	-	-	-	-	-	-	-	17	A-2-4	Granular	2	N/A				34	23.0	610.2	120	140		2.71	0.409

Values for Soil Strength Correlation	
Reference	Value
HI PI (Sowers)	0.25
MD PI (Sowers)	0.175
LO PI (Sowers)	0.075
T&P	0.133

Layer 3

	N_{60}	% Rec	HP	% Gr	% CS	% FS	% Silt	% Clay	LL	PL	PI	% WC		Short-Term Cohesion (psf) N-values PPR	Sowers	T & P	Correlated LT Cohesion (psf) per GB-7	phi (deg)	Midpoint Sample Depth (ft.)	Midpoint Sample Elevation (ft.)	Correlated Dry Unit Wt. (pcf) per GB-7	Correlated Moist Unit Wt. (pcf) per GB-7	Correlated C_c	Assumed Specific Gravity (G_s)	Computed Void Ratio (e)
Max	99	100	4.5	1	2	10	49	38	35	20	15	15	Max	4500	4000	4000	250	28	28.0	607.2	130	140	0.225	2.72	0.306
Min	81	78	4.5	1	2	10	49	38	35	20	15	10	Min	4500	4000	4000	250	28	26.0	604.2	130	140	0.225	2.72	0.306
Average	90	88	4.5	1	2	10	49	38	35	20	15	13	Average	4500	4000	4000	250	28	26.8	605.5	130	140	0.225	2.72	0.306
Std Dev	13	11	0.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2	Std Dev	0	0	0	0	0	1.0	1.3	0	0	N/A	0.00	0.000
Avg + Std	103	99	4.5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	15	Avg + Std	4500	4000	4000	250	28	27.7	606.7	130	140	N/A	2.72	0.306
Avg - Std	77	76	4.5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	11	Avg - Std	4500	4000	4000	250	28	25.8	604.2	130	140	N/A	2.72	0.306

Alignment	Surface Elevation	Exploration ID	From		To	Sample ID	N_{60}	% Rec	HP	% Gr	% CS	% FS	% Silt	% Clay	LL	PL	PI	% WC	ODOT Class.	Soil Type	Layer	Short-Term Cohesion (psf) N-values PPR	Sowers	T & P	Correlated LT Cohesion (psf) per GB-7	phi (deg)	Midpoint Sample Depth (ft.)	Midpoint Sample Elevation (ft.)	Correlated Dry Unit Wt. (pcf) per GB-7	Correlated Moist Unit Wt. (pcf) per GB-7	Correlated C_c	Assumed Specific Gravity (G_s)	Computed Void Ratio (e)
SR 144	631.2	B-002-0-23	25	-	26.5	SS-14	81	78	4.5	-	-	-	-	-	-	-	-	15	A-6a	Cohesive	3	4500	4000	4000	250	28	26.0	605.2	130	140		2.72	0.306
SR 144	631.2	B-002-0-23	26.5	-	28	SS-15	99	78	4.5	-	-	-	-	-	-	-	-	14	A-6a	Cohesive	3	4500	4000	4000	250	28	27.0	604.2	130	140		2.72	0.306
SR 144	633.2	B-003-0-23	25	-	26.42	SS-10	Refusal	94	4.5	1	2	10	49	38	35	20	15	14	A-6a	Cohesive	3	4500	N/A	N/A	250	28	26.0	607.2			0.225	2.72	
SR 144	633.2	B-003-0-23	27.5	-	27.92	SS-11	Refusal	100	4.5	-	-	-	-	-	-	-	-	10	A-6a	Cohesive	3	4500	N/A	N/A	250	28	28.0	605.2				2.72	

PROJECT: ATH-144-06.04	DRILLING FIRM / OPERATOR: CENTRAL STAR / TS	DRILL RIG: DIEDRICH D-50 (SN311)	STATION / OFFSET: 318+78, 5' RT.	EXPLORATION ID B-001-0-23
TYPE: LANDSLIDE	SAMPLING FIRM / LOGGER: HDR / DM	HAMMER: AUTOMATIC HAMMER	ALIGNMENT: SR 144	
PID: 117974 SFN:	DRILLING METHOD: 2.25 HSA / NQ2	CALIBRATION DATE: 3/7/22	ELEVATION: 631.5 (MSL) EOB: 40.8 ft.	PAGE 1 OF 2
START: 1/24/23 END: 1/24/23	SAMPLING METHOD: SPT / NQ2	ENERGY RATIO (%): 84.9	LAT / LONG: 39.244460, -81.808967	

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
18 inches of Asphalt	631.5																	
	630.0																	
VERY STIFF TO HARD, RED-BROWN AND LIGHT BROWN, **SILTY CLAY**, SOME SAND, LITTLE GRAVEL, DAMP		1	12 12 10	31	67	SS-1	2.00	-	-	-	-	-	-	-	-	8	A-6b (V)	
		2																
		3																
		4																
Layer 1 - Stiff to Very Stiff Cohesive		5	6 9 13	31	78	SS-2	4.00	17	7	22	24	30	37	18	19	13	A-6b (7)	
		6																
		7																
		8	10 9 9	25	78	SS-3	3.00	-	-	-	-	-	-	-	-	11	A-6b (V)	
		9																
		10																
		11	6 5 6	16	67	SS-4	2.00	-	-	-	-	-	-	-	-	18	A-6b (V)	
	620.0																	
STIFF TO VERY STIFF, RED-BROWN AND LIGHT BROWN, **SILT AND CLAY**, "AND" SAND, LITTLE STONE FRAGMENTS, DAMP		12																
@ 13.5' - 14.0' : Light Brown Coarse and Fine Sand, Trace Stone Fragments		13	2 3 13	23	78	SS-5	1.50	16	17	24	29	14	28	17	11	14	A-6a (2)	
		14																
	616.5	W 616.5																
MEDIUM DENSE, GRAY-BROWN, **STONE FRAGMENTS WITH SAND, SILT, AND CLAY**, DAMP		15																
@ 16.5' - 17.0' : Auger Grinding		16	1 3 6	13	78	SS-6	-	-	-	-	-	-	-	-	-	19	A-2-6 (V)	
		17																
Layer 2 - Medium Dense to Dense Granular		18	12 14 5	27	44	SS-7	-	51	11	8	14	16	33	18	15	11	A-2-6 (1)	
		19																
@ 19.0' - 20.0' : Auger Grinding		20	50/5"	-	100	SS-8	3.00	-	-	-	-	-	-	-	-	20	A-2-6 (V)	
@ 20.5' : Auger Refusal	611.0	TR																
LIMESTONE, GRAY, MODERATELY WEATHERED, STRONG, VERY THIN TO THIN BEDDED, CRYSTALLINE, JOINT AND BEDDING DISCONTINUITIES WITH STAINING, FRACTURED, OPEN APERTURE, VERY ROUGH, VERY BLOCKY GOOD SURFACE CONDITIONS; RQD 0%, REC 63%.		21	0		75	NQ2-1											CORE	
		22																
		23	0		50	NQ2-2											CORE	
	607.0	24																
CLAYSTONE, GRAY TRACE BROWN, MODERATELY WEATHERED, WEAK, THIN TO MEDIUM BEDDED, JOINT AND BEDDING DISCONTINUITIES, MODERATELY FRACTURED, NARROW APERTURE, SLICKENSIDED, VERY BLOCKY, POOR SURFACE CONDITIONS; RQD 44%, REC 100%.		25																
		26	67		100	NQ2-3											CORE	
		27																
		28																
	602.5	29																

PID: 117974	SFN:	PROJECT: ATH-144-06.04	STATION / OFFSET: 318+78, 5' RT.	START: 1/24/23	END: 1/24/23	PG 2 OF 2	B-001-0-23

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
CLAYSTONE, RED-BROWN AND GRAY, MODERATELY TO HIGHLY WEATHERED, VERY WEAK, LAMINATED TO VERY THIN BEDDED, FRIABLE, JOINT AND BEDDING DISCONTINUITIES, HIGHLY FRACTURED, OPEN APERTURE, SLICKENSIDED, LAMINATED, VERY POOR SURFACE CONDITIONS; RQD 0%, REC 100%. *(continued)*	601.5	31	0		100	NQ2-4											CORE	
CLAYSTONE, GRAY TRACE BROWN, MODERATELY WEATHERED, WEAK, THIN TO MEDIUM BEDDED, JOINT AND BEDDING DISCONTINUITIES, MODERATELY FRACTURED, NARROW APERTURE, SLICKENSIDED, VERY BLOCKY, POOR SURFACE CONDITIONS; RQD 52%, REC 100%.	599.0	32																
SANDSTONE, GRAY, SLIGHTLY WEATHERED, MODERATELY STRONG, FINE TO MEDIUM GRAINED, THICK TO VERY THICK BEDDED, JOINT AND BEDDING DISCONTINUITIES, SLIGHTLY FRACTURED TO INTACT, TIGHT APERTURE, SLIGHTLY ROUGH, INTACT, GOOD SURFACE CONDITIONS; RQD 83%, REC 99%. @ 34.2' - 35.4' : Gray-Brown to olive-gray, moderately fractured with staining, open aperture @ 36.0' - 36.4' : Qu = 4943 psi	597.3	33 34 35 36 37 38 39 40	41		100	NQ2-5											CORE	
	590.7	EOB	90		99	NQ2-6											CORE	

NOTES: BOREHOLE CAPPED WITH QUICK-CRETE CONCRETE PATCH; NQ2-1 AND NQ2-2 CORED WITH IMPREGNATED BIT; NQ2-3 THROUGH NQ2-6 CORED WITH SURFACE SET BIT

ABANDONMENT METHODS, MATERIALS, QUANTITIES: TREMIED 20 LB. BENTONITE POWDER; 94 LB. CEMENT; 50 GAL. WATER

PROJECT: ATH-144-06.04	DRILLING FIRM / OPERATOR: CENTRAL STAR / TS	DRILL RIG: DIEDRICH D-50 (SN311)	STATION / OFFSET: 319+82, 7' RT.	EXPLORATION ID B-002-0-23
TYPE: LANDSLIDE	SAMPLING FIRM / LOGGER: HDR / DM	HAMMER: AUTOMATIC HAMMER	ALIGNMENT: SR 144	
PID: 117974 SFN:	DRILLING METHOD: 2.25 HSA / NQ2	CALIBRATION DATE: 3/7/22	ELEVATION: 631.2 (MSL) EOB: 48.5 ft.	PAGE 1 OF 2
START: 1/19/23 END: 1/20/23	SAMPLING METHOD: SPT / ST / NQ2	ENERGY RATIO (%): 84.9	LAT / LONG: 39.244719, -81.809127	

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
19 inches of Asphalt	631.2																	
STIFF TO VERY STIFF, RED-BROWN AND BROWN, **CLAY**, "AND" SAND, SOME SILT, TRACE STONE FRAGMENTS, DAMP (FILL)	629.6		6 5 4	13	78	SS-1	3.50	-	-	-	-	-	-	-	-	19	A-7-6 (V)	
Layer 1 - Stiff to Very Stiff Cohesive			3 3 5	11	67	SS-2	3.00	7	13	28	24	28	43	20	23	20	A-7-6 (8)	
			6 6 5	16	78	SS-3	2.00	-	-	-	-	-	-	-	-	15	A-7-6 (V)	
			5 6 8	20	83	SS-4	2.50	-	-	-	-	-	-	-	-	17	A-7-6 (V)	
	622.2		10 21 15	51	89	SS-5	2.00	-	-	-	-	-	-	-	-	17	A-4a (V)	
STIFF TO VERY STIFF, RED-BROWN AND BROWN, **SANDY SILT**, LITTLE CLAY, TRACE STONE FRAGMENTS, DAMP @ 9.5' - 10.5' : Brown and Dark Brown Highly Weathered Sandstone Fragments			8 6 9	21	67	SS-6	1.50	-	-	-	-	-	-	-	-	13	A-4a (V)	
			13 11 9	28	89	SS-7A	2.00	-	-	-	-	-	-	-	-	20	A-4a (V)	
						SS-7B	-	2	30	49	14	5	NP	NP	NP	9	A-3a (0)	
@ 12.5' - 13.0' : Brown Coarse and Fine Sand, Little Silt, Trace Gravel, Trace Clay Layer			3 7 9	23	89	SS-8	1.00	8	13	35	27	17	27	17	10	13	A-4a (2)	
			5 8 6	20	50	SS-9	2.00	-	-	-	-	-	-	-	-	13	A-4a (V)	
	613.2		3 4 5	13	56	SS-10	3.50	-	-	-	-	-	-	-	-	13	A-4a (V)	
STIFF TO VERY STIFF, LIGHT BROWN TO OLIVE, **SILT AND CLAY**, "AND" SAND, LITTLE STONE FRAGMENTS, DAMP @ 18.6' - 19.1' : Qu = 2337 psf					100	ST-11	4.00	20	22	14	22	22	36	21	15	14	A-6a (3)	
@ 20.5' : Anvil Hammer Issues. Stopped SPT sampler at 12 inches and pulled sample.	610.7	W 611.2	5 6/6"	-	100	SS-12	4.00	-	-	-	-	-	-	-	-	17	A-6a (V)	
@ 20.5' Auger Grinding			50/0"	-		SS-13	-	-	-	-	-	-	-	-	-	-		
LIMESTONE, GRAY, SLIGHTLY TO MODERATELY WEATHERED, VERY STRONG, CRYSTALLINE. (BOULDER)	608.7		46		58	NQ2-1											CORE	
HARD, GRAY AND LIGHT BROWN, **SILT AND CLAY**, LITTLE SAND, LITTLE GRAVEL, DAMP			0		0	NQ2-2											CORE	
Layer 3 - Hard Cohesive			8 23 34	81	78	SS-14	4.50	-	-	-	-	-	-	-	-	15	A-6a (V)	
	603.2		18 23 47	99	78	SS-15	4.50	-	-	-	-	-	-	-	-	14	A-6a (V)	
CLAYSTONE, RED-BROWN WITH BROWN, MODERATELY TO HIGHLY WEATHERED, VERY WEAK.	602.7	TR	50/5"	-	100	SS-16	-	-	-	-	-	-	-	-	-	-	Rock (V)	
			75		75	NQ2-3											CORE	

PID: 117974	SFN:	PROJECT: ATH-144-06.04	STATION / OFFSET: 319+82, 7' RT.	START: 1/19/23	END: 1/20/23	PG 2 OF 2	B-002-0-23

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
CLAYSTONE, RED-BROWN WITH BROWN, MODERATELY TO HIGHLY WEATHERED, VERY WEAK, THIN BEDDED, ARENACEOUS, CALCAREOUS, JOINT AND BEDDING DISCONTINUITIES, MODERATELY FRACTURED, NARROW APERTURE, SLICKENSIDED, VERY BLOCKY, POOR SURFACE CONDITIONS; RQD 82%, REC 95%. *(continued)*	601.2	31																
@ 30.8' - 31.2' : Qu = 51 psi	597.7	32	87		100	NQ2-4											CORE	
SANDSTONE, GRAY, SLIGHTLY WEATHERED, MODERATELY STRONG, FINE GRAINED, MEDIUM TO THICK BEDDED, CALCAREOUS, JOINT AND BEDDING DISCONTINUITIES, SLIGHTLY FRACTURED, TIGHT APERTURE, SLIGHTLY ROUGH, INTACT TO BLOCKY, GOOD SURFACE CONDITIONS; RQD 100%, REC 100%.	591.2	33 34 35 36 37 38 39	89		100	NQ2-5											CORE	
CLAYSTONE, RED-BROWN AND GRAY, SLIGHTLY TO MODERATELY WEATHERED, WEAK TO SLIGHTLY STRONG, THIN BEDDED, ARENACEOUS, CALCAREOUS, JOINT AND BEDDING DISCONTINUITIES, NARROW TO OPEN APERTURE, SLICKENSIDED TO SLIGHTLY ROUGH, FAIR SURFACE CONDITIONS; RQD 66%, REC 100%. @ 40.0' - 41.9' : Olive-Gray @ 41.9' - 42.5' : Limestone @ 44.5' - 45.5' : Calcareous with Limestone Nodules @ 46.5' - 48.0' : Calcareous with Limestone Nodules @ 47.4' - 47.8' : Qu = 2388 psi @ 48.0' - 48.5' : Limestone	582.7	40 41 42 43 44 45 46 47 48 EOB	63		100	NQ2-6											CORE	

NOTES: BOREHOLE CAPPED WITH QUICK-CRETE CONCRETE PATCH;

ABANDONMENT METHODS, MATERIALS, QUANTITIES: TREMIED 20 LB. BENTONITE POWDER; 94 LB. CEMENT; 50 GAL. WATER

PROJECT: ATH-144-06.04	DRILLING FIRM / OPERATOR: CENTRAL STAR / TS	DRILL RIG: DIEDRICH D-50 (SN311)	STATION / OFFSET: 320+89, 8' RT.	EXPLORATION ID B-003-0-23
TYPE: LANDSLIDE	SAMPLING FIRM / LOGGER: HDR / DM	HAMMER: AUTOMATIC HAMMER	ALIGNMENT: SR 144	
PID: 117974 SFN:	DRILLING METHOD: 2.25 HSA / NQ2	CALIBRATION DATE: 3/7/22	ELEVATION: 633.2 (MSL) EOB: 52.5 ft.	PAGE 1 OF 2
START: 1/23/23 END: 1/23/23	SAMPLING METHOD: SPT / ST / NQ2	ENERGY RATIO (%): 84.9	LAT / LONG: 39.244977, -81.809307	

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
15 inches of Asphalt	633.2																	
	631.9																	
STIFF TO VERY STIFF, BROWN AND ORANGE-BROWN, **SILT AND CLAY**, "AND" SAND, TRACE SANDSTONE FRAGMENTS, DAMP (FILL) Layer 1 - Stiff to Very Stiff Cohesive			5 5 5	14	67	SS-1	3.00	3	10	47	22	18	28	16	12	14	A-6a (2)	
			5 4 5	13	44	SS-2	2.50	-	-	-	-	-	-	-	-	12	A-6a (V)	
	624.7		10 9 8	24	56	SS-3	3.00	-	-	-	-	-	-	-	-	15	A-6a (V)	
VERY DENSE, LIGHT BROWN, **COARSE AND FINE SAND**, LITTLE SILT, TRACE CLAY, DAMP			74 30 13	61	78	SS-4	-	0	47	35	13	5	NP	NP	NP	7	A-3a (0)	
	620.7																	
MEDIUM DENSE, BROWN AND ORANGE-BROWN, **STONE FRAGMENTS WITH SAND AND SILT**, LITTLE CLAY, DAMP Layer 2 - Medium Dense to Dense Granular			6 8 8	23	67	SS-5	-	-	-	-	-	-	-	-	-	12	A-2-4 (V)	
			6 7 8	21	67	SS-6	-	7	14	44	21	14	25	18	7	11	A-2-4 (0)	
			2 7 5	17	56	SS-7	-	-	-	-	-	-	-	-	-	16	A-2-4 (V)	
	612.2	W 612.2			54	ST-8	-	34	15	27	15	9	25	17	8	11	A-2-4 (0)	
DENSE, GRAY AND GRAY-BROWN, **STONE FRAGMENTS WITH SAND AND SILT**, TRACE CLAY, DAMP			13 9 13	31	56	SS-9	-	-	-	-	-	-	-	-	-	17	A-2-4 (V)	
	608.2																	
HARD, RED-BROWN, BROWN AND GRAY, **SILT AND CLAY**, LITTLE SAND, TRACE STONE FRAGMENTS, DAMP (RESIDUUM)			18 35 50/5"	-	94	SS-10	4.50	1	2	10	49	38	35	20	15	14	A-6a (10)	
			50/5"	-	100	SS-11	4.50	-	-	-	-	-	-	-	-	10	A-6a (V)	
	603.2																	

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 3/6/23 15:11 - C:\PWWORKING\EAST01\D30528211\20230124_ATH-144-6.04_10-Z_BORING LOGS WITH LAB.GPJ

PID: 117974	SFN:	PROJECT: ATH-144-06.04	STATION / OFFSET: 320+89, 8' RT.	START: 1/23/23	END: 1/23/23	PG 2 OF 2	B-003-0-23

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
CLAYSTONE, RED-BROWN TRACE BROWN, HIGHLY WEATHERED, VERY WEAK.	603.2	TR	40 50/4"	-	100	SS-12	-	-	-	-	-	-	-	-	-	-	Rock (V)	
	600.7	31 32																
SANDSTONE, GRAY, MODERATELY WEATHERED, MODERATELY STRONG, VERY FINE TO FINE GRAINED, THIN TO MEDIUM BEDDED, JOINT AND BEDDING DISCONTINUITIES, SLIGHTLY TO MODERATELY FRACTURED, NARROW TO OPEN APERTURE, SLIGHTLY ROUGH, BLOCKY, FAIR SURFACE CONDITIONS; RQD 69%, REC 100%. @ 37.5' - 37.7' : Vertical Fracture with Staining @ 37.9' - 38.9' : Vertical Fracture with Staining @ 39.5' - 40.3' : Vertical Fracture with Staining	592.7	33 34 35 36 37 38 39	62		100	NQ2-1											CORE	
SHALE, DARK GRAY, SLIGHTLY WEATHERED, WEAK, THIN TO MEDIUM BEDDED, JOINT AND BEDDING DISCONTINUITIES, MODERATELY TO SLIGHTLY FRACTURED, TIGHT APERTURE, SLIGHTLY ROUGH TO SLICKENSIDED, BLOCKY, FAIR TO POOR SURFACE CONDITIONS; RQD 60%, REC 100%. @ 41.5' - 41.9' : Qu = 753 psi	590.2	40 41 42 43 44	83		100	NQ2-2											CORE	
CLAYSTONE, RED-BROWN AND GRAY, SLIGHTLY TO MODERATELY WEATHERED, SLIGHTLY STRONG, THIN TO MEDIUM BEDDED, CALCAREOUS, JOINT AND BEDDING DISCONTINUITIES, MODERATELY TO SLIGHTLY FRACTURED, SLIGHTLY ROUGH TO SLICKENSIDED, VERY BLOCKY, FAIR TO POOR SURFACE CONDITIONS; RQD 95%, REC 100%. @ 43.0' - 45.0' : Limestone Laminations and Calcareous Nodules @ 44.9' - 45.8' : Red-Brown @ 47.0' - 49.0' : Limestone Laminations and Calcareous Nodules Below 49.5' : Red-Brown, Friable @ 51.6' - 52.0' : Qu = 1224 psi	580.7	45 46 47 48 49 50 51 52 EOB	93		100	NQ2-3											CORE	

NOTES: BOREHOLE CAPPED WITH QUICK-CRETE CONCRETE PATCH;

ABANDONMENT METHODS, MATERIALS, QUANTITIES: TREMIED 20 LB. BENTONITE POWDER; 94 LB. CEMENT; 50 GAL. WATER

Rock Strength Parameter Determination
and
Laboratory Testing

9999 Carver Road, Suite 210, Cincinnati, OH 45242-5583 **hdrinc.com**
(513) 984-7500

ODOT District 10
ATH-144-6.08

Rock Strength Parameter Determination

Computed By = AKB
Checked By = DCM

BEDROCK TESTING

Project	Exploration ID	Sample Depth (ft)	Sample ID	Rock Type	Color	Moist Unit Weight (pcf)	Compressive Strength (psi)	(MPa)	Er Modulus (psi)	(MPa)	GSI Range	USE	Em (Hoek & Brown) Modulus (GPa)	(psi)	Lesser of Er vs Em (psi)	Em (Yang) Modulus (MPa)	(psi)
ATH-144-6.04	B-002-0-23	30.8	NQ2-4	Claystone	Red-brown	148.2	51	0.4	1,728	12	15-25	20	0.1	15294	1728	0.3	43
				Claystone	Maximum	148.2	51						Claystone	Maximum	1728		
					Minimum	148.2	51							Minimum	1728		
					Average	148	51							Average	1728		
					Std Dev	N/A	N/A							Std Dev	N/A		
					Adopted Value	150	50							Adopted Value	1700		

Project	Exploration ID	Sample Depth (ft)	Sample ID	Rock Type	Color	Moist Unit Weight (pcf)	Compressive Strength (psi)	(MPa)	Er Modulus (psi)	(MPa)	GSI Range	USE	Em (Hoek & Brown) Modulus (GPa)	(psi)	Lesser of Er vs Em (psi)	Em (Yang) Modulus (MPa)	(psi)
ATH-144-6.04	B-001-0-23	36	NQ2-6	Sandstone	Gray	165.2	4943	34.1	1,029,792	7100	55-65	60	10.4	1505691	1029792	1127.1	163470
				Sandstone	Maximum	165.2	4943						Sandstone	Maximum	1029792		
					Minimum	165.2	4943							Minimum	1029792		
					Average	165	4943							Average	1029792		
					Std Dev	N/A	N/A							Std Dev	N/A		
					Adopted Value	165	4900							Adopted Value	1029700		

Project	Exploration ID	Sample Depth (ft)	Sample ID	Rock Type	Color	Moist Unit Weight (pcf)	Compressive Strength (psi)	(MPa)	Er Modulus (psi)	(MPa)	GSI Range	USE	Em (Hoek & Brown) Modulus (GPa)	(psi)	Lesser of Er vs Em (psi)	Em (Yang) Modulus (MPa)	(psi)
ATH-144-6.04	B-003-0-23	41.5	NQ2-2	Shale	Dark Gray	164.3	753	5.2	85,568	590	30-40	35	1.0	139360	85568	29.6	4293
				Shale	Maximum	164.3	753						Shale	Maximum	85568		
					Minimum	164.3	753							Minimum	85568		
					Average	164	753							Average	85568		
					Std Dev	N/A	N/A							Std Dev	N/A		
					Adopted Value	165	750							Adopted Value	85500		

Project	Exploration ID	Sample Depth (ft)	Sample ID	Rock Type	Color	Moist Unit Weight (pcf)	Compressive Strength (psi)	(MPa)	Er Modulus (psi)	(MPa)	GSI Range	USE	Em (Hoek & Brown) Modulus (GPa)	(psi)	Lesser of Er vs Em (psi)	Em (Yang) Modulus (MPa)	(psi)
ATH-144-6.04	B-002-0-23	47.4	NQ2-6	Claystone	Gray	163.8	2388	16.5	702,353	4843	30-40	35	1.7	248175	248175	242.9	35234
ATH-144-6.04	B-003-0-23	51.6	NQ2-3	Claystone	Red-brown/Gray	162.4	1224	8.4	255,000	1758	20-30	25	0.7	99915	99915	55.6	8069
				Claystone	Maximum	163.8	2388						Claystone	Maximum	248175		
					Minimum	162.4	1224							Minimum	99915		
					Average	163	1806							Average	174045		
					Std Dev	1	823							Std Dev	104835		
					Adopted Value	165	1800							Adopted Value	174000		

krm	0.0005

BEDROCK QUALITY

Project	Exploration ID	Rock Type	Depth Range (ft.) From	To	Thickness (ft)	Layer RQD (%)	Weighted RQD*(Length / Total Length)
ATH-144-6.04	B-001-0-23	Claystone	24.5	29	4.5	44	13.5
ATH-144-6.04	B-001-0-23	Claystone	29	32.5	3.5	0	0.0
ATH-144-6.04	B-001-0-23	Claystone	32.5	34.2	1.7	52	6.0
ATH-144-6.04	B-002-0-23	Claystone	28.5	33.5	5	82	27.9
				Claystone	14.7	RQD SUM	47
				Maximum	5	82	
				Minimum	1.7	0	
				Average	3.7	44.5	
				Adopted Value			45

Project	Exploration ID	Rock Type	Depth Range (ft.) From	To	Thickness (ft)	Layer RQD (%)	Weighted RQD*(Length / Total Length)
ATH-144-6.04	B-001-0-23	Sandstone	34.2	40.8	6.6	83	26.0
ATH-144-6.04	B-002-0-23	Sandstone	33.5	40	6.5	100	30.8
ATH-144-6.04	B-003-0-23	Sandstone	32.5	40.5	8	69	26.2
				Sandstone	21.1	RQD SUM	83
				Maximum	8	100	
				Minimum	6.5	69	
				Average	7.0	84.0	
				Adopted Value			80

Project	Exploration ID	Rock Type	Depth Range (ft.) From	To	Thickness (ft)	Layer RQD (%)	Weighted RQD*(Length / Total Length)
ATH-144-6.04	B-003-0-23	Shale	40.5	43	2.5	60	60.0
				Shale	2.5	RQD SUM	60
				Maximum	2.5	60	
				Minimum	2.5	60	
				Average	2.5	60.0	
				Adopted Value			60

Project	Exploration ID	Rock Type	Depth Range (ft.) From	To	Thickness (ft)	Layer RQD (%)	Weighted RQD*(Length / Total Length)
ATH-144-6.04	B-002-0-23	Claystone	40	48.5	8.5	66	31.2
ATH-144-6.04	B-003-0-23	Claystone	43	52.5	9.5	95	50.1
				Claystone	18	RQD SUM	81
				Maximum	9.5	95	
				Minimum	8.5	66	
				Average	9.0	80.5	
				Adopted Value			80

Table 10.4.6.5-1—Estimation of E_m Based on GSI

Expression	Notes/Remarks	Reference
$E_m\left(GPa\right)=\sqrt{\frac{q_u}{100}}10^{\frac{GSI-10}{40}}$ for $q_u \le 100$ MPa $E_m\left(GPa\right)=10^{\frac{GSI-10}{40}}$ for $q_u \le 100$ MPa	Accounts for rocks with $q_u < 100$ MPa; notes q_u in MPa	Hoek and Brown (1997); Hoek et al. (2002)
$E_m=\frac{E_R}{100}e^{GSI/21.7}$	Reduction factor on intact modulus, based on *GSI*	Yang (2006)

Notes: E_r = modulus of intact rock, E_m = equivalent rock mass modulus, *GSI* = geological strength index, q_u = uniaxial compressive strength, and 1 MPa = 2.09 ksf.

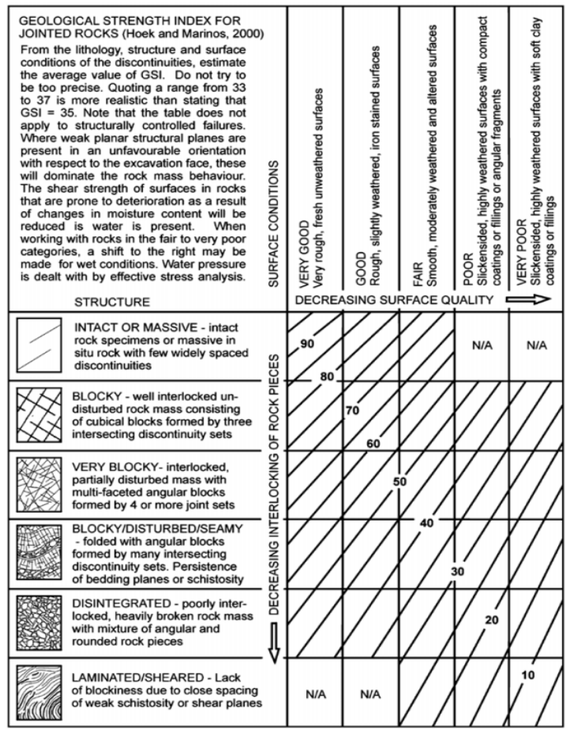


Figure 10.4.6.4-1—Determination of *GSI* for Jointed Rock Mass (Hoek and Marinos, 2000)

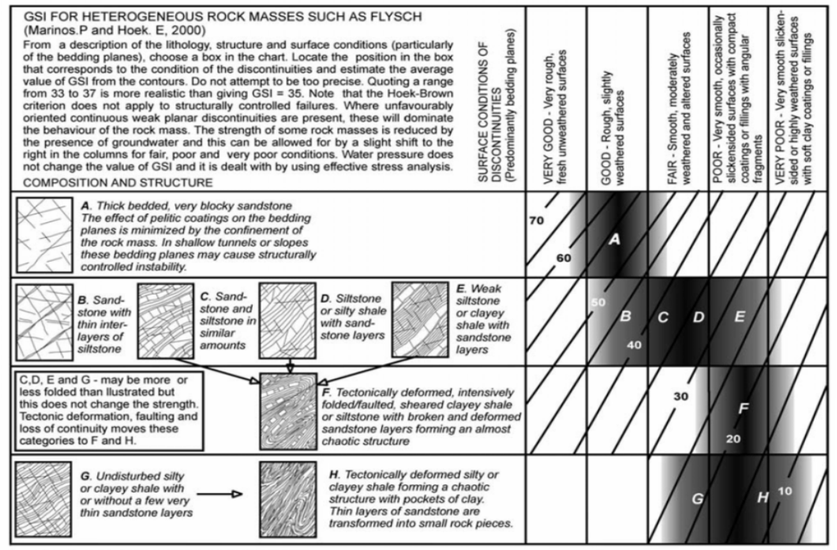


Figure 10.4.6.4-2—Determination of *GSI* for Tectonically Deformed Heterogeneous Rock Masses (Marinos and Hoek 2000)

National Engineering & Architectural Services Inc.
5710 Westbourne Avenue
Columbus, OH 43213
614-892-0162

Unconfined Compressive Strength of Rock Core (ASTM D7012 Method C)

(Project: ATH-144-6.04 (10-Z), Boring Location: B-001-0-23, NQ2-6, Depth: 36.0 - 36.4ft)

Tested Date: 2/6/2023

Specimen Properties

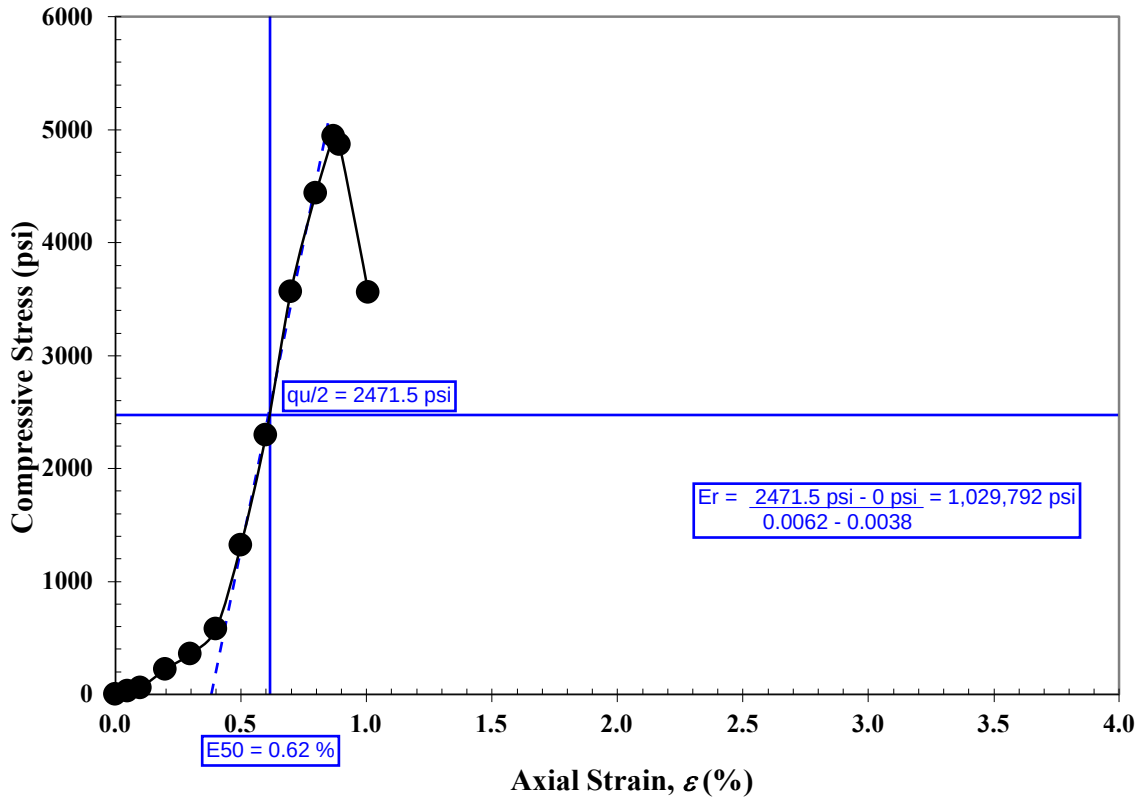
Average Dia., D_{avg} (in):	1.98
Average Height, H_{avg} (in):	4.36
Length to Diameter Ratio:	2.20
Area, A (in^2):	3.08
Volume, V (in^3):	13.45
Wet Mass of Specimen (lb):	1.3
Moisture Content (%):	1.7
Dry Mass of Specimen (lb):	1.3
Wet Unit Weight, γ (lb/ft^3):	165.2
Dry Unit Weight, γ_d (lb/ft^3):	162.4

Final Specimen Figure

Results

Unconfined Compressive Strength (psi): **4943** **34** (MPa)

Strain (%): **0.9**



Notes: Sandstone, gray, slightly weathered, moderately strong, very fine to fine grained.

National Engineering & Architectural Services Inc.
5710 Westbourne Avenue
Columbus, OH 43213
614-892-0162

Unconfined Compressive Strength of Rock Core (ASTM D7012 Method C)

(Project: ATH-144-6.04 (10-Z), Boring Location: B-002-0-23, NQ2-4, Depth: 30.8 - 31.2ft)

Tested Date: 2/6/2023

Specimen Properties

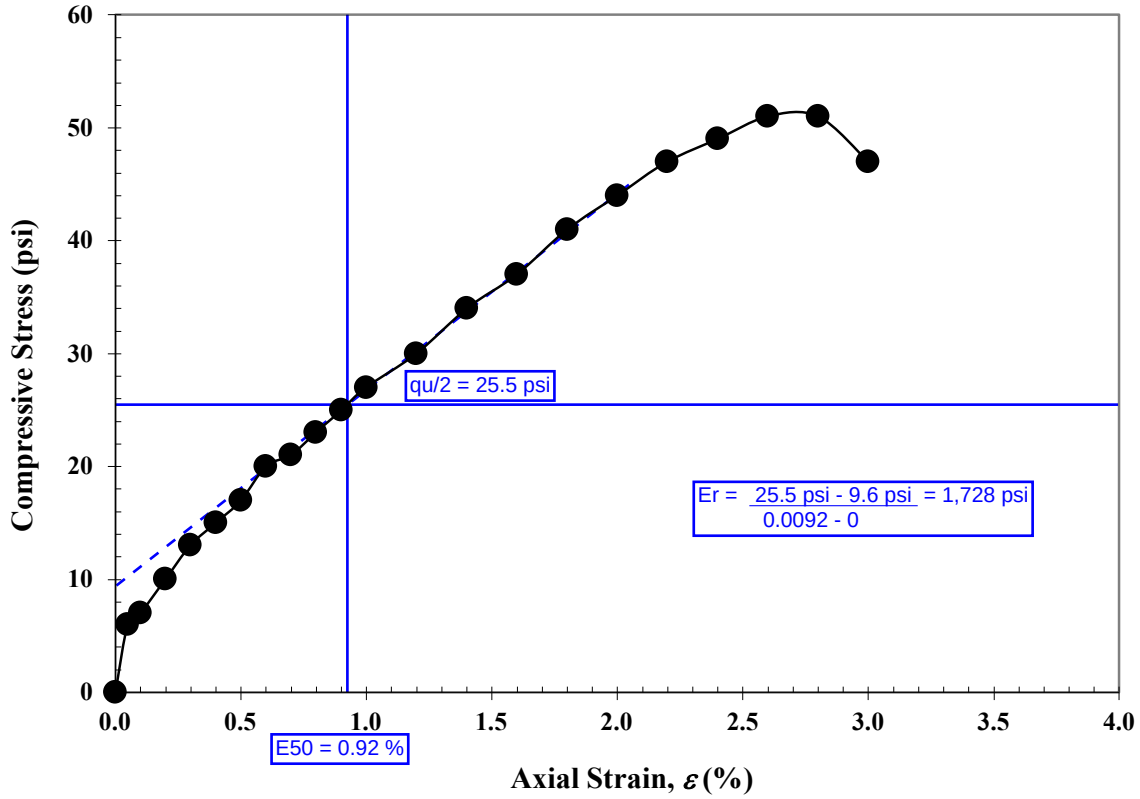
Average Dia., D_{avg} (in):	2.00
Average Height, H_{avg} (in):	4.19
Length to Diameter Ratio:	2.09
Area, A (in^2):	3.14
Volume, V (in^3):	13.14
Wet Mass of Specimen (lb):	1.1
Moisture Content (%):	7.2
Dry Mass of Specimen (lb):	1.1
Wet Unit Weight, γ (lb/ft^3):	148.2
Dry Unit Weight, γ_d (lb/ft^3):	138.3

Final Specimen Figure

Results

Unconfined Compressive Strength (psi): **51** **0.4** (MPa)

Strain (%): **2.6**



Notes: Claystone, gray, highly weathered, very weak, slickensided.

Sample trimming procedure does not conform to ASTM D4543 and the results reported may differ from the results obtained from a test specimen that meets the requirements of Practice D4543.

National Engineering & Architectural Services Inc.
5710 Westbourne Avenue
Columbus, OH 43213
614-892-0162

Unconfined Compressive Strength of Rock Core (ASTM D7012 Method C)

(Project: ATH-144-6.04 (10-Z), Boring Location: B-002-0-23, NQ2-6, Depth: 47.4 - 47.8ft)

Tested Date: 2/6/2023

Specimen Properties

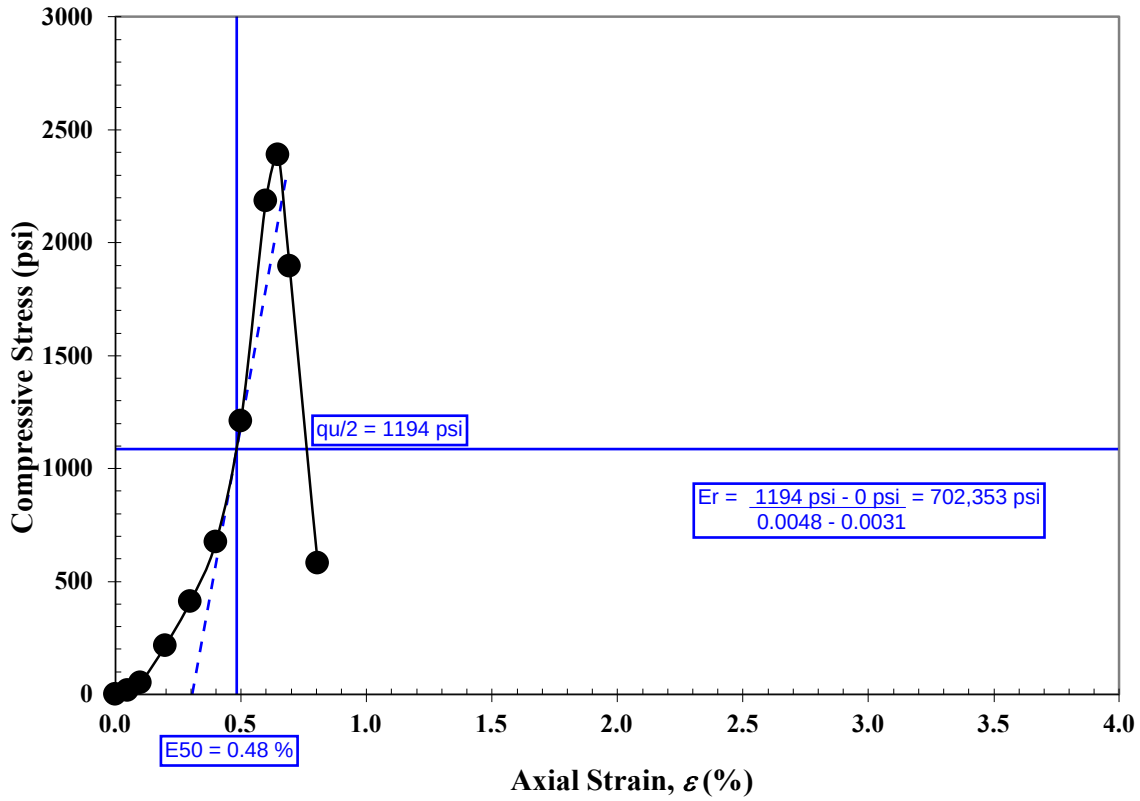
Average Dia., D_{avg} (in):	1.98
Average Height, H_{avg} (in):	4.47
Length to Diameter Ratio:	2.25
Area, A (in^2):	3.09
Volume, V (in^3):	13.80
Wet Mass of Specimen (lb):	1.3
Moisture Content (%):	2.4
Dry Mass of Specimen (lb):	1.3
Wet Unit Weight, γ (lb/ft^3):	163.8
Dry Unit Weight, γ_d (lb/ft^3):	159.9

Final Specimen Figure

Results

Unconfined Compressive Strength (psi): **2388** **16** (MPa)

Strain (%): **0.6**



Notes: Siltstone, gray, slightly weathered, slightly strong.

Sample trimming procedure does not conform to ASTM D4543 and the results reported may differ from the results obtained from a test specimen that meets the requirements of Practice D4543.

National Engineering & Architectural Services Inc.
5710 Westbourne Avenue
Columbus, OH 43213
614-892-0162

Unconfined Compressive Strength of Rock Core (ASTM D7012 Method C)

(Project: ATH-144-6.04 (10-Z), Boring Location: B-003-0-23, NQ2-2, Depth: 41.5 - 41.9ft)

Tested Date: 2/6/2023

Specimen Properties

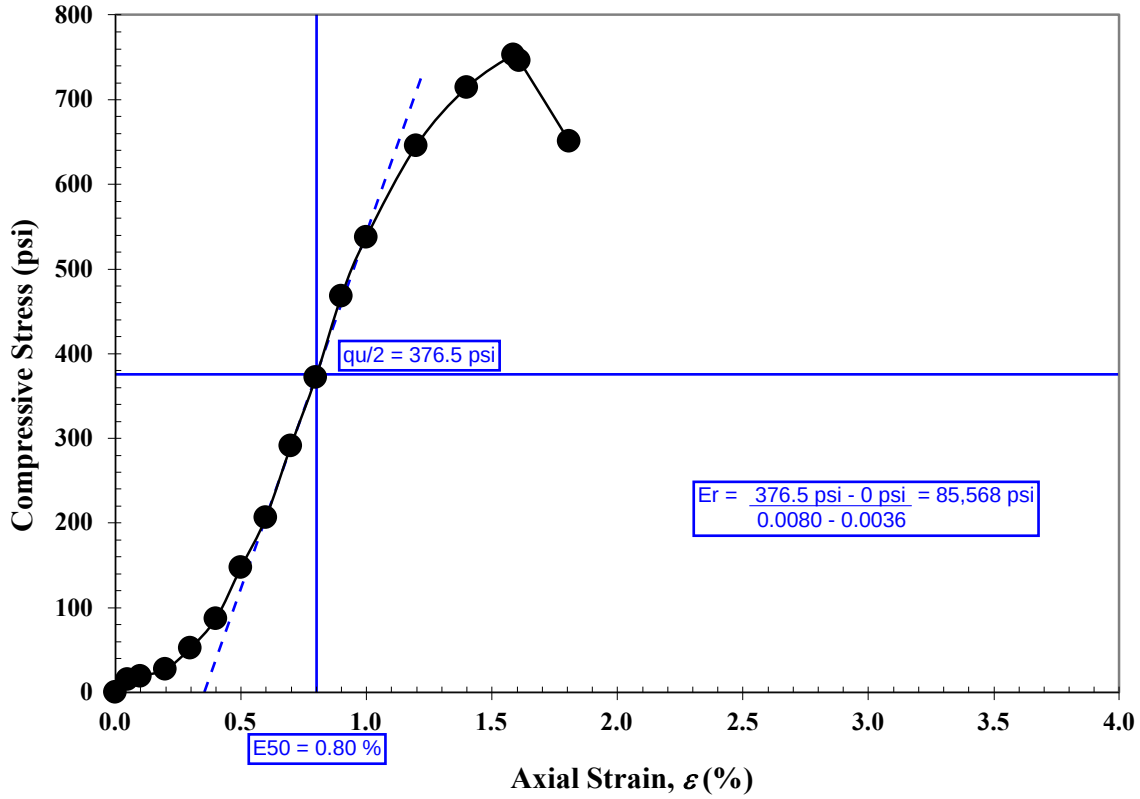
Average Dia., D_{avg} (in):	1.98
Average Height, H_{avg} (in):	4.54
Length to Diameter Ratio:	2.29
Area, A (in^2):	3.09
Volume, V (in^3):	14.02
Wet Mass of Specimen (lb):	1.3
Moisture Content (%):	3.3
Dry Mass of Specimen (lb):	1.3
Wet Unit Weight, γ (lb/ft^3):	164.3
Dry Unit Weight, γ_d (lb/ft^3):	159.0

Final Specimen Figure

Results

Unconfined Compressive Strength (psi): **753** **5** (MPa)

Strain (%): **1.6**



Notes: Shale, dark gray, slightly weathered, weak.

Sample trimming procedure does not conform to ASTM D4543 and the results reported may differ from the results obtained from a test specimen that meets the requirements of Practice D4543.

National Engineering & Architectural Services Inc.
5710 Westbourne Avenue
Columbus, OH 43213
614-892-0162

Unconfined Compressive Strength of Rock Core (ASTM D7012 Method C)

(Project: ATH-144-6.04 (10-Z), Boring Location: B-003-0-23, NQ2-3, Depth: 51.6 - 52.0ft)

Tested Date: 2/6/2023

Specimen Properties

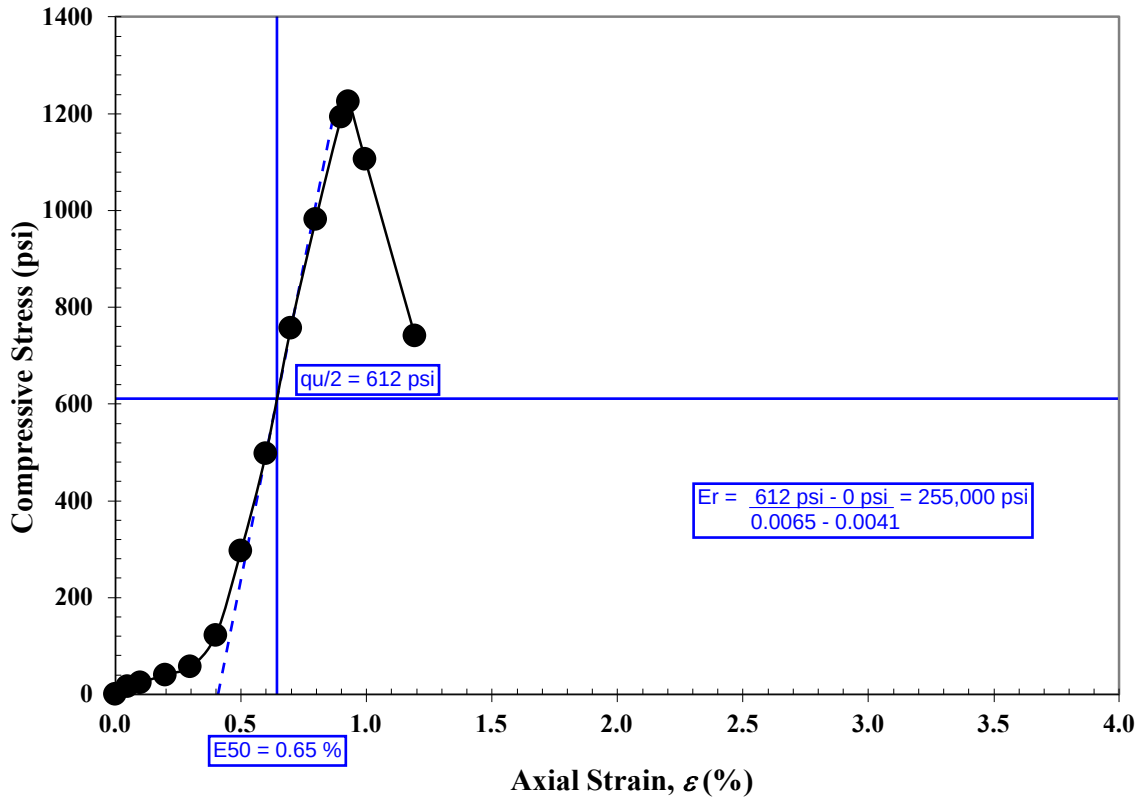
Average Dia., D_{avg} (in):	1.99
Average Height, H_{avg} (in):	4.52
Length to Diameter Ratio:	2.27
Area, A (in^2):	3.12
Volume, V (in^3):	14.12
Wet Mass of Specimen (lb):	1.3
Moisture Content (%):	4.0
Dry Mass of Specimen (lb):	1.3
Wet Unit Weight, γ (lb/ft^3):	162.4
Dry Unit Weight, γ_d (lb/ft^3):	156.1

Final Specimen Figure

Results

Unconfined Compressive Strength (psi): **1224** **8** (MPa)

Strain (%): **0.9**



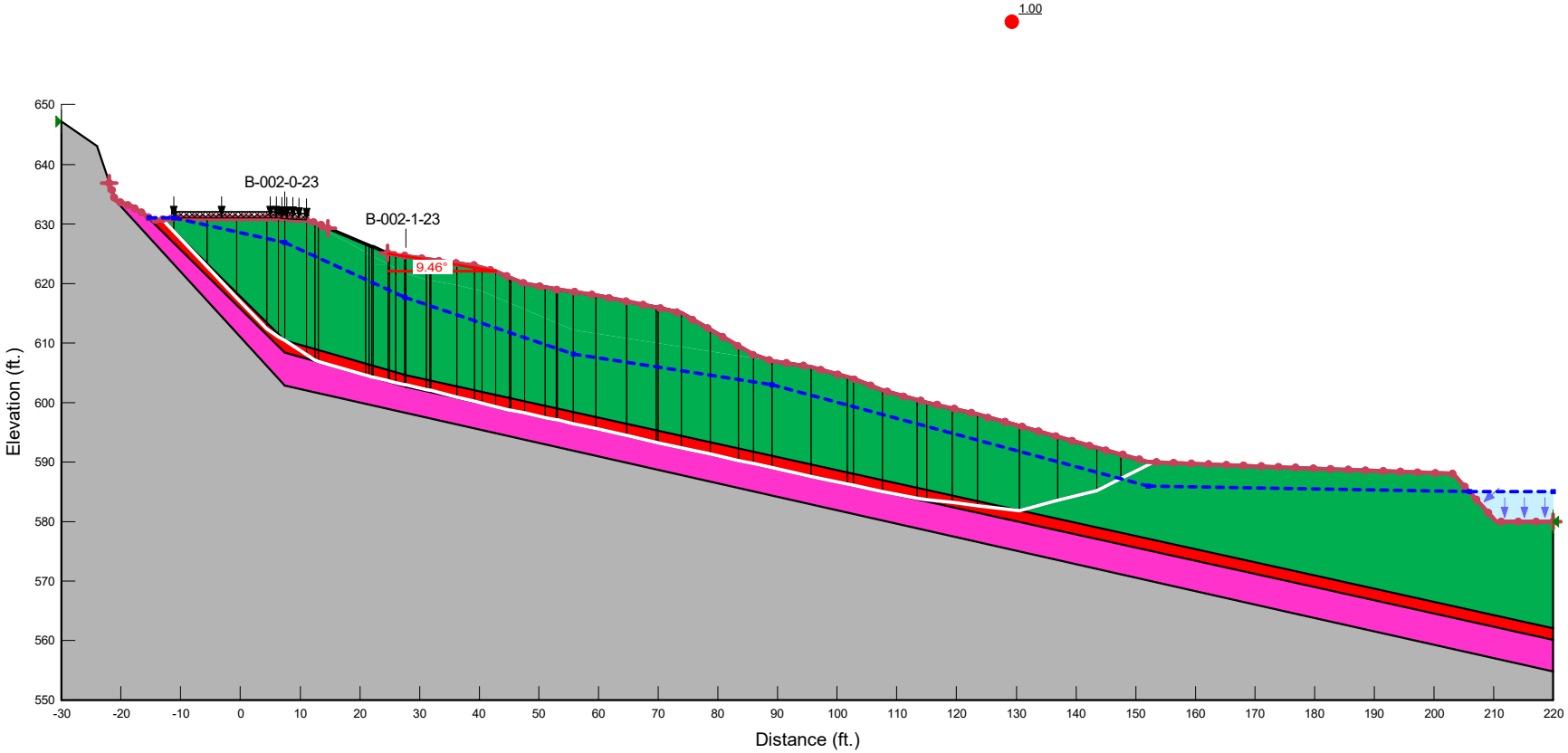
Notes: Claystone, maroonish brown and gray, slightly weathered, weak, calcareous.

Sample trimming procedure does not conform to ASTM D4543 and the results reported may differ from the results obtained from a test specimen that meets the requirements of Practice D4543.

Slope Stability Analyses

Station 319+25
Existing Conditions

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	1. Stiff to Very Stiff Cohesive	Mohr-Coulomb	140	140	24
	3. Hard Cohesive	Mohr-Coulomb	140	250	28
	Bedrock	Bedrock (Impenetrable)			
	Weak Rock	Mohr-Coulomb	140	0	18



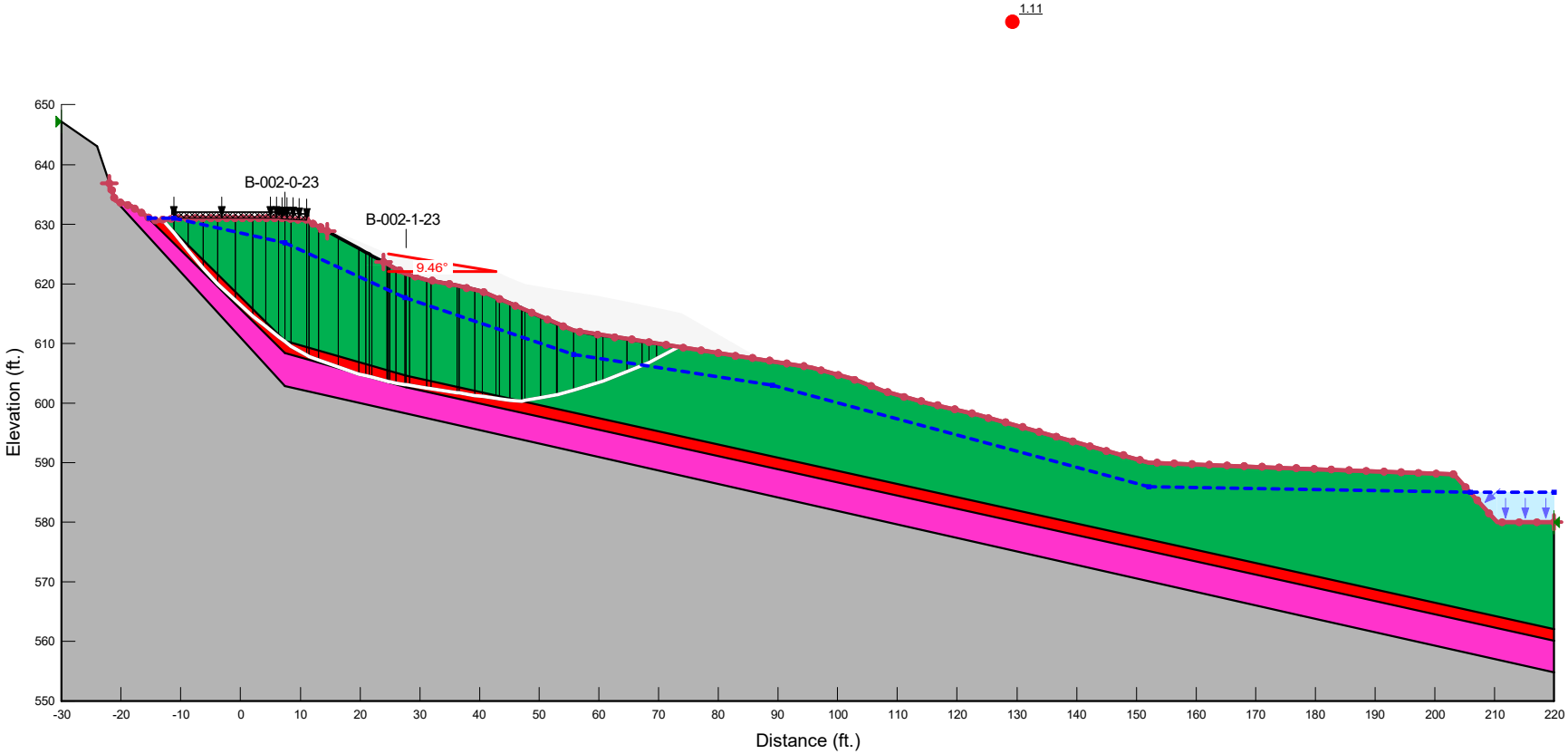
Sta. 319+25 Existing (Global)

ATH-144-6.04 Slope Stability.gsz

03/06/2023 1:350

Performed as a comparison to the existing geometry - not used in design.

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	1. Stiff to Very Stiff Cohesive	Mohr-Coulomb	140	140	24
	3. Hard Cohesive	Mohr-Coulomb	140	250	28
	Bedrock	Bedrock (Impenetrable)			
	Weak Rock	Mohr-Coulomb	140	0	18

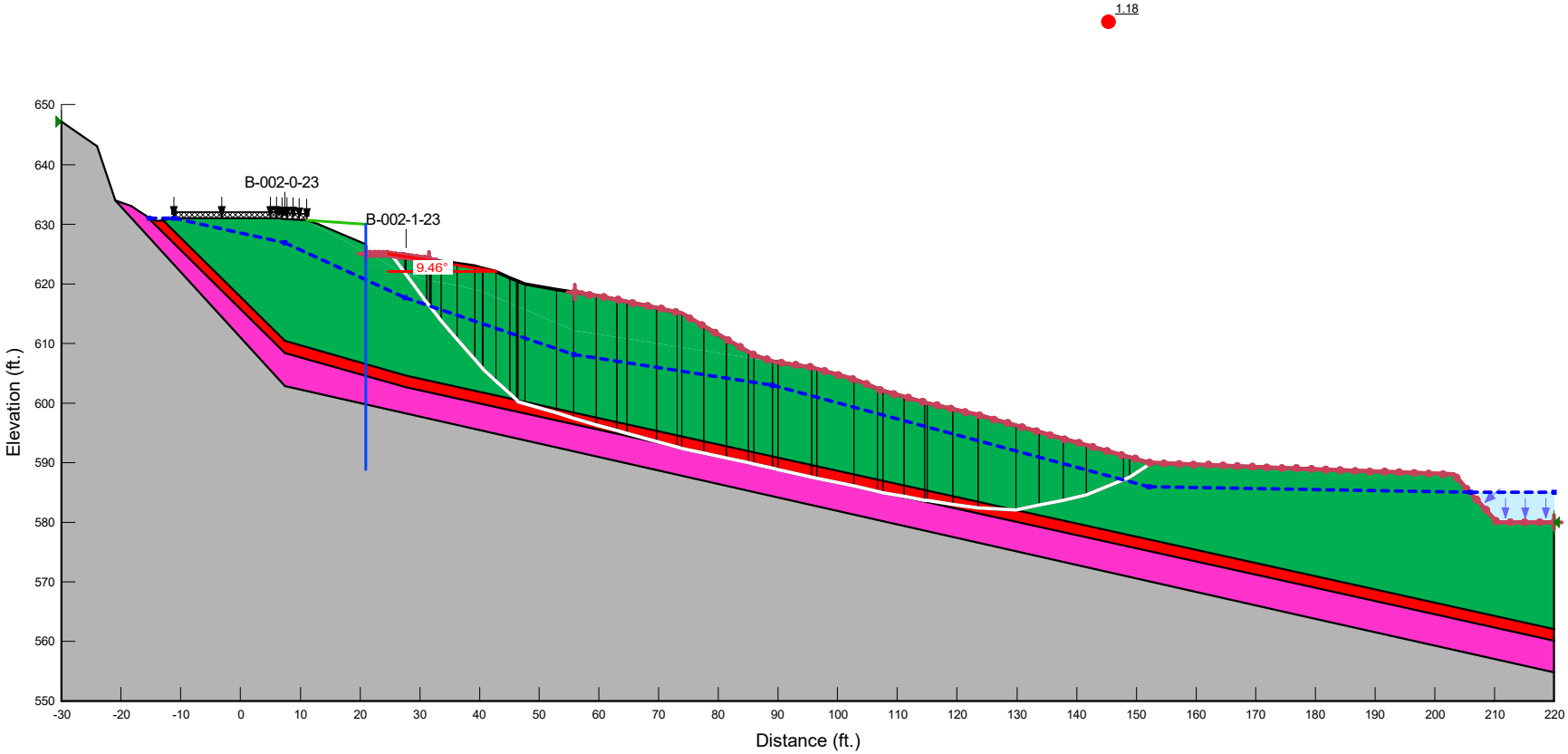


Sta. 319+25 Reconstructed (Global)	
ATH-144-6.04 Slope Stability.gsz	
03/09/2023	1:350

Station 319+25
Downslope Stability

9999 Carver Road, Suite 210, Cincinnati, OH 45242-5583
(513) 984-7500
hdrinc.com

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	1. Stiff to Very Stiff Cohesive	Mohr-Coulomb	140	140	24
	3. Hard Cohesive	Mohr-Coulomb	140	250	28
	Bedrock	Bedrock (Impenetrable)			
	Weak Rock	Mohr-Coulomb	140	0	18

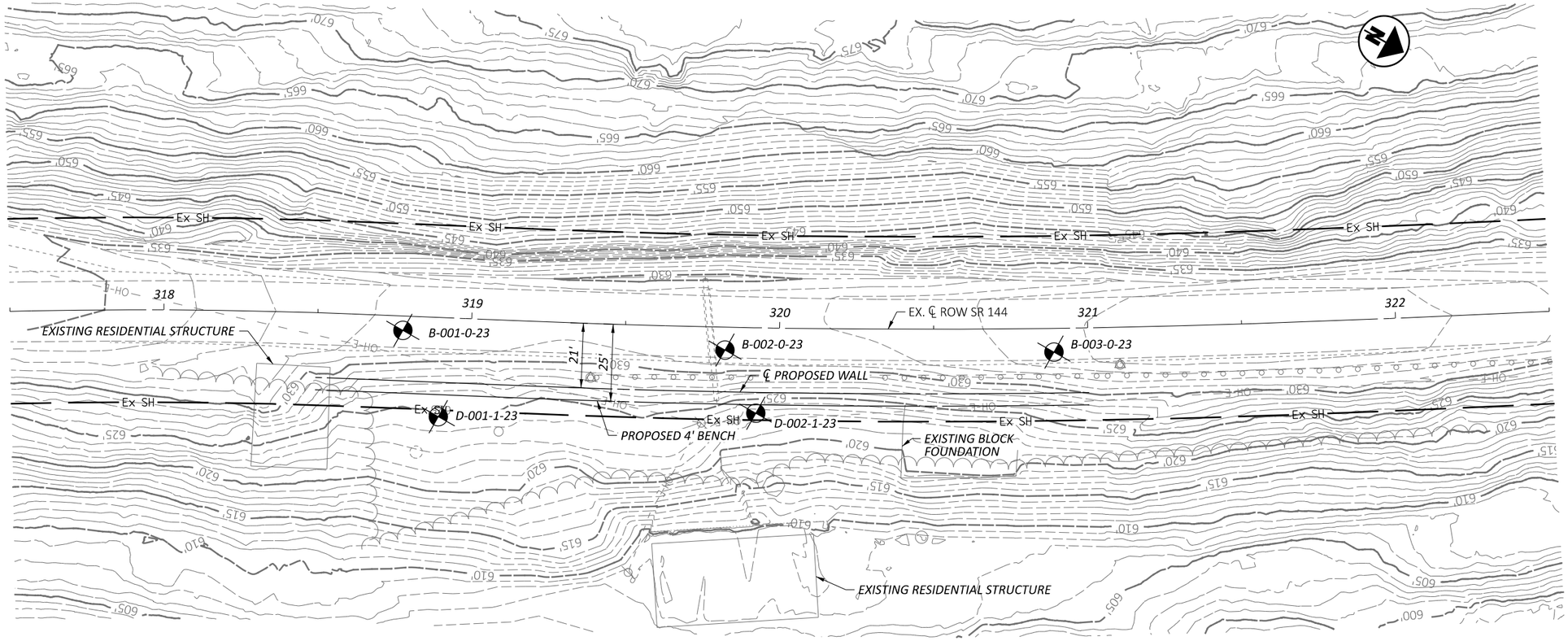


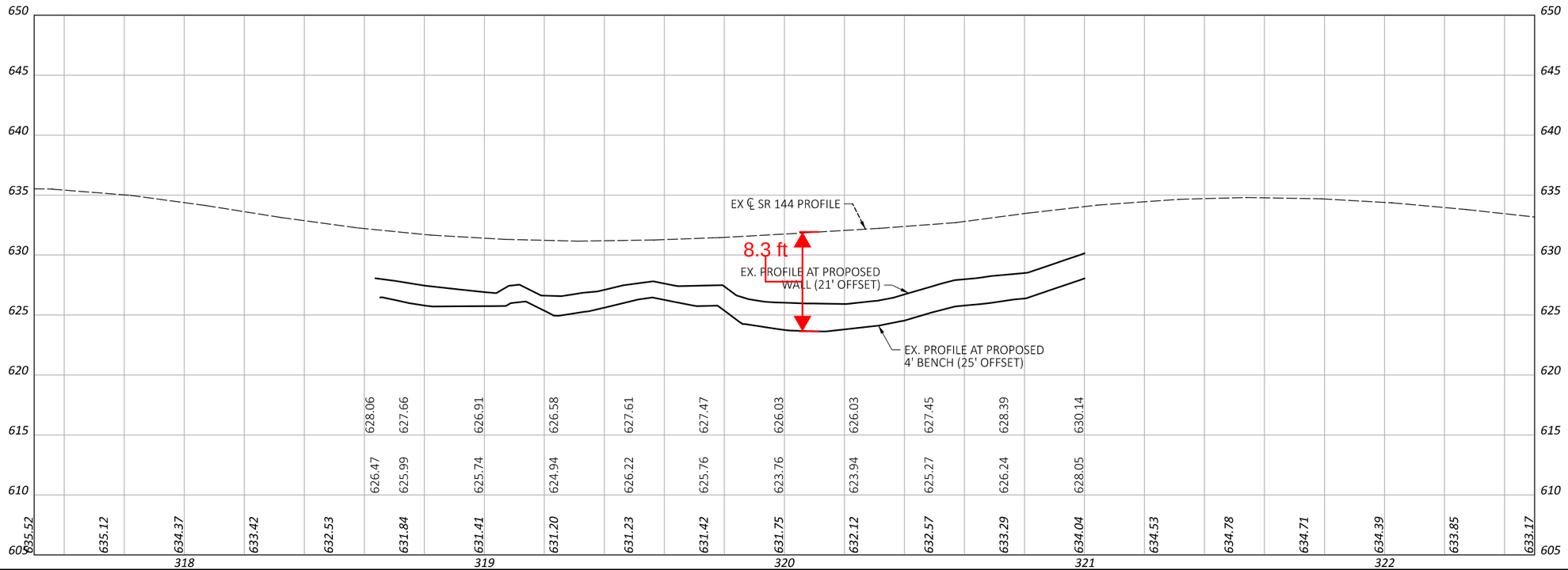
Sta. 319+25 Existing (Downslope Stability)

ATH-144-6.04 Slope Stability.gsz

03/06/2023 1:350

Wall Profile





HORIZONTAL SCALE IN FEET
0 20 40

WALL PROFILE

DESIGN AGENCY

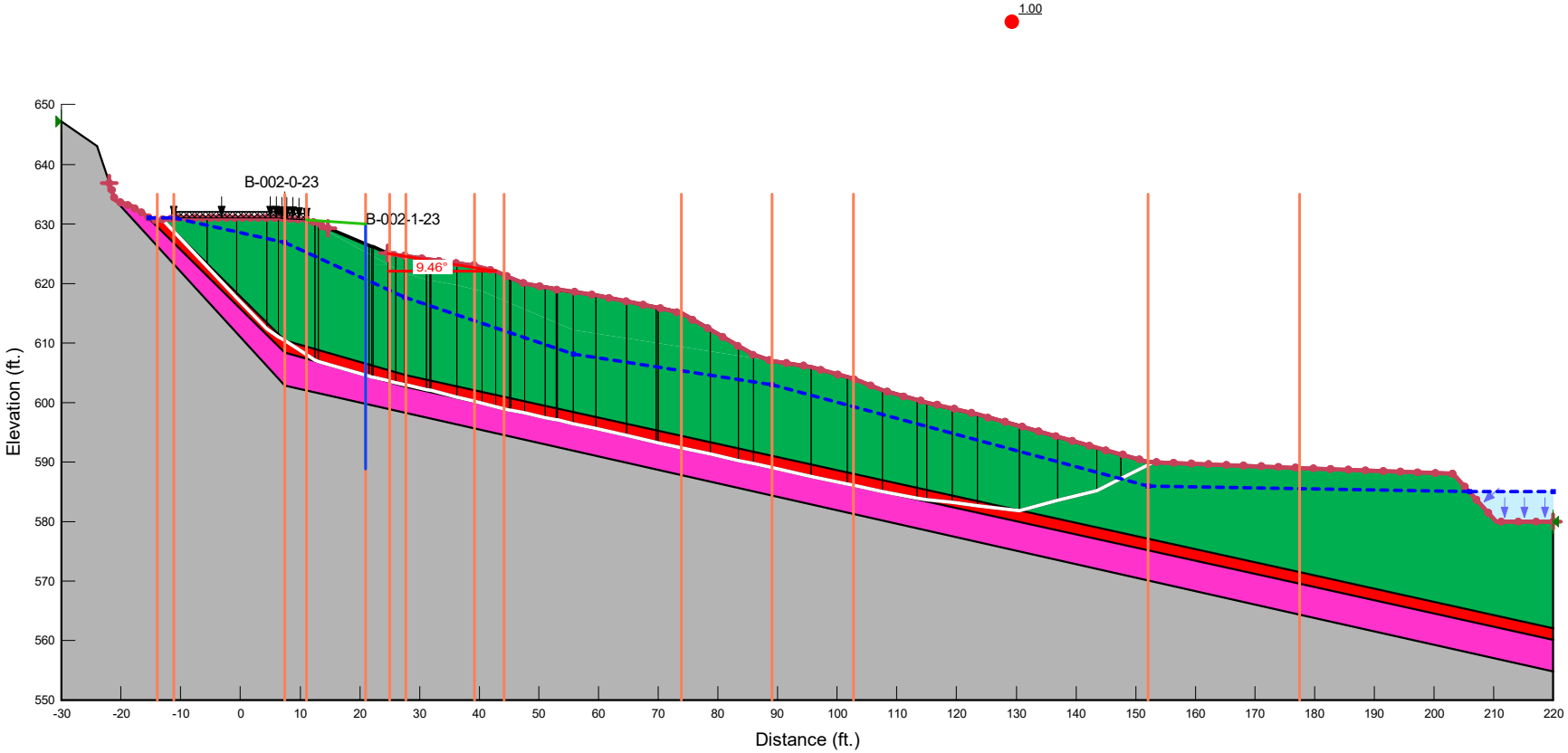
DESIGNER AKB
REVIEWER DMV 03-10-23
PROJECT ID 117974
SHEET TOTAL

ATH-144-6.04

MODEL: CLX_RW_SR144 - Plan 1 [Sheet] PAPERSIZE: 17x11 (in.) DATE: 3/9/2023 TIME: 9:11:10 AM USER: ABARATTA
pw:\\ohiodot-pw.bentley.com:ohiodot-pw-02\Documents\01 Active Projects\District 10\Athens\117974\02-Engineering_HDR\Geotechnical\Sheets\117974_YP902.dgn

UA Slope Analyses

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	1. Stiff to Very Stiff Cohesive	Mohr-Coulomb	140	140	24
	3. Hard Cohesive	Mohr-Coulomb	140	250	28
	Bedrock	Bedrock (Impenetrable)			
	Weak Rock	Mohr-Coulomb	140	0	18



Sta. 319+25 Existing (UA Slope)

ATH-144-6.04 Slope Stability.gsz

03/06/2023 1:350

Station 319+25
Existing Conditions

UA Slope Program Version 2.3 - C:\Users\abaratta\Desktop\ATH-144-6.04 Existing Condition.ua3*

File Run Options Help

Calculated Results

Factor of Safety: 1.00

Force per Shaft: 0.000 lb

Acting Point X: 0.000 ft Y: 0.000 ft

Analysis Unit System

(•) English ( ) Metric

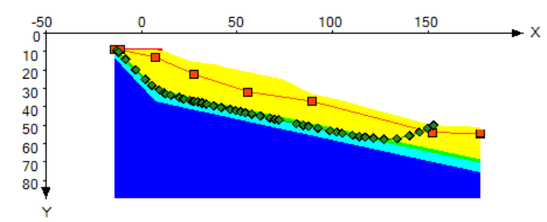
Number of Vertical Sections and Soil Layers

Vertical Section Num: 17 Soil Layer Num: 6

Analysis Method

( ) Total Stress (•) Effective Stress

Chart (Double-Click for More Options)



Soil Properties

	Cohesion (psf)	Friction Angle	Total Unit Weight (pcf)
Layer1	0.1	0.0	250.0
Layer2	200.0	28.0	120.0
Layer3	120.0	24.0	140.0
Layer4	0.0	18.0	140.0
Layer5	250.0	28.0	140.0
Layer6	4000.0	45.0	140.0

Adjusted to match Slope/W results

Slope Profile Vertical Sections

	Section 1	Section 2	Section 3	Section 4	Section 5	Section 6	Section 7	Section 8	Section 9	Section 10	Section 11	Section 12	Section 13	Section 14
X (ft)	-14.00	-11.20	-11.20	7.40	11.10	11.10	21.00	21.00	25.00	27.70	39.20	44.20	73.90	89.10
Y1 (ft)	9.50	9.00	8.00	8.10	8.30	9.30	13.40	13.40	15.00	15.40	17.00	18.60	25.00	33.00
Y2 (ft)	9.50	9.00	9.00	9.10	9.30	9.30	13.40	13.40	15.00	15.40	17.00	18.60	25.00	33.00
Y3 (ft)	9.50	9.00	9.00	9.10	9.30	9.30	13.40	13.40	15.00	15.40	17.00	18.60	25.00	33.00
Y4 (ft)	9.50	11.10	11.10	29.60	30.70	30.70	33.50	33.50	34.60	35.40	37.90	39.00	45.60	49.00
Y5 (ft)	10.50	13.20	13.20	31.60	32.70	32.70	35.50	35.50	36.60	37.40	39.90	41.00	47.60	51.00
Y6 (ft)	13.70	16.70	16.70	37.10	37.90	37.90	40.20	40.20	41.10	41.70	44.30	45.40	52.20	55.60
Y7 (ft)	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00

Coordinates of Crest X: 11.10 ft Y: 9.30 ft Coordinates of Toe X: 89.10 ft Y: 33.00 ft

Drilled Shaft Information

(•) Calculate without Drilled Shaft

( ) Automatic Load Transfer Factor

( ) Manually Defined Load Transfer Factor

[ ] Anchor (On/Off)

Anchor force: 0.00 lb

Anchor angle: 0.00

Anchor spacing: 0.00 ft

Auto ( ) On (•) Off 0.000 (n)

Xmin 0.00 Diameter: 0.30 ft

Xmax 0.00 CTC Spacing: 0.00 ft

XDelta 0.00 X Coordinate: 0.00 ft

[ ] Auto Save Data

Run

Pore Water Pressure

Pore Pressure Options: ( ) No Pore Pressure ( ) Constant Ratio (•) Specified phreatic surface

	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6	Point 7	Point 8
X (ft)	-14.00	-11.20	7.40	27.50	55.80	89.10	152.10	177.50
Y (ft)	9.00	9.00	13.10	22.30	31.90	37.00	54.00	54.50

Slip Surface

	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6	Point 7	Point 8	Point 9	Point 10	Point 11	Point 12	Point 13	Point 14	Point 15	Point 16	Point 17	Po
X (ft)	-13.10	-13.03	-12.10	-8.39	-3.08	1.90	5.39	9.25	11.77	12.72	15.25	19.75	22.09	25.40	26.75	27.60	29.45	31.4
Y (ft)	9.30	9.34	10.31	14.22	19.79	25.01	28.28	30.81	32.47	32.99	33.74	35.07	35.76	36.52	36.82	37.02	37.44	37.8

Station 319+25
Post-Construction Conditions

9999 Carver Road, Suite 210, Cincinnati, OH 45242-5583 **hdrinc.com**
(513) 984-7500

UA Slope Program Version 2.3 - C:\Users\abaratta\Desktop\ATH-144-6.04 New Wall.ua3*

File Run Options Help

Calculated Results

Factor of Safety: 1.49

Force per Shaft: 164602.091 lb

Acting Point X: 21.000 ft Y: 27.077 ft

Analysis Unit System

(•) English ( ) Metric

Number of Vertical Sections and Soil Layers

Vertical Section Num: 17 Soil Layer Num: 6

Analysis Method

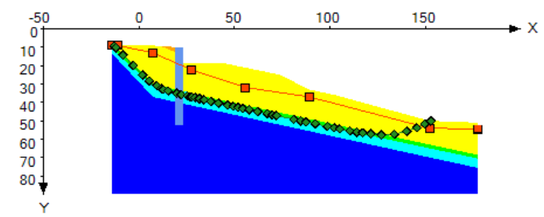
( ) Total Stress (•) Effective Stress

Soil Properties

	Cohesion (psf)	Friction Angle	Total Unit Weight (pcf)
Layer1	0.1	0.0	250.0
Layer2	200.0	28.0	120.0
Layer3	120.0	24.0	140.0
Layer4	0.0	18.0	140.0
Layer5	250.0	28.0	140.0
Layer6	4000.0	45.0	140.0

Adjusted to match Slope/W results

Chart (Double-Click for More Options)



Slope Profile Vertical Sections

	Section 1	Section 2	Section 3	Section 4	Section 5	Section 6	Section 7	Section 8	Section 9	Section 10	Section 11	Section 12	Section 13	Section 14
X (ft)	-14.00	-11.20	-11.20	7.40	11.10	11.10	21.00	21.00	25.00	27.70	39.20	44.20	73.90	89.10
Y1 (ft)	9.50	9.00	9.00	9.10	9.30	9.30	10.10	18.60	18.60	18.60	18.60	18.60	25.00	33.00
Y2 (ft)	9.50	9.00	9.00	9.10	9.30	9.30	10.10	18.60	18.60	18.60	18.60	18.60	25.00	33.00
Y3 (ft)	9.50	9.00	9.00	9.10	9.30	9.30	13.40	18.60	18.60	18.60	18.60	18.60	25.00	33.00
Y4 (ft)	9.50	11.10	11.10	29.60	30.70	30.70	33.50	33.50	34.60	35.40	37.90	39.00	45.60	49.00
Y5 (ft)	10.50	13.20	13.20	31.60	32.70	32.70	35.50	35.50	33.60	37.40	39.90	41.00	47.60	51.00
Y6 (ft)	13.70	16.70	16.70	37.10	37.90	37.90	40.20	40.20	41.10	41.70	44.30	45.40	52.20	55.60
Y7 (ft)	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00

Coordinates of Crest X: 11.10 ft Y: 9.30 ft Coordinates of Toe X: 89.10 ft Y: 33.00 ft

Drilled Shaft Information

( ) Calculate without Drilled Shaft

( ) Automatic Load Transfer Factor

(•) Manually Defined Load Transfer Factor

[ ] Anchor (On/Off)

Anchor force: 0.00 lb

Anchor angle: 0.00

Anchor spacing: 0.00 ft

Auto ( ) On (•) Off 0.000 (n)

Xmin 0.00 Diameter: 4.00 ft

Xmax 0.00 CTC Spacing: 6.00 ft

XDelta 0.00 X Coordinate: 21.00 ft

[ ] Auto Save Data

Run

Pore Water Pressure

Pore Pressure Options: ( ) No Pore Pressure ( ) Constant Ratio (•) Specified phreatic surface

	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6	Point 7	Point 8
X (ft)	-14.00	-11.20	7.40	27.50	55.80	89.10	152.10	177.50
Y (ft)	9.00	9.00	13.10	22.30	31.90	37.00	54.00	54.50

Slip Surface

	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6	Point 7	Point 8	Point 9	Point 10	Point 11	Point 12	Point 13	Point 14	Point 15	Point 16	Point 17	Po
X (ft)	-13.10	-13.03	-12.10	-8.39	-3.08	1.90	5.39	9.25	11.77	12.72	15.25	19.75	22.09	25.40	26.75	27.60	29.45	31.4
Y (ft)	9.30	9.34	10.31	14.22	19.79	25.01	28.28	30.81	32.47	32.99	33.74	35.07	35.76	36.52	36.82	37.02	37.44	37.8

Wall Calculations

Geometry

	Elevation (ft)	
Top of Backfill =	630.7	*at Outside Edge of Shoulder*
Top of Wall =	629.9	*at C/L of Wall*
Existing Ground Surface =	626.6	*at C/L of Wall*
Maintenance Bench =	621.4	*at C/L of Wall*
Slip Plane =	604.6	*at C/L of Wall*

	Horiz. Distance from C/L (ft)	
Start of Wall Backfill =	11.1	*at Outside Edge of Shoulder*
Wall =	21.0	*at C/L of Wall*
Backfill Slope Angle =	12.0	H:1V

Wall Loading Profile

	Top Elev.	Thickness (ft)	Cohesion (psf)	Phi (deg)	Unit Wt (pcf)
Item 203	629.9	3.3	200	28	120
Stiff to V. Stiff Cohesive	626.6	5.2	140	24	140
Bottom of Wall/Maintenance Bench	621.4				
Weighted Value		8.5	165	26	130

Earth Pressure Coefficients

	Deg		
Shear Resistance, Φ =	29		
Wall Friction , δ^A =	0.0		
Wall Slope, θ =	90		
Backfill Slope, β =	4.76		
Revised Backfill Slope, β =	4.76		
Backfill Condition	INFINITE		
Horz. Backslope Dist.	9.9	feet	*(C/L of Wall - Edge of Shoulder)*
Wall Height (H)	8.5	feet	*(Top of Wall - Maintenance Bench)*
Slope Height (h)	0.8	feet	*(Top of Backfill - Top of Wall)*
I =	2.69	degrees	

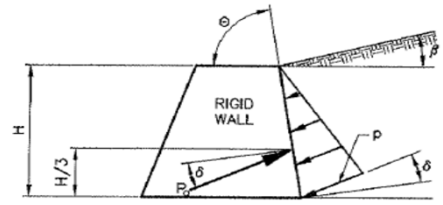


Figure 3.11.5.3-1—Notation for Coulomb Active Earth Pressure

Active Earth Coefficient

$$K_a = \frac{\sin^2(\theta+\Phi)}{(\sin^2(\theta)*\sin(\theta-\delta)*[1+\sqrt{(\sin(\Phi+\delta)*\sin(\Phi-\beta))/(\sin(\theta-\delta)*\sin(\theta+\beta))}]^2)}$$

K_a = 0.372

At-Rest Earth Coefficient

$K_o = (1- \sin(\phi))*(1+\sin(\beta))$

K_o = 0.565

Notes:

A. *Wall friction neglected*

B. *Figure and Equation for Active Earth Pressure from AASHTO 3.11.5.3 (LRFD Design Manual).*

C. *The wall backfill will consist of proposed fill and cohesive overburden. Using the soil layer thicknesses and respective soil parameters as determined by backcalculation in SlopeW, a weighted average was determined and assumed for the entire backfill (c' = 165 psf and φ' = 26°, per backcalculated UA Slope Values). The parameters were converted to equivalent soil strength parameters c' = 0 psf and φ'= 29° for computing earth pressures based on a 1 degree increase in friction angle for every 50 psf decrease in cohesion up to 150 psf (Ref: Hall's Thesis).*

Soil Lateral Design Profile

	Top Elev	Depth (ft)	Cohesion (psf)	Phi (deg)	Unit Wt (pcf)	ε50	k
Stiff to V. Stiff Cohesive	618.6	11.3	1200	0	77.6	0.007	N/A
Hard Cohesive	606.5	23.4	4000	0	77.6	0.005	N/A

Bedrock Lateral Design Profile

	Top Elev	Depth (ft)	qu (psi)	Em (psi)	Unit Wt (pcf)	RQD (%)	krm
Claystone	599.8	30.1	50	1700	150	45	0.0005
Sandstone	597.7	32.2	4900	1029700	165	80	0.0005
Claystone	591.2	38.7	1800	174000	165	80	0.0005

Depths referenced below the top of wall, starting at the lowered ground surface. ε50 and k values per LPile Technical Manual.

Wall Loading Computations

Earth Pressure Model = CONVENTIONAL *(Conventional or UA SLOPE)* UA SLOPE

1) Soil Unit Weight = 130 pcf *Weighted Average Along Cantilevered Wall Height*

2) Determine Coefficient of Earth Pressure (K)

Restraint Condition = ACTIVE *(Active or At-Rest)*

Ka = 0.372

3) Determine Equivalent Fluid Weight (G_H)

G_H = $(\gamma_m) * (K_a)$

G_H = 48 *For application to CONVENTIONAL Earth Pressure Model*

4) Artificially Lowered Ground Surface (ODOT GDM Section 903.3.2, pg. 9-14) for FS_{dh} < 1.30

Consider Lowered G. S.? YES

Lowered Ground Surface (ft) = 2.8 = dt (tan(β_{dh})

β_{dh} = 9.46 = steepness of the slope downhill of the drilled shaft

FS_{dh} = 1.18 = Factor of Safety down slope of the proposed wall

d_t = 16.8 = depth below bench to the shear surface at the location of the drilled shaft

5) Modification of p-y curves (ODOT GDM Section 903.2, pg. 9-13)

P_m = $0.64*(S/D)^{0.34}$ *(Ref: Reese, Isenhower, & Wang - 2006)*

D = 4 feet *(shaft diameter or pile flange width)*

Assumed Shaft Spacing = 6 feet *(center-to-center pile spacing)*

P_m = 0.73 *For retaining wall, applies from top of wall to top of rock/bottom of drilled shafts*

For a row of drilled shafts, applies below shear plane to top of rock/bottom of drilled shafts

Reduce p-multiplier? NO *For application above shear plane if using a row of spaced drilled shafts instead of a retaining wal*

FS_{UAS} = N/A = Factor of Safety from UASlope including shafts

p-multipler = 0.73 = (P_m - P_m/FS_{UAS}) *From top of wall to bottom of shear plane*

6) Determine Lateral Thrust

Conventional Earth Pressure Theory *UA SLOPE*

Exposed Wall Height (H) = 8.5 feet Depth from T/Wall to Slip Plane = 25.3 feet

Wall Height (H) + GS_{AL} = 11.3

P = $1/2 * G_H * H^2$

P = 3088 lbs/foot

P_{SH} = P*(Shaft Spacing) *(earth loading)*

P_{SH} = 18531 lbs/shaft Force Per Shaft = 164602 lbs/shaft

7) Resolve horizontal earth force to distributed triangular load (for LPILE)

w = $2*P_{SH}/H$

w = 3280 lbs/foot per shaft (Earth - Service Limit) 13012 lbs/foot per shaft

w = 273 lbs/inch per shaft (Earth - Service Limit) 1084 lbs/inch per shaft

γ_E = 1.5 *Earth Load Factor*

w = $(2*P_{SH}/H)*\gamma_E$

w = 410 lbs/inch per shaft (Earth - Strength Limit) 1627 lbs/inch per shaft

8) Determine live-load traffic surcharge force (P_s)

Include traffic surcharge? YES

Surcharge Pressure (q_s) = 250 psf

P_s = Ka * qs * H

P_s = 1051 lbs/foot *(surcharge resolved to distributed load)* 2354 lbs/foot

P_s = 6308 lbs/shaft 14123 lbs/shaft

9) Resolve surcharge to distributed rectangular load (for LPILE)

w = P_S/H

w = 558 lbs/foot per shaft (surcharge - unfactored) 558 lbs/foot per shaft

w = 47 lbs/inch per shaft (surcharge - unfactored) 47 lbs/inch per shaft

γ_S = 1.75 *Surcharge Load Factor - Strength I*

w = $(P_S/L)*\gamma_S$

w = 81 lbs/inch per shaft (Surcharge - Strength I) 81 lbs/inch per shaft

Distributed Lateral Loads for LPILE

CONVENTIONAL

Depth (ft.)	Service (lb/in)	Strength-I (lb/in)
0	47	81
11.3	320	491

Distributed Lateral Loads for LPILE

UA SLOPE

Depth (ft.)	Service (lb/in)	Strength-I (lb/in)
0	47	81
25.3	1131	1708

Steel Beam and Cross-Section Properties

Based on discussion with ODOT, this flange width considered acceptable to decrease weight of steel required in an equivalent W 36 section.

Assumed Pile Shape W 40x167

Pile Availability

AISC Member Producers	1
Non-Member Producers	1

Shaft Geometry

Shaft Diameter	48	in
Longest Beam Dimension	40.36335	in
Clear Distance	3.8183251	in

Steel Beam Geometry

Beam Depth (D)	38.6	in
Web Thickness (t_w)	0.65	in
Flange Width (B_f)	11.8	in
Flange Thickness (t_f)	1.03	in
Area of Steel (A_s)	49.2	in^2

Steel Properties

Yield Strength of Steel	50	ksi
Moment of Inertia (I_{xx}) of Steel	11600	in^4
Modulus of Elasticity of Steel (E)	29000	ksi
Modulus of Elasticity of Steel (E)	29000000	psi
EI (Steel Only)	3.364E+11	$lb*in^2$
Section Modulus (S_x)	600	in^3
Section Modulus (Z_x)	693	in^3
Shear-Buckling Coefficient (k)	5	
Ratio of Shear-Buckling Resistance (C)	1	
D/t_w	59.384615	
$1.12\sqrt{Ek/F_{yw}}$	60.313846	
$1.40\sqrt{Ek/F_{yw}}$	75.392307	

Determined by AASHTO LRFD Bridge Specifications Eqn's 6.10.9.3.2-4, 6.10.9.3.2-5, and 6.10.9.3.2-6

Shear Capacity Calculation

$V_u \le \phi V_{cr}$

$\phi_v =$ 1 *AASHTO LRFD Bridge Design Spec's 6.5.4.2*

$V_u =$ *shear in web due to factored permanent and construction loads applied to noncompact section (kips)*

$V_{cr} =$ *shear buckling resistance determined from Equation 6.10.9.3.3-1 (AASHTO LRFD Bridge Design Spec's)*

$V_n = V_{cr} = CV_p$

$V_p = 0.58F_{yw}Dt_w$

$V_p =$ *plastic shear force (kips)*

$C =$ *ratio of shear-buckling resistance to shear yield strength determined by AASHTO Eqn's 6.10.9.3.2-4, 6.10.9.3.2-5, 6.10.9.3.2-5, or 6.10.9.3.2-6*

$V_p =$ 0.58 * 50 * 38.6 * 0.65

$V_p =$ 727.6 kips

$\phi V_{cr} = \phi * C * V_p$

$\phi V_{cr} =$ 1 * 1 * 727.6

$\phi V_{cr =}$ 727.6 kips

$V_u =$ 556.19 kips *(from LPILE)*

$V_u =$ kips *(from PYWALL)*

$V_u < \phi V_{cr}$ **OK**

Flexure Capacity Calculation

$M_u \le \phi M_n$

$\phi_b =$ 1 *AASHTO LRFD Bridge Design Spec's 6.5.4.2*

$M_u =$ *Moment due to the factored loads*

$M_n =$ *Nominal flexural resistance of a section*

$S_x =$ *Elastic section modulus about the x-axis*

$\phi M_n = \phi * F_y * S_x$

$\phi M_n =$ 1 * 50 * 600

$\phi M_n =$ 30000 in*kips

$M_u =$ 25703 in*kips *(from LPILE)*

$M_u =$ in*kips *(from PYWALL)*

$M_u < \phi M_n$ **OK**

Minimum Pile Length

Top of Wall to Slip Plane =	25.3	ft	
Minimum Pile Length Below Slip Plane =	10	ft	*ODOT Minimum Required Length*
Minimum Required Pile Length =	35.3	ft	

Deflection Criteria

Pile Length Above Rock =	30.1	ft	Exposed Wall Height = 8.5 ft
Pile Length Above Rock =	361.2	in	Exposed Wall Height = 102 in

1.) *Per the ODOT GDM, pile-head deflection in the service limit state limited to 1% or less of the shaft length above bedrock, or 1% of total drilled shaft length if not embedded in bedrock.*

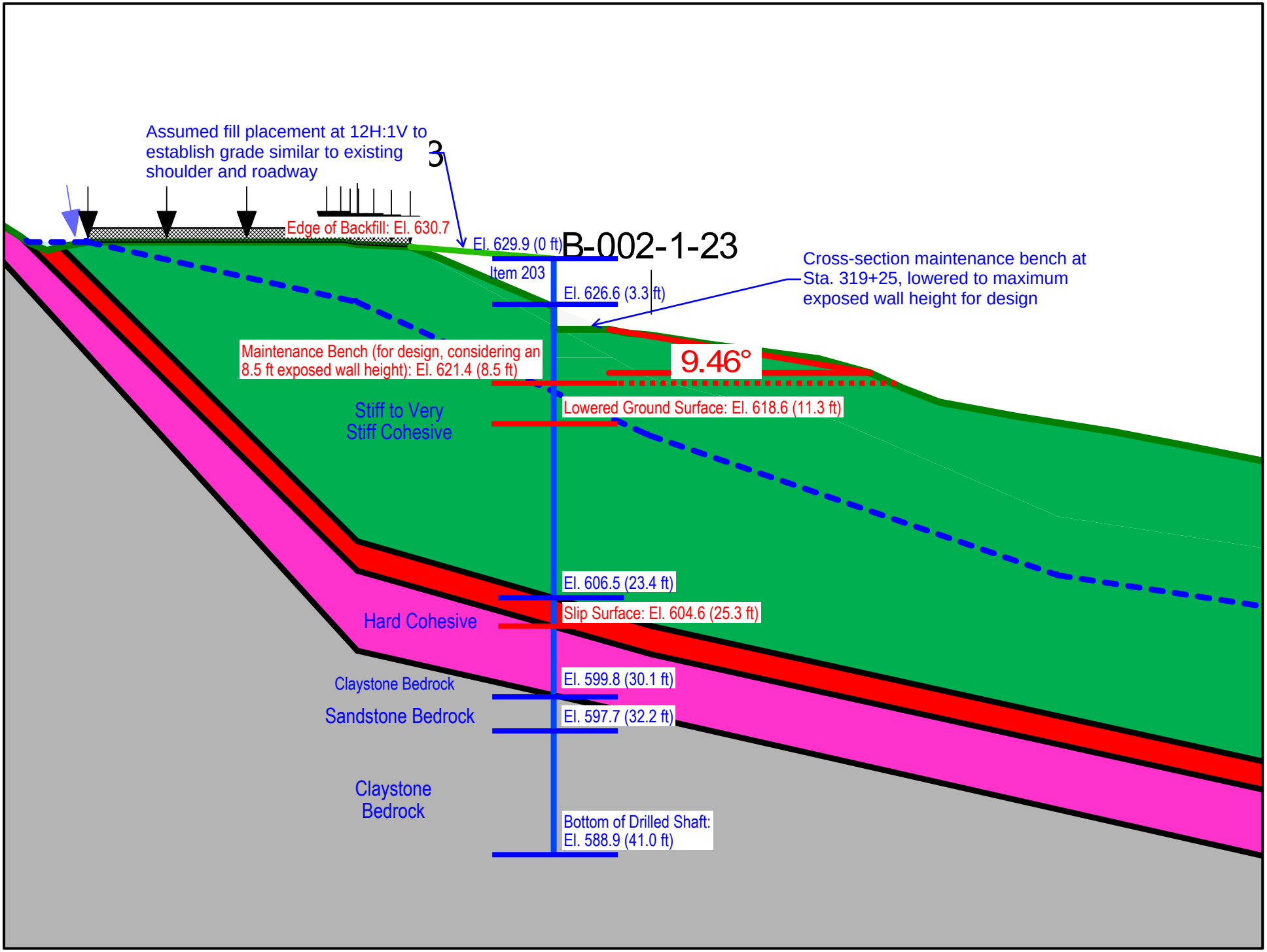
2.) *Following industry acceptance criteria, limit wall deflection to 1% of exposed wall height where ODOT landslide criteria does not govern. Alternatively, limit wall deflection to 1.5% of the exposed wall height in accordance with NCDOT guidelines. Use 1.5% wall deflection for PYWALL software.*

ODOT Landslide Criteria Governs YES

Drilled Shafts Located Within 10 feet of Edge of Pavement YES

1% Wall Height **OR** 2 inches- LPILE	2	in	$\delta =$ 1.992	in	*(from LPILE)*
1.5% Wall Height - PYWALL		in	$\delta =$	in	*(from PYWALL)*

LPILE Analyses
(W 40 x 167)


Assumed fill placement at 12H:1V to establish grade similar to existing shoulder and roadway
3
Edge of Backfill: El. 630.7
El. 629.9 (0 ft)
B-002-1-23
Item 203
El. 626.6 (3.3 ft)
Cross-section maintenance bench at Sta. 319+25, lowered to maximum exposed wall height for design
Maintenance Bench (for design, considering an 8.5 ft exposed wall height): El. 621.4 (8.5 ft)
9.46°
Stiff to Very Stiff Cohesive
Lowered Ground Surface: El. 618.6 (11.3 ft)
El. 606.5 (23.4 ft)
Hard Cohesive
Slip Surface: El. 604.6 (25.3 ft)
Claystone Bedrock
El. 599.8 (30.1 ft)
Sandstone Bedrock
El. 597.7 (32.2 ft)
Claystone Bedrock
Bottom of Drilled Shaft: El. 588.9 (41.0 ft)

Service Limit Analysis

```
================================================================================

                     LPile for Windows, Version 2019-11.002

                  Analysis of Individual Piles and Drilled Shafts
                 Subjected to Lateral Loading Using the p-y Method
                            © 1985-2019 by Ensoft, Inc.
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================================================================================

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--------------------------------------------------------------------------------
                              Files Used for Analysis
--------------------------------------------------------------------------------

Path to file locations:
\pwworking\east01\d3052832\

Name of input data file:
ATH-144-6.04 Service Case.lp11

Name of output report file:
ATH-144-6.04 Service Case.lp11

Name of plot output file:
ATH-144-6.04 Service Case.lp11

Name of runtime message file:
```

ATH-144-6.04 Service Case.lp11

Date and Time of Analysis

Date: March 9, 2023 Time: 15:22:40

Problem Title

Project Name: ATH-144-6.04

Job Number:

Client: ODOT D10

Engineer: HDR

Description: Service Case

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

 - Analysis uses p-y modification factors for p-y curves
 - Analysis uses layering correction (Method of Georgiadis)
 - Analysis includes loading by one distributed lateral load 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 = 41.000 ft
Depth of ground surface below top of pile = 11.3000 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	48.0000
2	41.000	48.0000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is an elastic pile

Cross-sectional Shape	=	Circular Pile
Length of section	=	41.000000 ft
Width of top of section	=	48.000000 in
Width of bottom of section	=	48.000000 in
Top Area	=	49.200000 sq. in
Bottom Area	=	49.200000 sq. in
Moment of Inertia at Top	=	11600. in^4
Moment of Inertia at Bottom	=	11600. in^4
Elastic Modulus	=	29000000. psi

Ground Slope and Pile Batter Angles

Ground Slope Angle	=	0.000 degrees
	=	0.000 radians
Pile Batter Angle	=	0.000 degrees
	=	0.000 radians

Soil and Rock Layering Information

The soil profile is modelled using 5 layers

Layer 1 is stiff clay without free water

Distance from top of pile to top of layer	=	11.300000 ft
Distance from top of pile to bottom of layer	=	23.400000 ft
Effective unit weight at top of layer	=	77.600000 pcf
Effective unit weight at bottom of layer	=	77.600000 pcf
Undrained cohesion at top of layer	=	1200. psf
Undrained cohesion at bottom of layer	=	1200. psf
Epsilon-50 at top of layer	=	0.007000
Epsilon-50 at bottom of layer	=	0.007000

Layer 2 is stiff clay without free water

Distance from top of pile to top of layer	=	23.400000 ft
Distance from top of pile to bottom of layer	=	30.100000 ft
Effective unit weight at top of layer	=	77.600000 pcf
Effective unit weight at bottom of layer	=	77.600000 pcf
Undrained cohesion at top of layer	=	4000. psf
Undrained cohesion at bottom of layer	=	4000. psf
Epsilon-50 at top of layer	=	0.005000
Epsilon-50 at bottom of layer	=	0.005000

Layer 3 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer	=	30.100000 ft
Distance from top of pile to bottom of layer	=	32.200000 ft
Effective unit weight at top of layer	=	150.000000 pcf
Effective unit weight at bottom of layer	=	150.000000 pcf
Uniaxial compressive strength at top of layer	=	50.000000 psi
Uniaxial compressive strength at bottom of layer	=	50.000000 psi
Initial modulus of rock at top of layer	=	1700. psi
Initial modulus of rock at bottom of layer	=	1700. psi
RQD of rock at top of layer	=	45.000000 %
RQD of rock at bottom of layer	=	45.000000 %
k rm of rock at top of layer	=	0.0005000
k rm of rock at bottom of layer	=	0.0005000

Layer 4 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer	=	32.200000 ft
Distance from top of pile to bottom of layer	=	38.700000 ft
Effective unit weight at top of layer	=	165.000000 pcf
Effective unit weight at bottom of layer	=	165.000000 pcf
Uniaxial compressive strength at top of layer	=	4900. psi
Uniaxial compressive strength at bottom of layer	=	4900. psi
Initial modulus of rock at top of layer	=	1029700. psi
Initial modulus of rock at bottom of layer	=	1029700. psi
RQD of rock at top of layer	=	80.000000 %
RQD of rock at bottom of layer	=	80.000000 %
k rm of rock at top of layer	=	0.0005000
k rm of rock at bottom of layer	=	0.0005000

Layer 5 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer	=	38.700000 ft
Distance from top of pile to bottom of layer	=	50.000000 ft
Effective unit weight at top of layer	=	165.000000 pcf
Effective unit weight at bottom of layer	=	165.000000 pcf
Uniaxial compressive strength at top of layer	=	1800. psi
Uniaxial compressive strength at bottom of layer	=	1800. psi
Initial modulus of rock at top of layer	=	174000. psi
Initial modulus of rock at bottom of layer	=	174000. psi
RQD of rock at top of layer	=	80.000000 %
RQD of rock at bottom of layer	=	80.000000 %
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 9.000 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 = 165.00 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	Undrained Cohesion psf	Uniaxial qu psi	RQD %	E50 or krm	Rock Mass Modulus psi
1	Stiff Clay	11.3000	77.6000	1200.	--	--	0.00700	--
	w/o Free Water	23.4000	77.6000	1200.	--	--	0.00700	--
2	Stiff Clay	23.4000	77.6000	4000.	--	--	0.00500	--
	w/o Free Water	30.1000	77.6000	4000.	--	--	0.00500	--
3	Weak	30.1000	150.0000	--	50.0000	45.0000	5.00E-04	1700.
	Rock	32.2000	150.0000	--	50.0000	45.0000	5.00E-04	1700.
4	Weak	32.2000	165.0000	--	4900.	80.0000	5.00E-04	1029700.
	Rock	38.7000	165.0000	--	4900.	80.0000	5.00E-04	1029700.
5	Weak	38.7000	165.0000	--	1800.	80.0000	5.00E-04	174000.
	Rock	50.0000	165.0000	--	1800.	80.0000	5.00E-04	174000.

p-y Modification Factors for Group Action

Distribution of p-y modifiers with depth defined using 2 points

Point No.	Depth X ft	p-mult	y-mult
1	11.300	0.7300	1.0000
2	30.100	0.7300	1.0000

Static Loading Type

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

Distributed Lateral Loading Used For All Load Cases

Distributed lateral load intensity defined using 2 points

Point No.	Depth X in	Dist. Load lb/in
1	0.000	47.000
2	303.600	1131.000

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length	Run Analysis
1	1	V = 0.0000 lbs	M = 0.0000 in-lbs	0.0000000	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:

Moment-curvature properties were derived from elastic section properties

---

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	11.3000	0.00	N.A.	No	0.00	241905.
2	23.4000	4.5430	Yes	No	241905.	444751.

3	30.1000	18.8000	No	Yes	N.A.	N.A.
4	32.2000	20.9000	No	Yes	N.A.	N.A.
5	38.7000	27.4000	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 = 0.0 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 in-lb^2	Soil Res. p lb/inch	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	1.9919	-1.85E-05	0.00	-0.00673	3.83E-08	3.36E+11	0.00	0.00	51.3917
0.4100	1.9588	622.0041	285.2579	-0.00673	1.2869	3.36E+11	0.00	0.00	64.5668
0.8200	1.9257	2807.	646.1409	-0.00673	5.8075	3.36E+11	0.00	0.00	82.1336
1.2300	1.8926	6980.	1093.	-0.00673	14.4414	3.36E+11	0.00	0.00	99.7004
1.6400	1.8595	13567.	1627.	-0.00673	28.0686	3.36E+11	0.00	0.00	117.2672
2.0500	1.8263	22992.	2247.	-0.00673	47.5688	3.36E+11	0.00	0.00	134.8340
2.4600	1.7932	35681.	2954.	-0.00673	73.8218	3.36E+11	0.00	0.00	152.4008
2.8700	1.7601	52059.	3747.	-0.00673	107.7074	3.36E+11	0.00	0.00	169.9676
3.2800	1.7270	72551.	4626.	-0.00673	150.1053	3.36E+11	0.00	0.00	187.5344
3.6900	1.6939	97583.	5592.	-0.00673	201.8953	3.36E+11	0.00	0.00	205.1012
4.1000	1.6608	127579.	6645.	-0.00672	263.9573	3.36E+11	0.00	0.00	222.6680
4.5100	1.6278	162966.	7783.	-0.00672	337.1709	3.36E+11	0.00	0.00	240.2348
4.9200	1.5947	204168.	9009.	-0.00672	422.4161	3.36E+11	0.00	0.00	257.8016
5.3300	1.5616	251610.	10320.	-0.00672	520.5725	3.36E+11	0.00	0.00	275.3684

5.7400	1.5286	305718.	11718.	-0.00671	632.5200	3.36E+11	0.00	0.00	292.9352
6.1500	1.4956	366917.	13203.	-0.00671	759.1383	3.36E+11	0.00	0.00	310.5020
6.5600	1.4626	435632.	14774.	-0.00670	901.3073	3.36E+11	0.00	0.00	328.0688
6.9700	1.4296	512288.	16431.	-0.00669	1060.	3.36E+11	0.00	0.00	345.6356
7.3800	1.3967	597311.	18175.	-0.00669	1236.	3.36E+11	0.00	0.00	363.2024
7.7900	1.3639	691126.	20005.	-0.00668	1430.	3.36E+11	0.00	0.00	380.7692
8.2000	1.3310	794158.	21921.	-0.00667	1643.	3.36E+11	0.00	0.00	398.3360
8.6100	1.2983	906832.	23924.	-0.00665	1876.	3.36E+11	0.00	0.00	415.9028
9.0200	1.2656	1029573.	26014.	-0.00664	2130.	3.36E+11	0.00	0.00	433.4696
9.4300	1.2329	1162808.	28190.	-0.00662	2406.	3.36E+11	0.00	0.00	451.0364
9.8400	1.2004	1306960.	30452.	-0.00661	2704.	3.36E+11	0.00	0.00	468.6032
10.2500	1.1679	1462456.	32801.	-0.00659	3026.	3.36E+11	0.00	0.00	486.1700
10.6600	1.1356	1629720.	35236.	-0.00656	3372.	3.36E+11	0.00	0.00	503.7368
11.0700	1.1033	1809177.	37758.	-0.00654	3743.	3.36E+11	0.00	0.00	521.3036
11.4800	1.0712	2001254.	39208.	-0.00651	4141.	3.36E+11	-470.7521	2162.	538.8704
11.8900	1.0393	2194979.	39565.	-0.00648	4541.	3.36E+11	-479.1755	2268.	556.4372
12.3000	1.0075	2390575.	39968.	-0.00645	4946.	3.36E+11	-487.3490	2380.	574.0040
12.7100	0.9759	2588268.	40418.	-0.00641	5355.	3.36E+11	-495.2657	2497.	591.5708
13.1200	0.9444	2788292.	40917.	-0.00637	5769.	3.36E+11	-502.9185	2620.	609.1375
13.5300	0.9132	2990888.	41464.	-0.00633	6188.	3.36E+11	-510.3002	2749.	626.7043
13.9400	0.8822	3196301.	42063.	-0.00628	6613.	3.36E+11	-517.4031	2886.	644.2711
14.3500	0.8514	3404785.	42713.	-0.00623	7044.	3.36E+11	-524.2192	3029.	661.8379
14.7600	0.8208	3616601.	43418.	-0.00618	7483.	3.36E+11	-530.7402	3181.	679.4047
15.1700	0.7905	3832015.	44177.	-0.00613	7928.	3.36E+11	-536.9574	3342.	696.9715
15.5800	0.7605	4051303.	44993.	-0.00607	8382.	3.36E+11	-542.8615	3512.	714.5383
15.9900	0.7308	4274746.	45867.	-0.00601	8844.	3.36E+11	-548.4432	3692.	732.1051
16.4000	0.7014	4502635.	46801.	-0.00595	9316.	3.36E+11	-553.6923	3884.	749.6719
16.8100	0.6723	4735268.	47796.	-0.00588	9797.	3.36E+11	-558.5984	4088.	767.2387
17.2200	0.6435	4972951.	48855.	-0.00581	10289.	3.36E+11	-563.1504	4305.	784.8055
17.6300	0.6152	5216000.	49978.	-0.00573	10792.	3.36E+11	-567.3366	4538.	802.3723
18.0400	0.5871	5464739.	51169.	-0.00565	11306.	3.36E+11	-571.1449	4786.	819.9391
18.4500	0.5595	5719499.	52427.	-0.00557	11833.	3.36E+11	-574.5623	5052.	837.5059
18.8600	0.5323	5980625.	53757.	-0.00549	12374.	3.36E+11	-577.5752	5338.	855.0727
19.2700	0.5055	6248468.	55159.	-0.00540	12928.	3.36E+11	-580.1693	5647.	872.6395
19.6800	0.4792	6523390.	56636.	-0.00530	13497.	3.36E+11	-582.3294	5979.	890.2063
20.0900	0.4533	6805765.	58190.	-0.00521	14081.	3.36E+11	-584.0394	6339.	907.7731
20.5000	0.4280	7095977.	59823.	-0.00511	14681.	3.36E+11	-585.2822	6729.	925.3399
20.9100	0.4031	7394420.	61537.	-0.00500	15299.	3.36E+11	-586.0399	7153.	942.9067
21.3200	0.3788	7701501.	63335.	-0.00489	15934.	3.36E+11	-586.2934	7616.	960.4735
21.7300	0.3550	8017641.	65220.	-0.00477	16588.	3.36E+11	-586.0223	8122.	978.0403
22.1400	0.3318	8343269.	67194.	-0.00465	17262.	3.36E+11	-585.2052	8678.	995.6071
22.5500	0.3092	8678832.	69260.	-0.00453	17956.	3.36E+11	-583.8192	9290.	1013.

22.9600	0.2872	9024788.	71421.	-0.00440	18672.	3.36E+11	-581.8403	9967.	1031.
23.3700	0.2659	9381610.	73679.	-0.00427	19410.	3.36E+11	-579.2429	10718.	1048.
23.7800	0.2452	9749786.	73902.	-0.00413	20172.	3.36E+11	-1444.	28969.	1066.
24.1900	0.2253	1.01E+07	72104.	-0.00398	20915.	3.36E+11	-1436.	31365.	1083.
24.6000	0.2061	1.05E+07	70435.	-0.00383	21640.	3.36E+11	-1427.	34060.	1101.
25.0100	0.1876	1.08E+07	68904.	-0.00367	22349.	3.36E+11	-1415.	37110.	1119.
25.4200	0.1699	1.11E+07	65303.	-0.00351	23043.	3.36E+11	-1402.	40580.	234.0981
25.8300	0.1530	1.14E+07	59022.	-0.00335	23678.	3.36E+11	-1386.	44553.	0.00
26.2400	0.1370	1.17E+07	52248.	-0.00318	24244.	3.36E+11	-1368.	49132.	0.00
26.6500	0.1217	1.20E+07	45568.	-0.00301	24742.	3.36E+11	-1347.	54453.	0.00
27.0600	0.1074	1.22E+07	38995.	-0.00283	25172.	3.36E+11	-1325.	60686.	0.00
27.4700	0.09390	1.23E+07	32541.	-0.00265	25536.	3.36E+11	-1299.	68062.	0.00
27.8800	0.08130	1.25E+07	26220.	-0.00247	25835.	3.36E+11	-1271.	76885.	0.00
28.2900	0.06960	1.26E+07	20047.	-0.00229	26070.	3.36E+11	-1239.	87575.	0.00
28.7000	0.05881	1.27E+07	14037.	-0.00210	26243.	3.36E+11	-1204.	100720.	0.00
29.1100	0.04893	1.27E+07	8209.	-0.00191	26355.	3.36E+11	-1165.	117165.	0.00
29.5200	0.03997	1.28E+07	2581.	-0.00173	26410.	3.36E+11	-1122.	138166.	0.00
29.9300	0.03192	1.28E+07	-2825.	-0.00154	26408.	3.36E+11	-1075.	165665.	0.00
30.3400	0.02480	1.27E+07	-7728.	-0.00136	26352.	3.36E+11	-918.0560	182144.	0.00
30.7500	0.01859	1.27E+07	-12366.	-0.00117	26251.	3.36E+11	-967.3161	256031.	0.00
31.1600	0.01329	1.26E+07	-17189.	-9.84E-04	26100.	3.36E+11	-993.5053	367756.	0.00
31.5700	0.00890	1.25E+07	-22076.	-8.01E-04	25901.	3.36E+11	-992.8633	548712.	0.00
31.9800	0.00541	1.24E+07	-26879.	-6.18E-04	25651.	3.36E+11	-959.8806	872262.	0.00
32.3900	0.00282	1.23E+07	-171623.	-4.38E-04	25353.	3.36E+11	-57879.	1.01E+08	0.00
32.8000	0.00110	1.07E+07	-435624.	-2.70E-04	22157.	3.36E+11	-49439.	2.20E+08	0.00
33.2100	1.60E-04	7967612.	-637877.	-1.34E-04	16485.	3.36E+11	-32778.	1.01E+09	0.00
33.6200	-2.10E-04	4432542.	-626342.	-4.29E-05	9171.	3.36E+11	37467.	8.76E+08	0.00
34.0300	-2.62E-04	1804404.	-430542.	2.73E-06	3733.	3.36E+11	42127.	7.91E+08	0.00
34.4400	-1.84E-04	196004.	-226360.	1.74E-05	405.5264	3.36E+11	40874.	1.10E+09	0.00
34.8500	-9.10E-05	-422979.	-66233.	1.57E-05	875.1297	3.36E+11	24218.	1.31E+09	0.00
35.2600	-2.90E-05	-455724.	13327.	9.28E-06	942.8765	3.36E+11	8123.	1.38E+09	0.00
35.6700	2.46E-07	-291838.	33132.	3.81E-06	603.8029	3.36E+11	-72.4622	1.45E+09	0.00
36.0800	8.50E-06	-129707.	26512.	7.28E-07	268.3583	3.36E+11	-2619.	1.52E+09	0.00
36.4900	7.41E-06	-30961.	14194.	-4.47E-07	64.0565	3.36E+11	-2389.	1.59E+09	0.00
36.9000	4.10E-06	9963.	4925.	-6.00E-07	20.6127	3.36E+11	-1379.	1.65E+09	0.00
37.3100	1.50E-06	17505.	235.8719	-3.99E-07	36.2182	3.36E+11	-527.3114	1.72E+09	0.00
37.7200	1.69E-07	12284.	-1213.	-1.82E-07	25.4148	3.36E+11	-61.7353	1.79E+09	0.00
38.1300	-2.82E-07	5568.	-1102.	-5.10E-08	11.5195	3.36E+11	106.7889	1.86E+09	0.00
38.5400	-3.33E-07	1437.	-518.1183	1.81E-10	2.9724	3.36E+11	130.7042	1.93E+09	0.00
38.9500	-2.80E-07	469.4587	-149.1960	1.41E-08	0.9713	3.36E+11	19.2642	3.38E+08	0.00
39.3600	-1.94E-07	-31.4270	-67.8834	1.73E-08	0.06502	3.36E+11	13.7897	3.50E+08	0.00
39.7700	-1.10E-07	-198.5137	-14.1070	1.56E-08	0.4107	3.36E+11	8.0706	3.62E+08	0.00

40.1800	-4.00E-08	-170.2398	13.2134	1.29E-08	0.3522	3.36E+11	3.0352	3.73E+08	0.00
40.5900	1.76E-08	-68.4935	17.3008	1.12E-08	0.1417	3.36E+11	-1.3737	3.85E+08	0.00
41.0000	7.02E-08	0.00	0.00	1.07E-08	0.00	3.36E+11	-5.6591	1.98E+08	0.00

* The above values of total stress are combined axial and bending stresses.

Output Summary for Load Case No. 1:

Pile-head deflection = 1.99190605 inches
Computed slope at pile head = -0.00673004 radians
Maximum bending moment = 12764713. inch-lbs
Maximum shear force = -637877. lbs
Depth of maximum bending moment = 29.52000000 feet below pile head
Depth of maximum shear force = 33.21000000 feet below pile head
Number of iterations = 22
Number of zero deflection points = 4

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

Boundary Condition Type 1, Shear and Moment

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

Pile Length feet	Pile Head Deflection inches	Maximum Moment ln-lbs	Maximum Shear lbs
41.00000	1.99190605	12764713.	-637877.
38.95000	2.01856061	12979088.	-650369.
36.90000	1.99006685	12623055.	-643611.
34.85000	2.00283647	12758225.	-655045.
32.80000	6.07525153	7824002.	-206502.
30.75000	25.74676502	4073365.	-89528.
28.70000	79.61190706	3976586.	-90717.

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	0.00	M, in-lb	0.00	0.00	1.9919	-0.00673	-637877.	1.28E+07

Maximum pile-head deflection = 1.9919060465 inches
Maximum pile-head rotation = -0.0067300381 radians = -0.385603 deg.

Summary of Warning Messages

The following warning was reported 1182 times

**** Warning ****

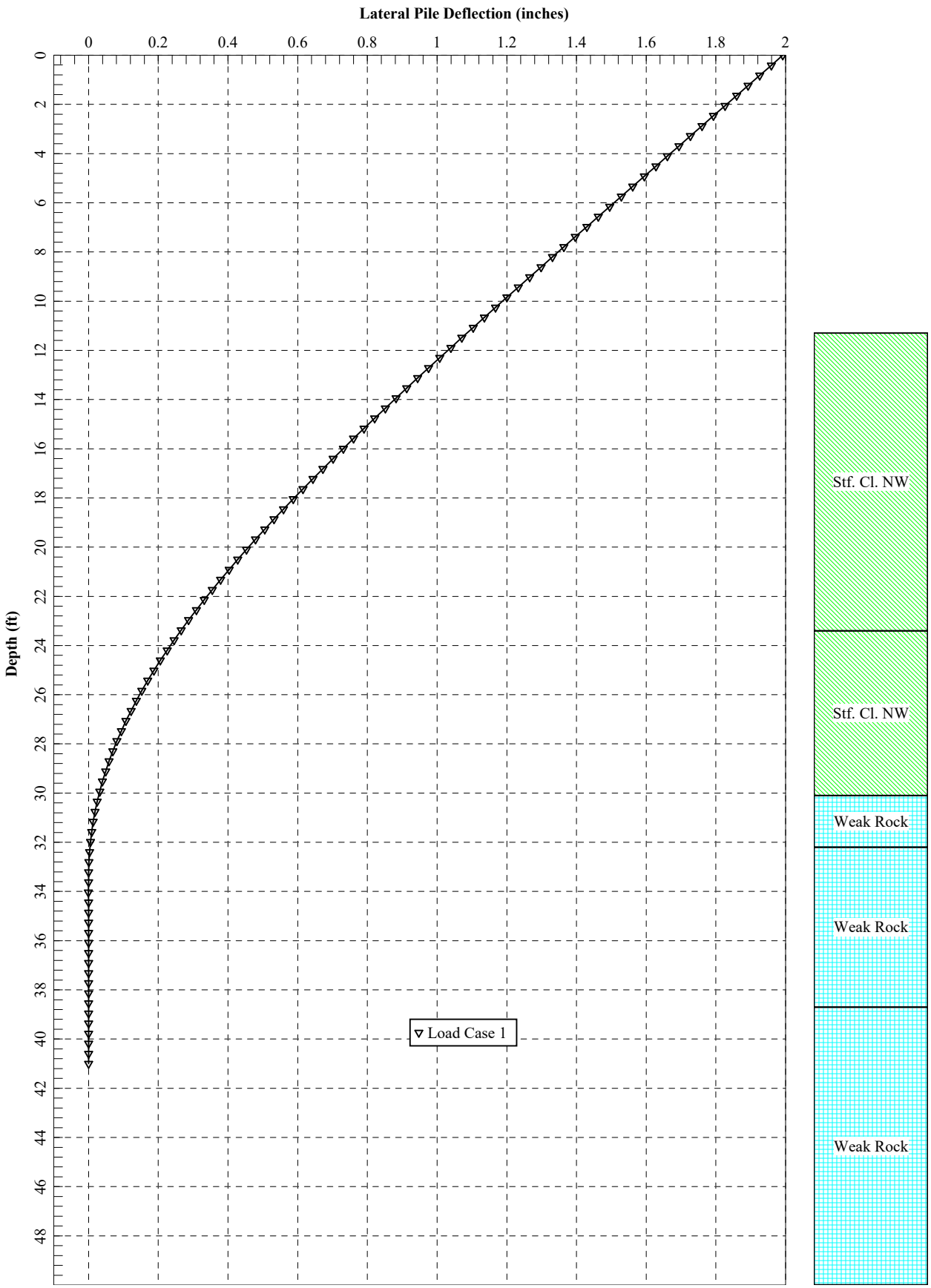
An unreasonable input value for compressive strength has been specified
for a soil defined using the weak rock criteria. The input value is less
than 100 psi. Please check your input data for correctness.

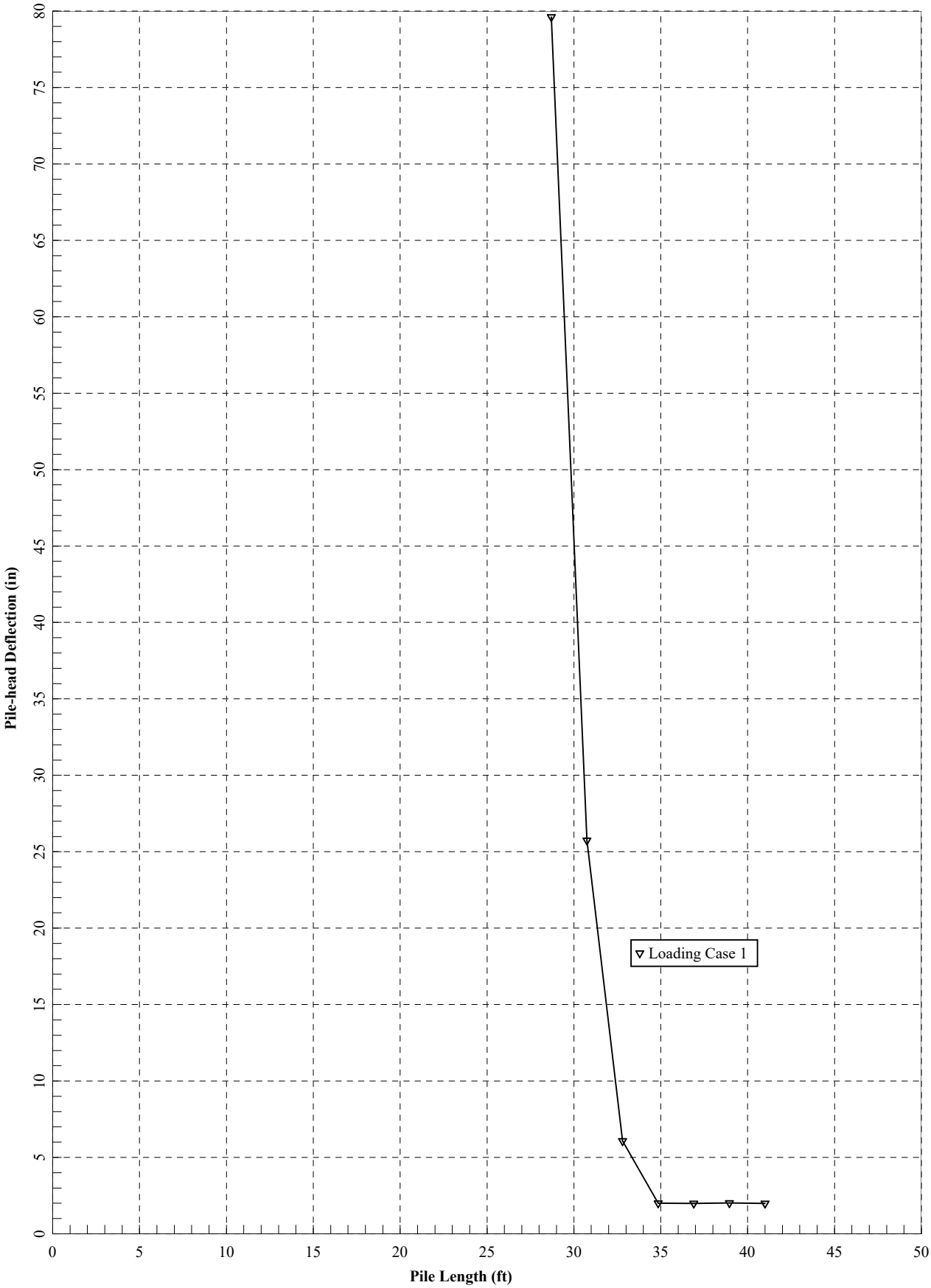
The following warning was reported 2007 times

**** Warning ****

An unreasonable input value for unconfined compressive strength has been specified for a soil defined using the weak rock criteria. The input value is greater than 500 psi. Please check your input data for correctness.

The analysis ended normally.


Lateral Pile Deflection (inches)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
Depth (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
Load Case 1
Stf. Cl. NW
Stf. Cl. NW
Weak Rock
Weak Rock
Weak Rock


Pile-head Deflection (in)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
Pile Length (ft)
0
5
10
15
20
25
30
35
40
45
50
Loading Case 1

Strength Limit Analysis

```
================================================================================

                     LPile for Windows, Version 2019-11.002

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

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--------------------------------------------------------------------------------
                              Files Used for Analysis
--------------------------------------------------------------------------------

Path to file locations:
\pwworking\east01\d3052832\

Name of input data file:
ATH-144-6.04 Strength Case.lp11

Name of output report file:
ATH-144-6.04 Strength Case.lp11

Name of plot output file:
ATH-144-6.04 Strength Case.lp11

Name of runtime message file:
```

ATH-144-6.04 Strength Case.lp11

Date and Time of Analysis

Date: March 9, 2023 Time: 15:09:54

Problem Title

Project Name: ATH-144-6.04

Job Number:

Client: ODOT D10

Engineer: HDR

Description: Strength Case

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

 - Analysis uses p-y modification factors for p-y curves
 - Analysis uses layering correction (Method of Georgiadis)
 - Analysis includes loading by one distributed lateral load 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 = 41.000 ft
Depth of ground surface below top of pile = 11.3000 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	48.0000
2	41.000	48.0000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is an elastic pile

Cross-sectional Shape	=	Circular Pile
Length of section	=	41.000000 ft
Width of top of section	=	48.000000 in
Width of bottom of section	=	48.000000 in
Top Area	=	49.200000 sq. in
Bottom Area	=	49.200000 sq. in
Moment of Inertia at Top	=	11600. in^4
Moment of Inertia at Bottom	=	11600. in^4
Elastic Modulus	=	29000000. psi

Ground Slope and Pile Batter Angles

Ground Slope Angle	=	0.000 degrees
	=	0.000 radians
Pile Batter Angle	=	0.000 degrees
	=	0.000 radians

Soil and Rock Layering Information

The soil profile is modelled using 5 layers

Layer 1 is stiff clay without free water

Distance from top of pile to top of layer	=	11.300000 ft
Distance from top of pile to bottom of layer	=	23.400000 ft
Effective unit weight at top of layer	=	77.600000 pcf
Effective unit weight at bottom of layer	=	77.600000 pcf
Undrained cohesion at top of layer	=	1200. psf
Undrained cohesion at bottom of layer	=	1200. psf
Epsilon-50 at top of layer	=	0.007000
Epsilon-50 at bottom of layer	=	0.007000

Layer 2 is stiff clay without free water

Distance from top of pile to top of layer	=	23.400000 ft
Distance from top of pile to bottom of layer	=	30.100000 ft
Effective unit weight at top of layer	=	77.600000 pcf
Effective unit weight at bottom of layer	=	77.600000 pcf
Undrained cohesion at top of layer	=	4000. psf
Undrained cohesion at bottom of layer	=	4000. psf
Epsilon-50 at top of layer	=	0.005000
Epsilon-50 at bottom of layer	=	0.005000

Layer 3 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer	=	30.100000 ft
Distance from top of pile to bottom of layer	=	32.200000 ft
Effective unit weight at top of layer	=	150.000000 pcf
Effective unit weight at bottom of layer	=	150.000000 pcf
Uniaxial compressive strength at top of layer	=	50.000000 psi
Uniaxial compressive strength at bottom of layer	=	50.000000 psi
Initial modulus of rock at top of layer	=	1700. psi
Initial modulus of rock at bottom of layer	=	1700. psi
RQD of rock at top of layer	=	45.000000 %
RQD of rock at bottom of layer	=	45.000000 %
k rm of rock at top of layer	=	0.0005000
k rm of rock at bottom of layer	=	0.0005000

Layer 4 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer	=	32.200000 ft
Distance from top of pile to bottom of layer	=	38.700000 ft
Effective unit weight at top of layer	=	165.000000 pcf
Effective unit weight at bottom of layer	=	165.000000 pcf
Uniaxial compressive strength at top of layer	=	4900. psi
Uniaxial compressive strength at bottom of layer	=	4900. psi
Initial modulus of rock at top of layer	=	1029700. psi
Initial modulus of rock at bottom of layer	=	1029700. psi
RQD of rock at top of layer	=	80.000000 %
RQD of rock at bottom of layer	=	80.000000 %
k rm of rock at top of layer	=	0.0005000
k rm of rock at bottom of layer	=	0.0005000

Layer 5 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer	=	38.700000 ft
Distance from top of pile to bottom of layer	=	50.000000 ft
Effective unit weight at top of layer	=	165.000000 pcf
Effective unit weight at bottom of layer	=	165.000000 pcf
Uniaxial compressive strength at top of layer	=	1800. psi
Uniaxial compressive strength at bottom of layer	=	1800. psi
Initial modulus of rock at top of layer	=	174000. psi
Initial modulus of rock at bottom of layer	=	174000. psi
RQD of rock at top of layer	=	80.000000 %
RQD of rock at bottom of layer	=	80.000000 %
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 9.000 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 = 165.00 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	Undrained Cohesion psf	Uniaxial qu psi	RQD %	E50 or krm	Rock Mass Modulus psi
1	Stiff Clay	11.3000	77.6000	1200.	--	--	0.00700	--
	w/o Free Water	23.4000	77.6000	1200.	--	--	0.00700	--
2	Stiff Clay	23.4000	77.6000	4000.	--	--	0.00500	--
	w/o Free Water	30.1000	77.6000	4000.	--	--	0.00500	--
3	Weak	30.1000	150.0000	--	50.0000	45.0000	5.00E-04	1700.
	Rock	32.2000	150.0000	--	50.0000	45.0000	5.00E-04	1700.
4	Weak	32.2000	165.0000	--	4900.	80.0000	5.00E-04	1029700.
	Rock	38.7000	165.0000	--	4900.	80.0000	5.00E-04	1029700.
5	Weak	38.7000	165.0000	--	1800.	80.0000	5.00E-04	174000.
	Rock	50.0000	165.0000	--	1800.	80.0000	5.00E-04	174000.

p-y Modification Factors for Group Action

Distribution of p-y modifiers with depth defined using 2 points

Point No.	Depth X ft	p-mult	y-mult
1	11.300	0.7300	1.0000
2	30.100	0.7300	1.0000

Static Loading Type

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

Distributed Lateral Loading Used For All Load Cases

Distributed lateral load intensity defined using 2 points

Point No.	Depth X in	Dist. Load lb/in
1	0.000	81.000
2	303.600	1708.000

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length	Run Analysis
1	1	V = 0.0000 lbs	M = 0.0000 in-lbs	0.0000000	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

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

Number of Pile Sections Analyzed = 1

Pile Section No. 1:

Moment-curvature properties were derived from elastic section properties

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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	11.3000	0.00	N.A.	No	0.00	241905.
2	23.4000	4.5430	Yes	No	241905.	444751.

3	30.1000	18.8000	No	Yes	N.A.	N.A.
4	32.2000	20.9000	No	Yes	N.A.	N.A.
5	38.7000	27.4000	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 = 0.0 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 in-lb^2	Soil Res. p lb/inch	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	3.7879	-1.11E-04	0.00	-0.01244	2.30E-07	3.36E+11	0.00	0.00	87.5916
0.4100	3.7267	1060.	479.5967	-0.01244	2.1934	3.36E+11	0.00	0.00	107.3664
0.8200	3.6655	4719.	1073.	-0.01244	9.7639	3.36E+11	0.00	0.00	133.7328
1.2300	3.6043	11616.	1796.	-0.01244	24.0321	3.36E+11	0.00	0.00	160.0992
1.6400	3.5430	22387.	2648.	-0.01244	46.3184	3.36E+11	0.00	0.00	186.4656
2.0500	3.4818	37673.	3630.	-0.01244	77.9433	3.36E+11	0.00	0.00	212.8320
2.4600	3.4206	58110.	4742.	-0.01244	120.2273	3.36E+11	0.00	0.00	239.1984
2.8700	3.3594	84337.	5984.	-0.01244	174.4909	3.36E+11	0.00	0.00	265.5648
3.2800	3.2982	116993.	7356.	-0.01244	242.0545	3.36E+11	0.00	0.00	291.9312
3.6900	3.2370	156715.	8857.	-0.01244	324.2387	3.36E+11	0.00	0.00	318.2976
4.1000	3.1758	204143.	10488.	-0.01243	422.3640	3.36E+11	0.00	0.00	344.6640
4.5100	3.1147	259913.	12248.	-0.01243	537.7508	3.36E+11	0.00	0.00	371.0304
4.9200	3.0535	324664.	14138.	-0.01243	671.7196	3.36E+11	0.00	0.00	397.3968
5.3300	2.9924	399036.	16159.	-0.01242	825.5910	3.36E+11	0.00	0.00	423.7632

5.7400	2.9313	483665.	18308.	-0.01241	1001.	3.36E+11	0.00	0.00	450.1296
6.1500	2.8702	579190.	20588.	-0.01241	1198.	3.36E+11	0.00	0.00	476.4960
6.5600	2.8092	686249.	22997.	-0.01240	1420.	3.36E+11	0.00	0.00	502.8625
6.9700	2.7483	805480.	25536.	-0.01239	1667.	3.36E+11	0.00	0.00	529.2289
7.3800	2.6874	937523.	28205.	-0.01237	1940.	3.36E+11	0.00	0.00	555.5953
7.7900	2.6265	1083014.	31003.	-0.01236	2241.	3.36E+11	0.00	0.00	581.9617
8.2000	2.5657	1242593.	33931.	-0.01234	2571.	3.36E+11	0.00	0.00	608.3281
8.6100	2.5051	1416897.	36989.	-0.01232	2932.	3.36E+11	0.00	0.00	634.6945
9.0200	2.4445	1606564.	40177.	-0.01230	3324.	3.36E+11	0.00	0.00	661.0609
9.4300	2.3840	1812234.	43494.	-0.01228	3749.	3.36E+11	0.00	0.00	687.4273
9.8400	2.3237	2034544.	46941.	-0.01225	4209.	3.36E+11	0.00	0.00	713.7937
10.2500	2.2635	2274132.	50518.	-0.01222	4705.	3.36E+11	0.00	0.00	740.1601
10.6600	2.2035	2531637.	54224.	-0.01218	5238.	3.36E+11	0.00	0.00	766.5265
11.0700	2.1437	2807696.	58060.	-0.01214	5809.	3.36E+11	0.00	0.00	792.8929
11.4800	2.0840	3102949.	60658.	-0.01210	6420.	3.36E+11	-555.9627	1313.	819.2593
11.8900	2.0246	3404575.	61994.	-0.01205	7044.	3.36E+11	-566.1037	1376.	845.6257
12.3000	1.9655	3712967.	63410.	-0.01200	7682.	3.36E+11	-575.9636	1442.	871.9921
12.7100	1.9066	4028525.	64907.	-0.01194	8335.	3.36E+11	-585.5348	1511.	898.3585
13.1200	1.8480	4351656.	66489.	-0.01188	9003.	3.36E+11	-594.8092	1584.	924.7249
13.5300	1.7897	4682772.	68154.	-0.01181	9688.	3.36E+11	-603.7785	1660.	951.0913
13.9400	1.7317	5022296.	69907.	-0.01174	10391.	3.36E+11	-612.4339	1740.	977.4577
14.3500	1.6741	5370655.	71747.	-0.01167	11112.	3.36E+11	-620.7665	1824.	1004.
14.7600	1.6169	5728287.	73677.	-0.01159	11852.	3.36E+11	-628.7666	1913.	1030.
15.1700	1.5601	6095637.	75698.	-0.01150	12612.	3.36E+11	-636.4245	2007.	1057.
15.5800	1.5037	6473156.	77812.	-0.01141	13393.	3.36E+11	-643.7297	2106.	1083.
15.9900	1.4478	6861306.	80021.	-0.01131	14196.	3.36E+11	-650.6715	2211.	1109.
16.4000	1.3924	7260558.	82326.	-0.01121	15022.	3.36E+11	-657.2384	2322.	1136.
16.8100	1.3376	7671390.	84729.	-0.01110	15872.	3.36E+11	-663.4185	2440.	1162.
17.2200	1.2832	8094292.	87233.	-0.01098	16747.	3.36E+11	-669.1994	2566.	1188.
17.6300	1.2295	8529762.	89839.	-0.01086	17648.	3.36E+11	-674.5678	2699.	1215.
18.0400	1.1764	8978307.	92549.	-0.01073	18576.	3.36E+11	-679.5099	2842.	1241.
18.4500	1.1239	9440448.	95366.	-0.01060	19532.	3.36E+11	-684.0113	2994.	1267.
18.8600	1.0721	9916712.	98292.	-0.01046	20517.	3.36E+11	-688.0565	3158.	1294.
19.2700	1.0210	1.04E+07	101329.	-0.01031	21533.	3.36E+11	-691.6294	3333.	1320.
19.6800	0.9706	1.09E+07	104478.	-0.01015	22580.	3.36E+11	-694.7128	3521.	1347.
20.0900	0.9211	1.14E+07	107744.	-0.00999	23660.	3.36E+11	-697.2887	3725.	1373.
20.5000	0.8724	1.20E+07	111128.	-0.00982	24774.	3.36E+11	-699.3380	3944.	1399.
20.9100	0.8245	1.25E+07	114633.	-0.00964	25923.	3.36E+11	-700.8403	4182.	1426.
21.3200	0.7775	1.31E+07	118262.	-0.00945	27108.	3.36E+11	-701.7742	4441.	1452.
21.7300	0.7315	1.37E+07	122018.	-0.00926	28330.	3.36E+11	-702.1169	4722.	1478.
22.1400	0.6864	1.43E+07	125903.	-0.00905	29592.	3.36E+11	-701.8442	5030.	1505.
22.5500	0.6424	1.49E+07	129920.	-0.00884	30893.	3.36E+11	-700.9303	5368.	1531.

22.9600	0.5995	1.56E+07	134074.	-0.00861	32237.	3.36E+11	-699.3479	5740.	1558.
23.3700	0.5577	1.63E+07	138366.	-0.00838	33623.	3.36E+11	-697.0678	6150.	1584.
23.7800	0.5170	1.69E+07	140229.	-0.00814	35054.	3.36E+11	-1740.	16558.	1610.
24.1900	0.4776	1.76E+07	139672.	-0.00789	36478.	3.36E+11	-1733.	17853.	1637.
24.6000	0.4394	1.83E+07	139285.	-0.00762	37897.	3.36E+11	-1724.	19302.	1663.
25.0100	0.4026	1.90E+07	139077.	-0.00735	39313.	3.36E+11	-1713.	20931.	1689.
25.4200	0.3671	1.97E+07	135709.	-0.00707	40729.	3.36E+11	-1699.	22772.	353.5309
25.8300	0.3331	2.03E+07	128258.	-0.00677	42076.	3.36E+11	-1683.	24864.	0.00
26.2400	0.3005	2.09E+07	120023.	-0.00647	43340.	3.36E+11	-1665.	27258.	0.00
26.6500	0.2694	2.15E+07	111885.	-0.00616	44520.	3.36E+11	-1643.	30016.	0.00
27.0600	0.2398	2.20E+07	103859.	-0.00584	45618.	3.36E+11	-1619.	33218.	0.00
27.4700	0.2119	2.25E+07	95959.	-0.00552	46634.	3.36E+11	-1592.	36969.	0.00
27.8800	0.1856	2.30E+07	88201.	-0.00518	47571.	3.36E+11	-1562.	41407.	0.00
28.2900	0.1609	2.34E+07	80601.	-0.00484	48430.	3.36E+11	-1528.	46719.	0.00
28.7000	0.1379	2.38E+07	73178.	-0.00450	49212.	3.36E+11	-1490.	53159.	0.00
29.1100	0.1166	2.41E+07	65952.	-0.00415	49920.	3.36E+11	-1448.	61088.	0.00
29.5200	0.09706	2.44E+07	58944.	-0.00379	50555.	3.36E+11	-1401.	71025.	0.00
29.9300	0.07927	2.47E+07	52177.	-0.00343	51120.	3.36E+11	-1349.	83748.	0.00
30.3400	0.06327	2.49E+07	46004.	-0.00307	51617.	3.36E+11	-1160.	90230.	0.00
30.7500	0.04905	2.52E+07	40116.	-0.00270	52056.	3.36E+11	-1233.	123658.	0.00
31.1600	0.03665	2.53E+07	33934.	-0.00234	52434.	3.36E+11	-1280.	171861.	0.00
31.5700	0.02607	2.55E+07	27590.	-0.00196	52747.	3.36E+11	-1299.	245101.	0.00
31.9800	0.01733	2.56E+07	21237.	-0.00159	52995.	3.36E+11	-1284.	364539.	0.00
32.3900	0.01043	2.57E+07	-179375.	-0.00121	53179.	3.36E+11	-80266.	3.79E+07	0.00
32.8000	0.00537	2.38E+07	-557463.	-8.52E-04	49344.	3.36E+11	-73429.	6.72E+07	0.00
33.2100	0.00204	2.02E+07	-890320.	-5.30E-04	41830.	3.36E+11	-61879.	1.49E+08	0.00
33.6200	1.58E-04	1.51E+07	-1128374.	-2.72E-04	31218.	3.36E+11	-34891.	1.09E+09	0.00
34.0300	-6.37E-04	9114764.	-1084756.	-9.49E-05	18858.	3.36E+11	52622.	4.06E+08	0.00
34.4400	-7.76E-04	4414665.	-811082.	4.01E-06	9134.	3.36E+11	58627.	3.71E+08	0.00
34.8500	-5.98E-04	1133720.	-524058.	4.46E-05	2346.	3.36E+11	58049.	4.78E+08	0.00
35.2600	-3.38E-04	-742070.	-250785.	4.74E-05	1535.	3.36E+11	53038.	7.73E+08	0.00
35.6700	-1.31E-04	-1334000.	-25576.	3.23E-05	2760.	3.36E+11	38526.	1.45E+09	0.00
36.0800	-2.02E-05	-993345.	84567.	1.52E-05	2055.	3.36E+11	6231.	1.52E+09	0.00
36.4900	1.91E-05	-501857.	84781.	4.31E-06	1038.	3.36E+11	-6144.	1.59E+09	0.00
36.9000	2.22E-05	-159101.	51269.	-5.20E-07	329.1755	3.36E+11	-7478.	1.65E+09	0.00
37.3100	1.40E-05	2631.	20844.	-1.66E-06	5.4431	3.36E+11	-4889.	1.72E+09	0.00
37.7200	5.86E-06	46008.	3561.	-1.31E-06	95.1883	3.36E+11	-2137.	1.79E+09	0.00
38.1300	1.08E-06	37667.	-2702.	-6.96E-07	77.9327	3.36E+11	-409.1923	1.86E+09	0.00
38.5400	-9.89E-07	19422.	-2753.	-2.79E-07	40.1839	3.36E+11	388.3801	1.93E+09	0.00
38.9500	-1.66E-06	10578.	-1517.	-5.93E-08	21.8861	3.36E+11	114.1934	3.38E+08	0.00
39.3600	-1.57E-06	4499.	-960.6210	5.09E-08	9.3073	3.36E+11	111.8295	3.50E+08	0.00
39.7700	-1.16E-06	1126.	-475.7917	9.21E-08	2.3292	3.36E+11	85.2556	3.62E+08	0.00

Weighted average shear over 1D = -556,187 lbs
See attached calculations

Positive values considered to be 0

40.1800	-6.67E-07	-183.2596	-141.6500	9.90E-08	0.3792	3.36E+11	50.5743	3.73E+08	0.00
40.5900	-1.86E-07	-268.0661	18.6239	9.57E-08	0.5546	3.36E+11	14.5777	3.85E+08	0.00
41.0000	2.75E-07	0.00	0.00	9.37E-08	0.00	3.36E+11	-22.1484	1.98E+08	0.00

* The above values of total stress are combined axial and bending stresses.

Output Summary for Load Case No. 1:

Pile-head deflection = 3.78790122 inches
Computed slope at pile head = -0.01244221 radians
Maximum bending moment = 25703398. inch-lbs
Maximum shear force = -1128374. lbs
Depth of maximum bending moment = 32.39000000 feet below pile head
Depth of maximum shear force = 33.62000000 feet below pile head
Number of iterations = 22
Number of zero deflection points = 4

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

Boundary Condition Type 1, Shear and Moment

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

Pile Length feet	Pile Head Deflection inches	Maximum Moment ln-lbs	Maximum Shear lbs
41.00000	3.78790122	25703398.	-1128374.
38.95000	3.81722607	26005047.	-1125486.
36.90000	3.79744768	25428080.	-1126326.
34.85000	4.05580055	24772828.	-1289580.
32.80000	34.80763565	12414341.	-323344.

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	0.00	M, in-lb	0.00	0.00	3.7879	-0.01244	-1128374.	2.57E+07

Maximum pile-head deflection = 3.7879012175 inches
Maximum pile-head rotation = -0.0124422097 radians = -0.712886 deg.

Weighted Average = -556,187 lbs

Summary of Warning Messages

The following warning was reported 1481 times

**** Warning ****

An unreasonable input value for compressive strength has been specified
for a soil defined using the weak rock criteria. The input value is less
than 100 psi. Please check your input data for correctness.

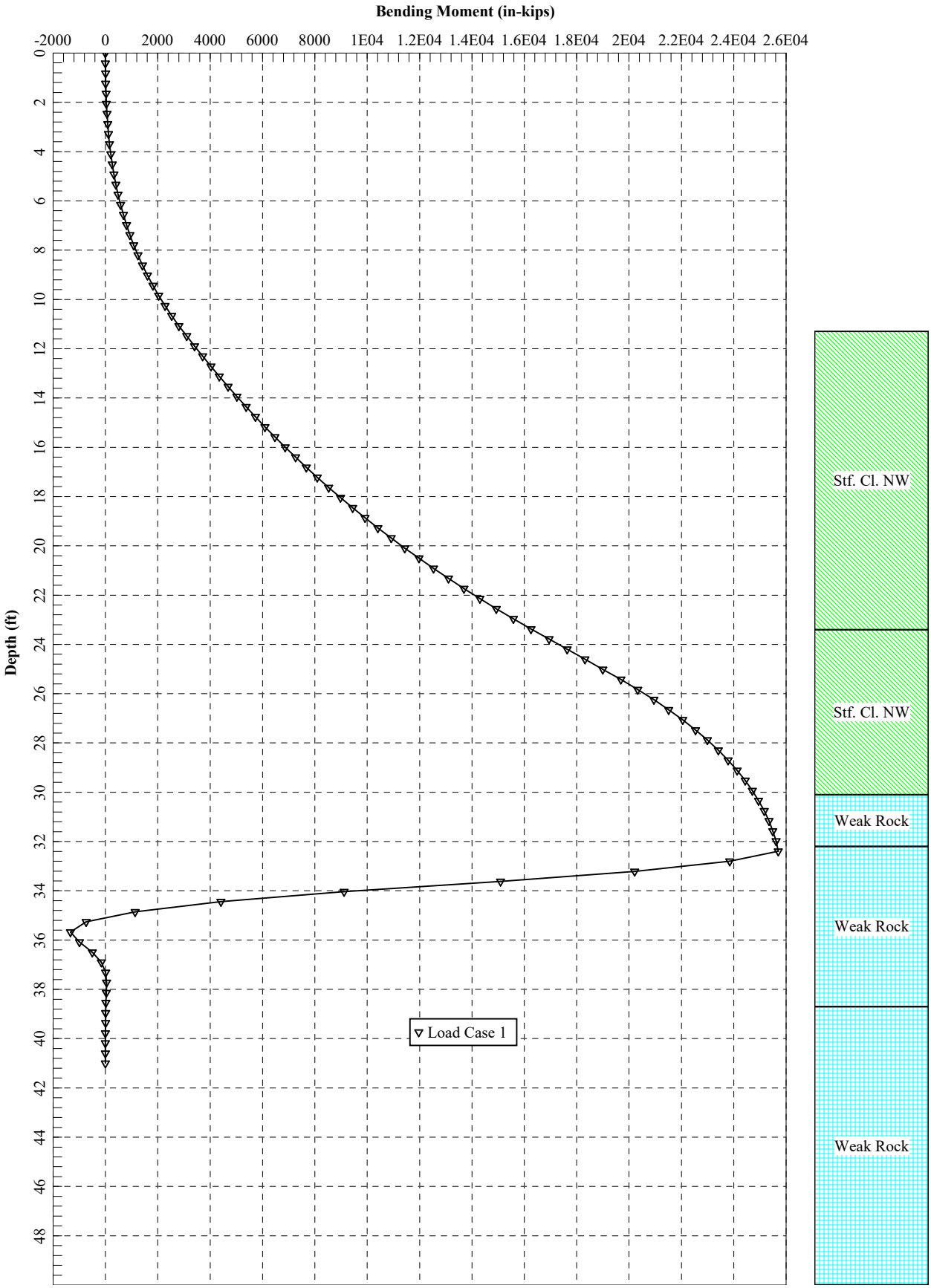
The following warning was reported 2397 times

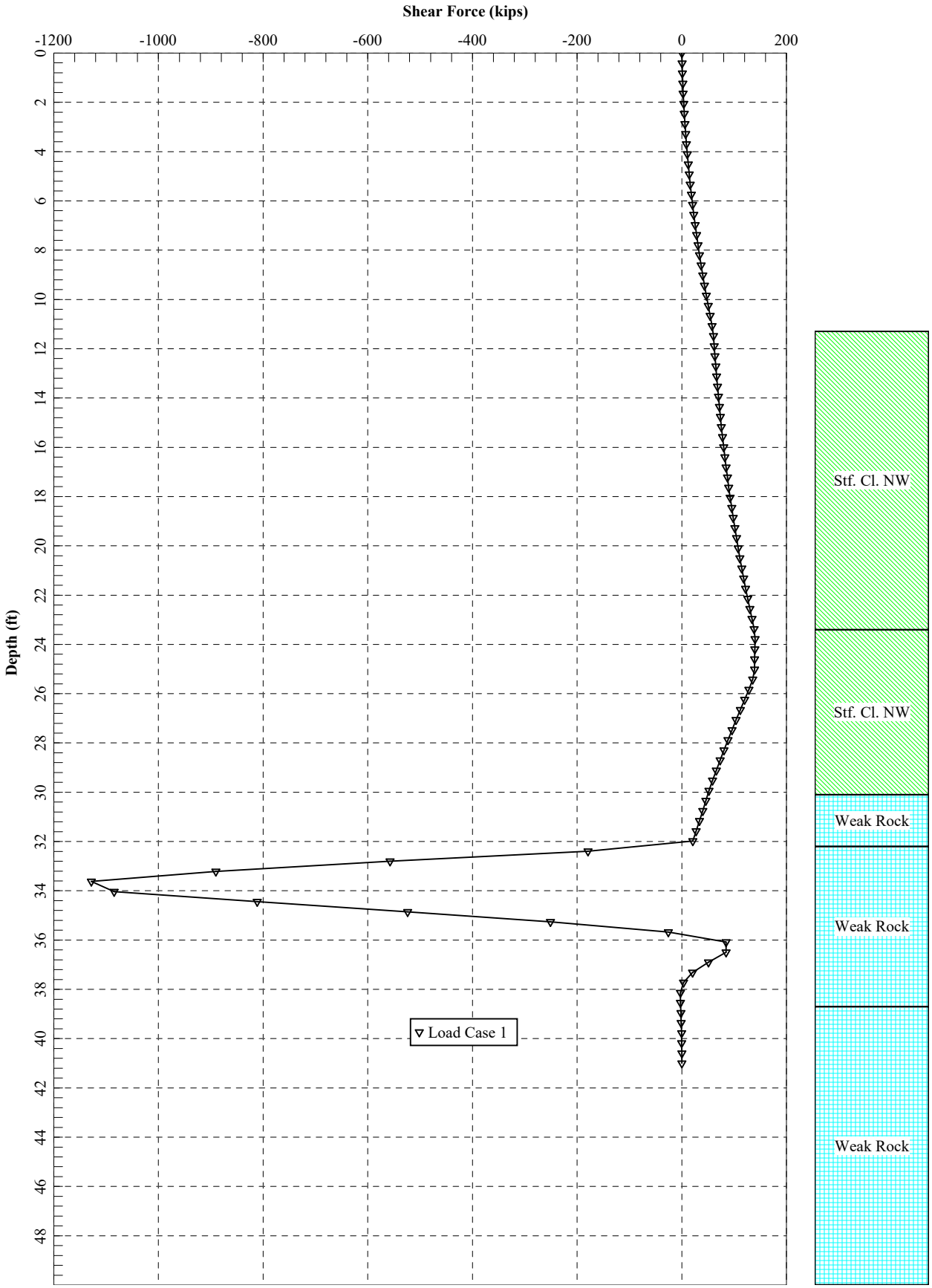
**** Warning ****

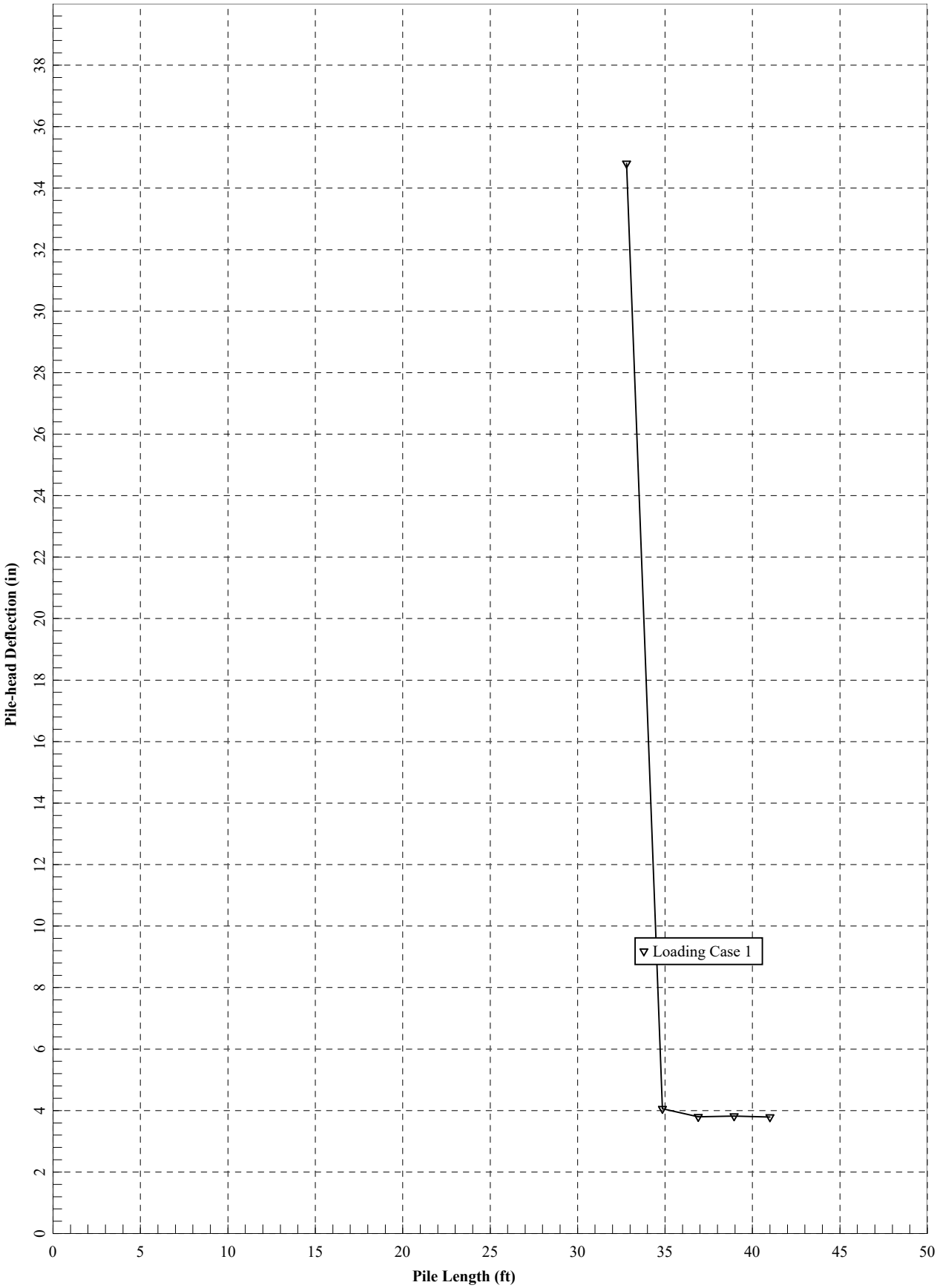
An unreasonable input value for unconfined compressive strength has been
specified for a soil defined using the weak rock criteria. The input value

is greater than 500 psi. Please check your input data for correctness.

The analysis ended normally.


Bending Moment (in-kips)
-2000
0
2000
4000
6000
8000
1E04
1.2E04
1.4E04
1.6E04
1.8E04
2E04
2.2E04
2.4E04
2.6E04
Depth (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
Load Case 1
Stf. Cl. NW
Stf. Cl. NW
Weak Rock
Weak Rock
Weak Rock


Shear Force (kips)
-1200
-1000
-800
-600
-400
-200
0
200
Depth (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
Load Case 1
Stf. Cl. NW
Stf. Cl. NW
Weak Rock
Weak Rock
Weak Rock


Pile-head Deflection (in)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
0
5
10
15
20
25
30
35
40
45
50
Pile Length (ft)
Loading Case 1

Average Shear/Moment Calculations over 1 Shaft Diameter

Depth Max Moment (ft)	32.39
Max Moment (in-lbs)	25700000
Depth Max Shear (ft)	33.62
Max Shear (lbs)	-1128374
Shaft Diameter (ft)	4
Average	20040263 / -556187

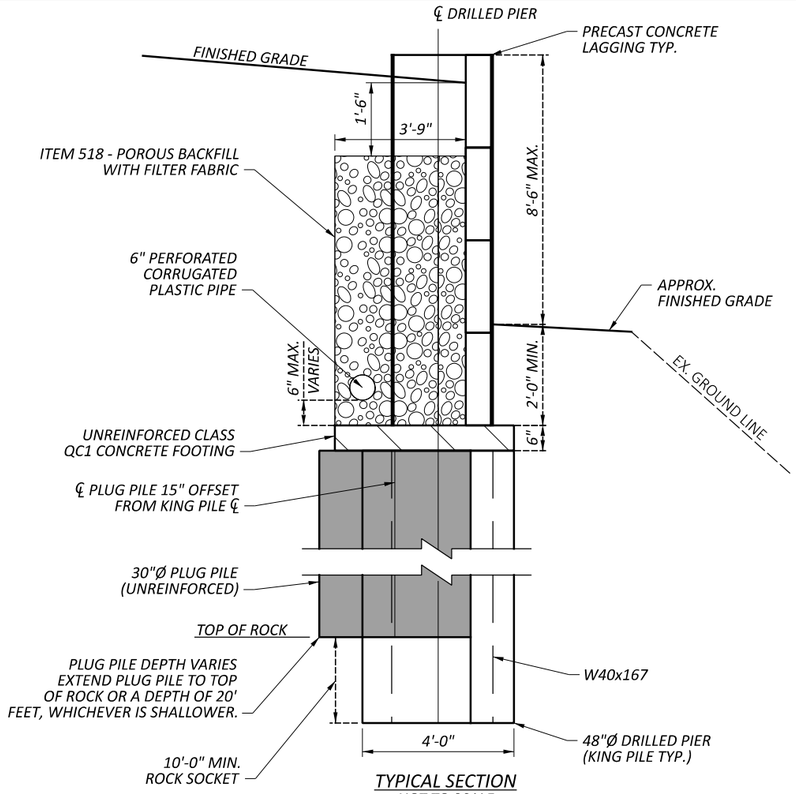
Paste LPile output and separate into columns using "fixed width" option.

Depth X feet	Weighted Moment in-lbs	Weighted Shear lbs
0	0	0
0.41	0	0
0.82	0	0
1.23	0	0
1.64	0	0
2.05	0	0
2.46	0	0
2.87	0	0
3.28	0	0
3.69	0	0
4.1	0	0
4.51	0	0
4.92	0	0
5.33	0	0
5.74	0	0
6.15	0	0
6.56	0	0
6.97	0	0
7.38	0	0
7.79	0	0
8.2	0	0
8.61	0	0
9.02	0	0
9.43	0	0
9.84	0	0
10.25	0	0
10.66	0	0
11.07	0	0
11.48	0	0
11.89	0	0
12.3	0	0
12.71	0	0
13.12	0	0
13.53	0	0
13.94	0	0
14.35	0	0
14.76	0	0
15.17	0	0
15.58	0	0
15.99	0	0
16.4	0	0
16.81	0	0
17.22	0	0
17.63	0	0
18.04	0	0
18.45	0	0
18.86	0	0
19.27	0	0
19.68	0	0
20.09	0	0
20.5	0	0
20.91	0	0
21.32	0	0
21.73	0	0
22.14	0	0
22.55	0	0
22.96	0	0
23.37	0	0
23.78	0	0
24.19	0	0
24.6	0	0
25.01	0	0
25.42	0	0
25.83	0	0
26.24	0	0
26.65	0	0
27.06	0	0
27.47	0	0
27.88	0	0
28.29	0	0
28.7	0	0
29.11	0	0
29.52	0	0
29.93	0	0
30.34	0	0
30.75	10332000	0
31.16	10373000	0
31.57	10455000	0
31.98	10496000	0
32.39	10537000	-73544
32.8	9758000	-228560
33.21	8282000	-365031
33.62	6191000	-462633
34.03	3737053	-444750
34.44	0	-332544
34.85	0	-214864
35.26	0	-102822
35.67	0	0
36.08	0	0
36.49	0	0
36.9	0	0
37.31	0	0
37.72	0	0
38.13	0	0
38.54	0	0
38.95	0	0
39.36	0	0
39.77	0	0
40.18	0	0
40.59	0	0
41	0	0

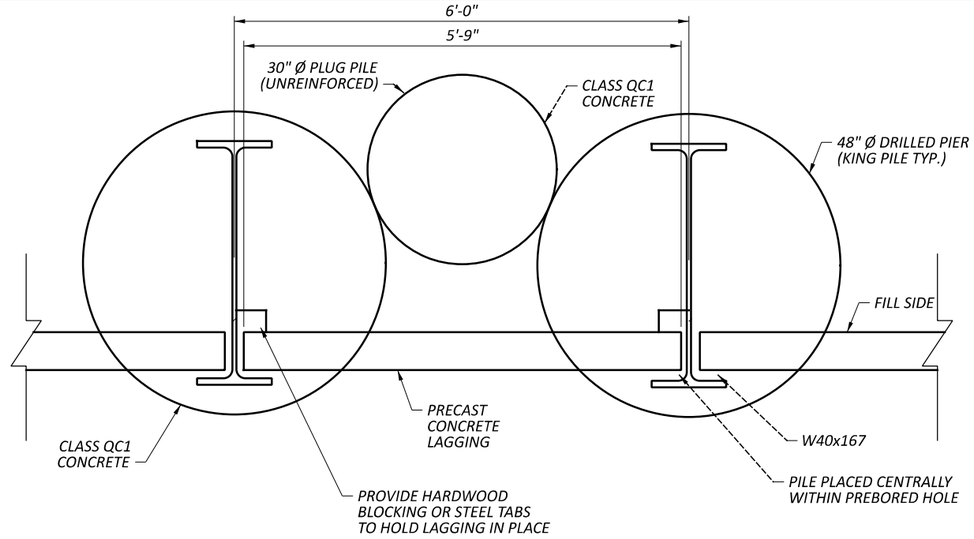
Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness in-lb^2	Soil Res. p lb/inch	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0	3.7879	-1.11E-04	0.00E+00	-0.01244	2.30E-07	3.36E+11	0	0	87.5916
0.41	3.7267	1060	479.5967	-0.01244	2.1934	3.36E+11	0	0	107.3664
0.82	3.6655	4719	1073	-0.01244	9.7639	3.36E+11	0	0	133.7328
1.23	3.6043	11616	1796	-0.01244	24.0321	3.36E+11	0	0	160.0992
1.64	3.543	22387	2648	-0.01244	46.3184	3.36E+11	0	0	186.4656
2.05	3.4818	37673	3630	-0.01244	77.9433	3.36E+11	0	0	212.832
2.46	3.4206	58110	4742	-0.01244	120.2273	3.36E+11	0	0	239.1984
2.87	3.3594	84337	5984	-0.01244	174.4909	3.36E+11	0	0	265.5648
3.28	3.2982	116993	7356	-0.01244	242.0545	3.36E+11	0	0	291.9312
3.69	3.237	156715	8857	-0.01244	324.2387	3.36E+11	0	0	318.2976
4.1	3.1758	204143	10488	-0.01243	422.364	3.36E+11	0	0	344.664
4.51	3.1147	259913	12248	-0.01243	537.7508	3.36E+11	0	0	371.0304
4.92	3.0535	324664	14138	-0.01243	671.7196	3.36E+11	0	0	397.3968
5.33	2.9924	399036	16159	-0.01242	825.591	3.36E+11	0	0	423.7632
5.74	2.9313	483665	18308	-0.01241	1001	3.36E+11	0	0	450.1296
6.15	2.8702	579190	20588	-0.01241	1198	3.36E+11	0	0	476.496
6.56	2.8092	686249	22997	-0.0124	1420	3.36E+11	0	0	502.8625
6.97	2.7483	805480	25536	-0.01239	1667	3.36E+11	0	0	529.2289
7.38	2.6874	937523	28205	-0.01237	1940	3.36E+11	0	0	555.5953
7.79	2.6265	1083014	31003	-0.01236	2241	3.36E+11	0	0	581.9617
8.2	2.5657	1242593	33931	-0.01234	2571	3.36E+11	0	0	608.3281
8.61	2.5051	1416897	36989	-0.01232	2932	3.36E+11	0	0	634.6945
9.02	2.4445	1606564	40177	-0.0123	3324	3.36E+11	0	0	661.0609
9.43	2.384	1812234	43494	-0.01228	3749	3.36E+11	0	0	687.4273
9.84	2.3237	2034544	46941	-0.01225	4209	3.36E+11	0	0	713.7937
10.25	2.2635	2274132	50518	-0.01222	4705	3.36E+11	0	0	740.1601
10.66	2.2035	2531637	54224	-0.01218	5238	3.36E+11	0	0	766.5265
11.07	2.1437	2807696	58060	-0.01214	5809	3.36E+11	0	0	792.8929
11.48	2.084	3102949	60658	-0.0121	6420	3.36E+11	-555.963	1313	819.2593
11.89	2.0246	3404575	61994	-0.01205	7044	3.36E+11	-566.104	1376	845.6257
12.3	1.9655	3712967	63410	-0.012	7682	3.36E+11	-575.964	1442	871.9921
12.71	1.9066	4028525	64907	-0.01194	8335	3.36E+11	-585.535	1511	898.3585
13.12	1.848	4351656	66489	-0.01188	9003	3.36E+11	-594.809	1584	924.7249
13.53	1.7897	4682772	68154	-0.01181	9688	3.36E+11	-603.779	1660	951.0913
13.94	1.7317	5022296	69907	-0.01174	10391	3.36E+11	-612.434	1740	977.4577
14.35	1.6741	5370655	71747	-0.01167	11112	3.36E+11	-620.767	1824	1004
14.76	1.6169	5728287	73677	-0.01159	11852	3.36E+11	-628.767	1913	1030
15.17	1.5601	6095637	75698	-0.0115	12612	3.36E+11	-636.425	2007	1057
15.58	1.5037	6473156	77812	-0.01141	13393	3.36E+11	-643.73	2106	1083
15.99	1.4478	6861306	80021	-0.01131	14196	3.36E+11	-650.672	2211	1109
16.4	1.3924	7260558	82326	-0.01121	15022	3.36E+11	-657.238	2322	1136
16.81	1.3376	7671390	84729	-0.0111	15872	3.36E+11	-663.419	2440	1162
17.22	1.2832	8094292	87233	-0.01098	16747	3.36E+11	-669.199	2566	1188
17.63	1.2295	8529762	89839	-0.01086	17648	3.36E+11	-674.568	2699	1215
18.04	1.1764	8978307	92549	-0.01073	18576	3.36E+11	-679.51	2842	1241
18.45	1.1239	9.44E+06	95366	-0.0106	19532	3.36E+11	-684.011	2994	1267
18.86	1.0721	9.92E+06	98292	-0.01046	20517	3.36E+11	-688.057	3158	1294
19.27	1.021	1.04E+07	101329	-0.01031	21533	3.36E+11	-691.629	3333	1320
19.68	0.9706	1.09E+07	104478	-0.01015	22580	3.36E+11	-694.713	3521	1347
20.09	0.9211	1.14E+07	107744	-0.00999	23660	3.36E+11	-697.289	3725	1373
20.5	0.8724	1.20E+07	111128	-0.00982	24774	3.36E+11	-699.338	3944	1399
20.91	0.8245	1.25E+07	114633	-0.00964	25923	3.36E+11	-700.84	4182	1426
21.32	0.7775	1.31E+07	118262	-0.00945	27108	3.36E+11	-701.774	4441	1452
21.73	0.7315	1.37E+07	122018	-0.00926	28330	3.36E+11	-702.117	4722	1478
22.14	0.6864	1.43E+07	125903	-0.00905	29592	3.36E+11	-701.844	5030	1505
22.55	0.6424	1.49E+07	129920	-0.00884	30893	3.36E+11	-700.93	5368	1531
22.96	0.5995	1.56E+07	134074	-0.00861	32237	3.36E+11	-699.348	5740	1558
23.37	0.5577	1.63E+07	138366	-0.00838	33623	3.36E+11	-697.068	6150	1584
23.78	0.517	1.69E+07	140229	-0.00814	35054	3.36E+11	-1740	16558	1610
24.19	0.4776	1.76E+07	139672	-0.00789	36478	3.36E+11	-1733	17853	1637
24.6	0.4394	1.83E+07	139285	-0.00762	37897	3.36E+11	-1724	19302	1663
25.01	0.4026	1.90E+07	139077	-0.00735	39313	3.36E+11	-1713	20931	1689
25.42	0.3671	1.97E+07	135709	-0.00707	40729	3.36E+11	-1699	22772	353.5309
25.83	0.3331	2.03E+07	128258	-0.00677	42076	3.36E+11	-1683	2.49E+04	0
26.24	3.01E-01	2.09E+07	120023	-6.47E-03	43340	3.36E+11	-1665	2.73E+04	0
26.65	0.2694	2.15E+07	111885	-6.16E-03	44520	3.36E+11	-1643	3.00E+04	0
27.06	2.40E-01	2.20E+07	103859	-5.84E-03	45618	3.36E+11	-1619	3.32E+04	0
27.47	0.2119	2.25E+07	95959	-5.52E-03	46634	3.36E+11	-1592	3.70E+04	0
27.88	0.1856	2.30E+07	88201	-5.18E-03	47571	3.36E+11	-1562	4.14E+04	0
28.29	0.1609	2.34E+07	80601	-4.84E-03	48430	3.36E+11	-1528	4.67E+04	0
28.7	0.1379	2.38E+07	73178	-4.50E-03	49212	3.36E+11	-1490	5.32E+04	0
29.11	1.17E-01	2.41E+07	65952	-4.15E-03	49920	3.36E+11	-1448	6.11E+04	0
29.52	9.71E-02	2.44E+07	58944	-3.79E-03	50555	3.36E+11	-1401	7.10E+04	0
29.93	7.93E-02	2.47E+07	52177	-3.43E-03	51120	3.36E+11	-1349	8.37E+04	0
30.34	6.33E-02	2.49E+07	46004	-3.07E-03	51617	3.36E+11	-1160	9.02E+04	0
30.75	4.91E-02	2.52E+07	40116	-2.70E-03	52056	3.36E+11	-1233	1.24E+05	0
31.16	3.67E-02	2.53E+07	33934	-2.34E-03	52434	3.36E+11	-1280	1.72E+05	0
31.57	2.61E-02	2.55E+07	27590	-1.96E-03	52747	3.36E+11	-1299	2.45E+05	0
31.98	1.73E-02	2.56E+07	21237	-1.59E-03	52995	3.36E+11	-1284	3.65E+05	0
32.39	1.04E-02	2.57E+07	-179375	-1.21E-03	53179	3.36E+11	-80266	3.79E+07	0
32.8	5.37E-03	2.38E+07	-557463	-8.52E-04	49344	3.36E+11	-73429	6.72E+07	0
33.21	2.04E-03	2.02E+07	-890320	-5.30E-04	41830	3.36E+11	-61879	1.49E+08	0
33.62	1.58E-04	1.51E+07	-1128374	-2.72E-04	31218	3.36E+11	-34891	1.09E+09	0
34.03	-6.37E-04	9.11E+06	-1084756	-9.49E-05	18858	3.36E+11	52622	4.06E+08	0
34.44	-7.76E-04	4414665	-811082	4.01E-06	9134	3.36E+11	58627	3.71E+08	0
34.85	-5.98E-04	1133720	-524058	4.46E-05	2346	3.36E+11	58049	4.78E+08	0
35.26	-3.38E-04	-742070	-250785	4.74E-05	1535	3.36E+11	53038	7.73E+08	0
35.67	-1.31E-04	-1334000	-25536	3.23E-05	2760	3.36E+11	38526	1.45E+09	0
36.08	-2.02E-05	-993345	84567	1.52E-05	2055	3.36E+11	6231	1.52E+09	0
36.49	1.91E-05	-501857	84781	4.31E-06	1038	3.36E+11	-6144	1.59E+09	0
36.9	2.22E-05	-159101	51269	-5.20E-07	329.1755	3.36E+11	-7478	1.65E+09	0
37.31	1.40E-05	2631	20844	-1.66E-06	5.4431	3.36E+11	-4889	1.72E+09	0
37.72	5.86E-06	46008	3561	-1.31E-06	95.1883	3.36E+11	-2137	1.79E+09	0
38.13	1.08E-06	37667	-2702	-6.96E-07	77.9327	3.36E+11	-409.192	1.86E+09	0
38.54	-9.89E-07	19422	-2753	-2.79E-07	40.1839	3.36E+11	388.3801	1.93E+09	0
38.95	-1.66E-06	10578	-1517	-5.93E-08	21.8861	3.36E+11	114.1934	3.38E+08	0
39.36	-1.57E-06	4499	-960.621	5.09E-08	9.3073	3.36E+11	111.8295	3.50E+08	0
39.77	-1.16E-06	1126	-475.792	9.21E-08	2.3292	3.36E+11	85.2556	3.62E+08	0
40.18	-6.67E-07	-183.26	-141.65	9.90E-08	0.3792	3.36E+11	50.5743	3.73E+08	0
40.59	-1.86E-07	-268.066	18.6239	9.57E-08	0.5546	3.36E+11	14.5777	3.85E+08	0
41	2.75E-07	0	0	9.37E-08	0	3.36E+11	-22.1484	1.98E+08	0

Soldier Pile Lagging Wall Detail

9999 Carver Road, Suite 210, Cincinnati, OH 45242-5583
(513) 984-7500
hdrinc.com

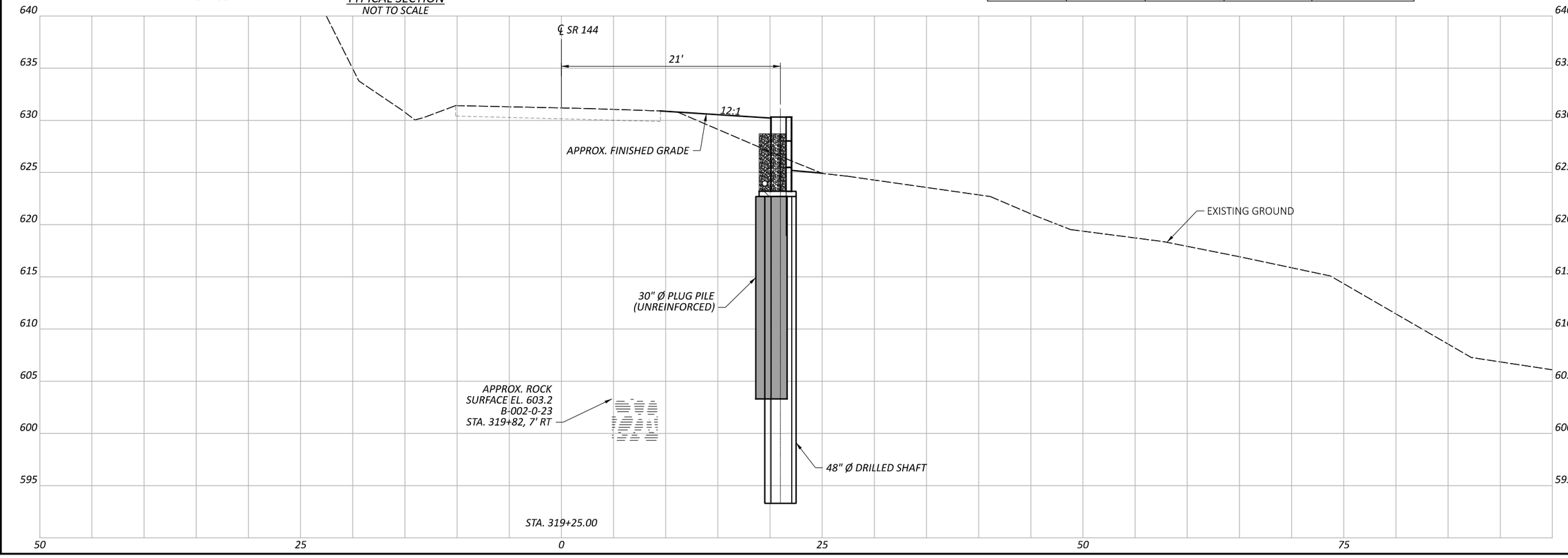


TYPICAL SECTION
NOT TO SCALE



PLAN - RETAINING WALL
NOT TO SCALE

BORING	STATION	OFFSET	APPROX. SURFACE ELEVATION	APPROX. ROCK SURFACE ELEVATION
B-001-0-23	318+78	5' RT	631.5	611.0
B-002-0-23	319+82	7' RT	631.2	603.2
B-003-0-23	320+89	8' RT	633.2	603.2



HORIZONTAL SCALE IN FEET
0 5 10 20

SOLDIER PILE AND LAGGING WALL DETAIL CRITICAL SECTION STA. 319+25

DESIGN AGENCY
HDR

DESIGNER AKB
REVIEWER DMV 02/24/23
PROJECT ID 116165
SHEET 1 TOTAL 1

ATH-144-6.04

MODEL: Sheet PAPERSIZE: 17x11 (in.) DATE: 3/10/2023 TIME: 4:54:45 PM USER: ABARATTA
pw:\\ohiodot-pw.bentley.com:ohiodot-pw-02\Documents\01 Active Projects\District 10\Athens\117974\402-Engineering_HDR\Geotechnical\Sheets\117974_WD001.dgn