Technical Design Memo

Client:	Ohio Department of Transportation, District 10
Project:	**NOB-147-9.93 (Task Order 10-LL)** **PID 117566**
HDR Project No:	10381935
Rev:	0
Calculation No:	1
Page:	1 of 95
Title:	Landslide Remediation Analyses and Design
Purpose:	Prepare slope stability analyses and wall calculations for the design of a landslide repair along the eastbound travel lane of State Route 147 (SR 147) in Noble County, Ohio.
Originator:	AKB
Date:	9/25/2023
Checked by:	DCM
Date:	9/27/2023
QC Review by:	DMV
Date:	9/29/2023

Summary

1. A landslide has occurred on the slope below SR 147 near mile marker 9.93 in Noble County, Ohio. The project location is shown on the attached Site Vicinity and Topographic Map. Based on observations gathered during the site reconnaissance performed on August 30, 2023, coupled with the findings from the geotechnical explorations performed by ODOT between December 7 and 15, 2022, a soldier pile and lagging retaining wall is recommended to stabilize the landslide and repair SR 147. 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 4 test borings (designated as Borings B-001-0-22, B-002-0-22, B-002-1-22, and B-003-0-22) to characterize the subsurface profile in the vicinity of the existing landslide and develop a repair. Three test borings were drilled within the eastbound lane, and 1 boring was drilled in the westbound lane, of SR 147 at the locations shown on the attached Boring Location Plan. Typed boring logs, as provided by ODOT, are also included. The soil profile, as encountered in the borings, generally consisted of an upper layer of medium stiff to very stiff colluvium, transitioning to very stiff to hard residuum with depth.

Boulders and cobbles were encountered within the soil matrix at a depth of 14.0 to 15.5 feet (El. 900.1 to El. 898.6) below the existing ground surface (bgs) in Boring B-002-1-22, and from 4.5 to 7.5 feet (El. 904.9 to El. 901.9) bgs in Boring B-003-1-22. The overburden soils were underlain by very weak claystone and shale bedrock. Free water was not recorded in any of the borings during drilling or at completion, with the boreholes noted to be dry prior to coring. 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 Borings B-002-0-22 and B-002-1-22, located near the design section at Sta. 525+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. Noble County is located within the Marietta Plateau region of the Allegheny (Kanawha) Plateaus section of the unglaciated and dissected Appalachian Plateaus province, primarily consisting of steep hills and ridges with intervening valleys. The northern part of the county, where the project is located, is further characterized by flat-topped hills at higher elevations than the north-central and southwestern reaches of Noble County. 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 northeastern portion of Noble County is drained by tributaries Beaver Creek, which drains into Senecaville Lake, which in turn outlets into Wills Creek in neighboring Guernsey County to the north. The site is directly drained by an unnamed stream, which drains into Seneca Lake approximately 0.8 mile northeast of the site.
The Cenozoic Era surficial materials within Noble County mainly consist of residuum and colluvium derived from the underlying sedimentary bedrock. The bedrock mapped below the project site is the Pennsylvanian-age Conemaugh Group. The Conemaugh Group consists of shale, siltstone, and sandstone, with minor amounts of limestone and coal.

4. The main coal seam of note within the Conemaugh Group is the Mahoning No. 7a coal. No significant mining activity is mapped at the project site according to information from the Ohio Department of Natural Resources. Surface mines and several mine openings are located approximately 1.3 miles south, 2.4 miles southwest, and 2.8 miles east of the project site. Available information does not indicate the associated coal seams or coal elevations for the surface mines. Where available, the mine openings indicate the Meigs Creek No. 9 (of the Monongahela Group) as the mined seam, with coal elevations of 1050 to 1110.

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 as an area of minimal flood hazard (Zone X).

6. HDR is unaware of any prior geotechnical explorations at the NOB-147-9.93 project site. A search of the available records on ODOT's Transportation Information Mapping System (TIMS) reveals

only the geographical locations of known landslide and rockfall activity in the project area. The nearest borings from prior studies were performed approximately 0.6 miles east and 0.8 miles northwest 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 525+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.

Limited groundwater information was available from the borings and published sources. However, elevated moisture contents were noted near the interface of the asphalt and soils, 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 in Borings B-002-0-22 and B-002-1-22 and extending to the unnamed stream at the base of the slope.

Bedrock depths along the slope below SR 147 were estimated based on the slope of the existing terrain, exposed bedrock within the unnamed stream, and overburden soil thicknesses encountered in the soil borings. Analyses were performed with a 2-foot thick "Weak Rock" layer along the interface of the residual soils and bedrock. Extending the failure surface search zone over the entire roadway resulted in a headscarp within the eastbound lane. As pavement deformation and cracking was observed within the westbound lane during the site reconnaissance, a secondary analysis was performed to limit the failure surface search zone to the westbound lane. Once the soil parameters and failure surfaces 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 24 feet from the centerline of the roadway. This offset allows for, at a minimum, an 11-foot travel lane, 2-foot shoulder, and 5-foot clearance between the back of the surveyed guardrail (located approximately 17.5 feet right of the SR 147 centerline) and the back of the

proposed 3-foot diameter drilled shaft. This recommended offset also allows for continuity with the existing features (roadway section, shoulder width, guardrail offset, etc.) located to the east and west of the project site. A 4-foot bench was included in front of the wall, and the existing grade elevation was used as the proposed bench elevation. Per direction from ODOT, design of the wall considered erosion/scour of the entire downslope soil mass to the top of bedrock.

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. Loading was analyzed for both slip surfaces, with the larger force for the slip surface with the headscarp in the eastbound lane carried forward into design. This governing computed unfactored force per shaft is **Ps = 51,100** pounds based on 36-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 = Medium Stiff to Stiff Colluvium
d. Layer 4 = Stiff to Very Stiff Colluvium
e. Layer 5 = Very Stiff to Hard Residuum
f. Layer 6 = Weak Rock
g. Layer 7 = 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. 525+25 for a 6-foot exposed wall height, increased to total wall height of 14.8 feet to account for scour in front of the wall to the top of bedrock, the following were considered relative to LPILE analyses:

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

- Convert concentrated load from UA Slope to distributed load
  - ½(D_L)(H_T) = 51,100 lbs.
    D_L = distributed load
    H_T = 14.8 feet (top/wall to slip surface, see attached)
  - D_L = [(51,100 lbs)(2)]/[(14.8')(12"/ft)] = Resolution of Triangular Area
    D_L = **575 lbs/in** (Service Load)
  - (575 lbs/in)(γ_{EH}) = (575 lbs/in)(1.5) = **863 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) = **46 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 = **5,031 lbs/ft**
  H = Wall Height = 14.8 feet (assuming scour of all soil to the top of bedrock, based on guidance from ODOT District 10)
- Horizontal Force Per Shaft (P_{SH}) = P*(S_{cc}) = **30,184 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)
  = **340 lbs/in per shaft (Service Load)**
  (340 lbs/in) (γ_{EH}) = (340 lbs/in) (1.5)
  = **510 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

Per direction from ODOT, all of the soil was considered to be lost to the top of bedrock due to scour/erosion from the adjacent stream. As such, the reduction to soil resistance was not applicable.

- Top of Wall El. 913.6 ft
  - Assumes approximately 3.2 feet of fill placement to re-establish grade.
- Maintenance Bench GS El. = 907.8 ft.
- Wall Height = 913.6 ft. – 907.8 ft. = 5.8 ft.
- GS for LPILE analysis = Top of Bedrock El. = 898.8 ft.
  - Wall Height for LPILE Analysis = 913.6 ft. – 898.8 ft. = **14.8 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 not anticipated to be located less than 10 feet from the edge of pavement. However, a limited pile head deflection of 2 inches or less was adopted for conservatism. (The centerline of the soldier pile and lagging wall is 11 feet from the edge of pavement.)

Computed Pile Head Deflection (W 21 x 101) = **1.52 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 = 14.8 ft below top of wall
+10.0 ft
24.8 ft minimum pile length

- **Bottom of Drilled Shaft = 29.8 ft ≥ 24.8 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 claystone and shale and our experience with such local bedrock types, **a minimum rock socket length of 15 feet** is recommended.

(f) Steel Reinforcement and Pile Cross Section Character

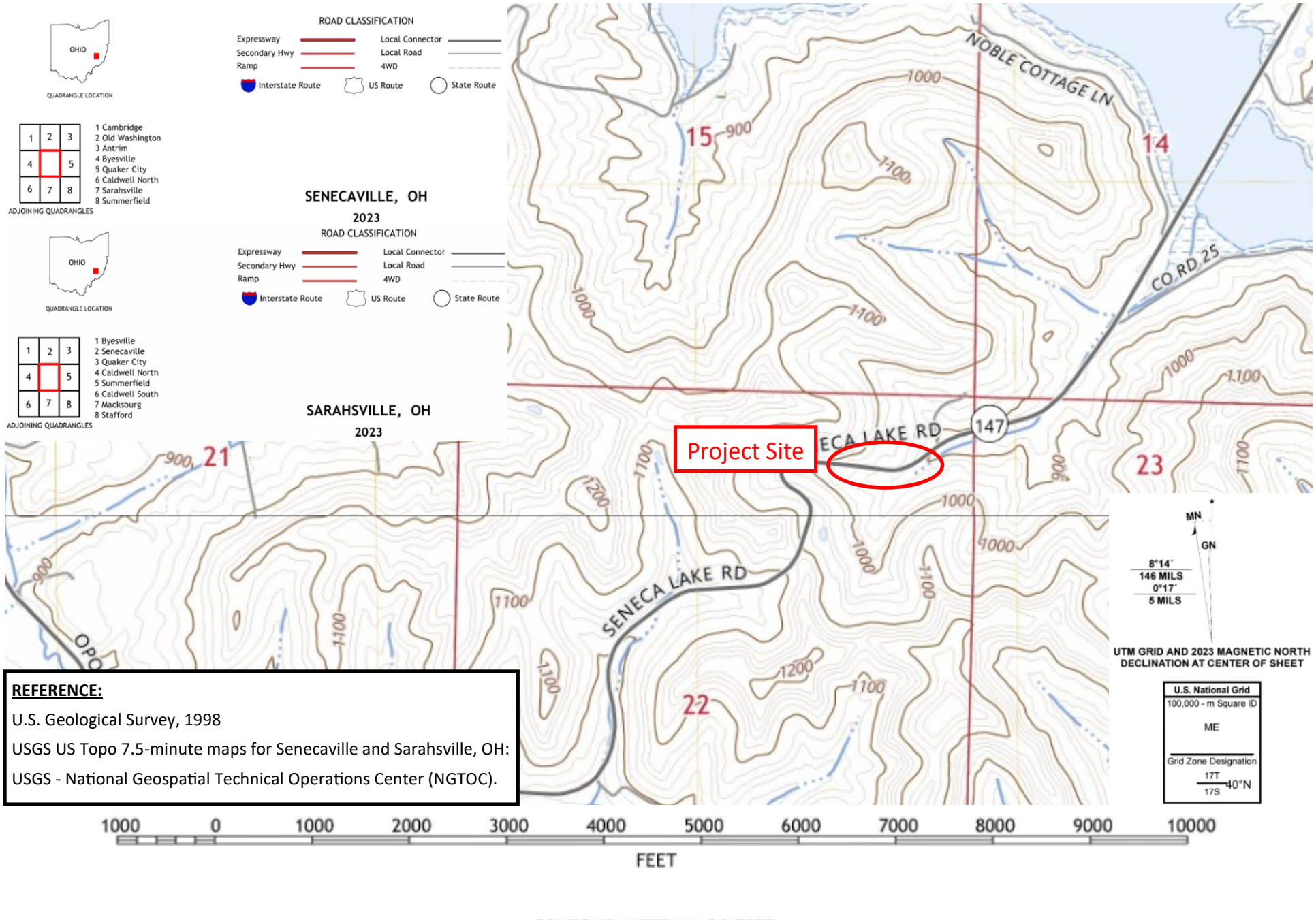
Use W 21 x 101 shaft reinforcement

A_s = Area of Steel = 29.8 in^2
I_x = Moment of Inertia around strong axis = 2420 in^4
T_w = web thickness = 0.5 in
E = Modulus of Elasticity of Steel = 29,000,000 psi
F_y = yield strength of steel = 50,000 psi
B_f = Flange Width = 12.3 in

10. 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, 1998

USGS US Topo 7.5-minute maps for Senecaville and Sarahsville, OH:

USGS - National Geospatial Technical Operations Center (NGTOC).

Boring Location Plan

NOB-147-9.93

MODEL: CLX_147 - Plan 1 [Sheet] PAPERSIZE: 34x22 (in.) DATE: 9/19/2023 TIME: 1:21:23 PM USER: CWAHLBRI
pw:\\ohiodot-pw.bentley.com:ohiodot-pw-02\Documents\01 Active Projects\District 10\Noble\117566\401-Engineering_HDR\Geotechnical\Sheets\117566_IP901.dgn

BORING LOCATION PLAN

HORIZONTAL SCALE IN FEET
0 20
10 40

DESIGN AGENCY	DESIGNER	REVIEWER	PROJECT ID	SHEET	TOTAL
HDR	AKB	DMV 09/22/23	117566	1	1

Boring Logs
and
Rock Core Photos

PROJECT: NOB-147-9.93	DRILLING FIRM / OPERATOR: ODOT / CAREY	DRILL RIG: CME 55 TRUCK	STATION / OFFSET:	EXPLORATION ID B-001-0-22
TYPE: LANDSLIDE	SAMPLING FIRM / LOGGER: ODOT / MCLEISH	HAMMER: CME AUTOMATIC	ALIGNMENT: CL SR 147	
PID: 117566 SFN:	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 4/18/22	ELEVATION: 926.3 (ft) EOB: 32.0 ft.	PAGE 1 OF 1
START: 12/7/22 END: 12/12/22	SAMPLING METHOD: SPT / NQ2	ENERGY RATIO (%): 87	LAT / LONG: 39.876313, -81.390074	

MATERIAL DESCRIPTION AND NOTES	ELEV. 926.3	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
ASPHALT (36")																		
	923.3																	
STIFF, BROWN, **SILTY CLAY**, SOME STONE FRAGMENTS, TRACE SAND, MOIST			3 3 3	9	44	SS-1	1.50	35	3	5	26	31	40	20	20	23	A-6b (8)	
@4.5'; MEDIUM STIFF	920.3		1 2 3	7	67	SS-2	1.00	-	-	-	-	-	-	-	-	20	A-6b (V)	
VERY STIFF, REDDISH BROWN AND GRAY, **CLAY**, "AND" STONE FRAGMENTS, SOME SILT, TRACE SAND, MOIST			3 7 10	25	100	SS-3	3.00	36	1	2	24	37	47	20	27	22	A-7-6 (13)	
	917.3	TR	3 9 12	30	83	SS-4	3.00	-	-	-	-	-	-	-	-	16	A-7-6 (V)	
DAMP **SHALE**, REDDISH BROWN, HIGHLY WEATHERED, VERY WEAK, LAMINATED.			9 17 24	59	89	SS-5	-	-	-	-	-	-	-	-	-	11	Rock (V)	
	914.3		15 25 54	115	100	SS-6	-	-	-	-	-	-	-	-	-	7	Rock (V)	
SHALE, DARK REDDISH BROWN, MODERATELY WEATHERED, VERY WEAK, LAMINATED, MICACEOUS, SLIGHTLY CALCAREOUS, JOINT, MODERATELY FRACTURED, NARROW, SLIGHTLY ROUGH; BLOCKY, POOR; RQD 15%, REC 100%.			32		100	NQ2-1											CORE	
@20.4' - 21.1'; HIGH ANGLE FRACTURE			7		100	NQ2-2											CORE	
@22.6' - 24.5'; S_c = 351 psi			30		100	NQ2-3											CORE	
	901.8																	
CLAYSTONE, REDDISH BROWN, HIGHLY WEATHERED, VERY WEAK, THIN TO MEDIUM BEDDED, CALCAREOUS, JOINT, MODERATELY FRACTURED, NARROW, SLIGHTLY ROUGH; BLOCKY, POOR; RQD 50%, REC 91%.																		
@26.7' - 26.8'; HIGH ANGLE FRACTURE			45		87	NQ2-4											CORE	
@31.5' - 31.6'; HIGH ANGLE FRACTURE	894.3	EOB																

NOTES: HOLE DRY BEFORE CORING. S_C = POINT LOAD STRENGTH VALUES AS PER ASTM D 5731. LAT/LONG FROM OGE HANDHELD GPS UNIT. ELEV FROM USGS 3DEP MAP SERVICE.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: AUGER CUTTINGS MIXED WITH 25 LB. BENTONITE CHIPS

PROJECT: NOB-147-9.93	DRILLING FIRM / OPERATOR: ODOT / CAREY	DRILL RIG: CME 55 TRUCK	STATION / OFFSET:	EXPLORATION ID B-002-0-22
TYPE: LANDSLIDE	SAMPLING FIRM / LOGGER: ODOT / SPROUSE	HAMMER: CME AUTOMATIC	ALIGNMENT: CL SR 147	
PID: 117566 SFN:	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 4/18/22	ELEVATION: 915.6 (ft) EOB: 12.8 ft.	PAGE 1 OF 1
START: 12/15/22 END: 12/15/22	SAMPLING METHOD: SPT / NQ2	ENERGY RATIO (%): 87	LAT / LONG: 39.876495, -81.389699	

MATERIAL DESCRIPTION AND NOTES	ELEV. 915.6	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
ASPHALT (18")	914.1	1																
STIFF, OLIVE BROWN AND DARK GRAY, **SANDY SILT**, SOME STONE FRAGMENTS, SOME CLAY, DAMP	912.6	2	4 3 4	10	33	SS-1	1.75	35	9	8	26	22	31	21	10	18	A-4a (3)	
VERY STIFF, BROWN AND GRAY, **CLAY**, SOME STONE FRAGMENTS, SOME SILT, TRACE SAND, DAMP		3	1 2 3	7	39	SS-2	2.50	31	2	2	26	39	47	25	22	22	A-7-6 (12)	
@4.5'; STIFF	909.6	4 5	1 3 4	10	67	SS-3	2.00	-	-	-	-	-	-	-	-	23	A-7-6 (V)	
VERY STIFF, BROWN AND RED, **SILT AND CLAY**, "AND" SAND, LITTLE STONE FRAGMENTS, MOIST		6	3 7 4	16	83	SS-4	2.25	11	13	23	28	25	32	20	12	21	A-6a (4)	
@7.5'; STIFF, SOME STONE FRAGMENTS, LITTLE SAND, DAMP		7 8	1 3 5	12	78	SS-5	1.50	27	4	9	34	26	34	22	12	17	A-6a (6)	
@9.0'; VERY STIFF	905.7	9	3 7	41	100	SS-6A	3.50	-	-	-	-	-	-	-	-	15	A-6a (V)	
		TR 10	21			SS-6B	-	-	-	-	-	-	-	-	-	9	Rock (V)	
SHALE, RED, HIGHLY WEATHERED, VERY WEAK, LAMINATED.		11	25 55/4"	-	100	SS-7	-	-	-	-	-	-	-	-	-	7	Rock (V)	
	902.8	12 EOB	43 50/3"	-	100	SS-8	-	-	-	-	-	-	-	-	-	6	Rock (V)	

NOTES: HOLE DRY UPON COMPLETION. LAT/LONG FROM OGE HANDHELD GPS UNIT. ELEV FROM USGS 3DEP MAP SERVICE.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: BACKFILLED WITH SOIL CUTTINGS

PROJECT: NOB-147-9.93	DRILLING FIRM / OPERATOR: ODOT / CAREY	DRILL RIG: CME 55 TRUCK	STATION / OFFSET:	EXPLORATION ID B-002-1-22	
TYPE: LANDSLIDE	SAMPLING FIRM / LOGGER: ODOT / MCLEISH	HAMMER: CME AUTOMATIC	ALIGNMENT: CL SR 147		
PID: 117566 SFN:	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 4/18/22	ELEVATION: 914.1 (ft) EOB: 39.5 ft.		PAGE 1 OF 1
START: 12/13/22 END: 12/14/22	SAMPLING METHOD: SPT / NQ2	ENERGY RATIO (%): 87	LAT / LONG: 39.876439, -81.389659		

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)	BACK FILL
ASPHALT (72")	914.1																	
STIFF, BROWN AND GRAY, **SILT AND CLAY**, LITTLE STONE FRAGMENTS, LITTLE SAND, DAMP	908.1		4 4 4	12	44	SS-1	2.00	20	3	7	34	36	37	23	14	22	A-6a (9)	
@8.0'; SOFT, NO RECOVERY, AUGER CUTTINGS TAKEN, MOIST			1 1 1	3	0	SS-2	-	-	-	-	-	-	-	-	-	25	A-6a (V)	
@9.5'; DAMP	903.1		1 2 2	6	28	SS-3	1.50	-	-	-	-	-	-	-	-	18	A-6a (V)	
VERY STIFF, BROWN, GRAY AND REDDISH BROWN, **CLAY**, "AND" STONE FRAGMENTS, LITTLE SILT, LITTLE SAND, DAMP			5 8 7	22	67	SS-4	2.50	45	4	7	18	26	43	26	17	25	A-7-6 (4)	
@12.5'; STIFF, WITH TRACE WOOD FRAGMENTS, MOIST			10 14 7	30	33	SS-5	1.50	-	-	-	-	-	-	-	-	30	A-7-6 (V)	
@14.0' - 15.5'; ENCOUNTERED BOULDERS/COBBLES	898.6	TR	9 10 10	29	28	SS-6	-	-	-	-	-	-	-	-	-	20	A-7-6 (V)	
CLAYSTONE, GRAY AND PURPLISH GRAY, MODERATELY WEATHERED, VERY WEAK.			3 12 36	70	67	SS-7	-	-	-	-	-	-	-	-	-	11	Rock (V)	
@17.0'; REDDISH BROWN.			10 19 28	68	78	SS-8	-	-	-	-	-	-	-	-	-	11	Rock (V)	
	894.6		29 56	-	100	SS-9	-	-	-	-	-	-	-	-	-	10	Rock (V)	
CLAYSTONE, DARK REDDISH BROWN, MODERATELY WEATHERED, VERY WEAK, THIN TO MEDIUM BEDDED, CALCAREOUS, JOINT, FRACTURED, NARROW, SLIGHTLY ROUGH; BLOCKY, POOR; RQD 21%, REC 83%.			25		78	NQ2-1											CORE	
			33		92	NQ2-2											CORE	
			7		90	NQ2-3											CORE	
	878.9		22		85	NQ2-4											CORE	
SHALE, DARK RED, MODERATELY WEATHERED, VERY WEAK, THINLY LAMINATED, MICACEOUS, JOINT, MODERATELY FRACTURED TO FRACTURED, NARROW, SLIGHTLY ROUGH; BLOCKY, POOR; RQD 25%, REC 100%. @36.2' - 39.1'; S_c = 450 psi	874.6	EOB																

NOTES: HOLE DRY BEFORE CORING. S_C = POINT LOAD STRENGTH VALUES AS PER ASTM D 5731. LAT/LONG FROM OGE HANDHELD GPS UNIT. ELEV FROM USGS 3DEP MAP SERVICE.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: AUGER CUTTINGS MIXED WITH 50 LB. BENTONITE CHIPS

PROJECT: NOB-147-9.93	DRILLING FIRM / OPERATOR: ODOT / CAREY	DRILL RIG: CME 55 TRUCK	STATION / OFFSET:	EXPLORATION ID B-003-0-22
TYPE: LANDSLIDE	SAMPLING FIRM / LOGGER: ODOT / MCLEISH	HAMMER: CME AUTOMATIC	ALIGNMENT: CL SR 147	
PID: 117566 SFN:	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 4/18/22	ELEVATION: 909.4 (ft) EOB: 42.5 ft.	PAGE 1 OF 1
START: 12/14/22 END: 12/14/22	SAMPLING METHOD: SPT / NQ2	ENERGY RATIO (%): 87	LAT / LONG: 39.876619, -81.389325	

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)	BACK FILL
ASPHALT (18")	909.4	1																
	907.9																	
VERY STIFF, BROWN AND BLACK, **SILT AND CLAY**, SOME STONE FRAGMENTS, LITTLE SAND, DAMP		2	5 6 12	26	56	SS-1	3.50	33	3	9	30	25	38	25	13	20	A-6a (5)	
		3	2 3 8	16	100	SS-2	2.50	-	-	-	-	-	-	-	-	23	A-6a (V)	
	904.6	4																
@4.5' - 7.5'; ENCOUNTERED BOULDERS/COBBLES		5	50	-	100	SS-3A	2.50	-	-	-	-	-	-	-	-	15	A-6a (V)	
VERY DENSE, BROWN, **STONE FRAGMENTS WITH SAND**, LITTLE SILT, TRACE CLAY, DAMP						SS-3B	-	-	-	-	-	-	-	-	-	4	A-1-b (V)	
	901.9	6	41 66	-	83	SS-4	-	60	6	17	13	4	NP	NP	NP	4	A-1-b (0)	
VERY STIFF, BROWN, **SILT AND CLAY**, "AND" STONE FRAGMENTS, LITTLE SAND, DAMP		7																
	898.9	8	4 5 6	16	44	SS-5	-	45	4	9	23	19	33	21	12	13	A-6a (2)	
		9																
		10	6 4 5	13	39	SS-6	3.50	-	-	-	-	-	-	-	-	14	A-6a (V)	
VERY STIFF, BROWN, **CLAY**, SOME SILT, SOME STONE FRAGMENTS, LITTLE SAND, DAMP		11	3 4 7	16	100	SS-7	3.50	23	5	7	30	35	41	23	18	24	A-7-6 (9)	
@12.0'; BROWN AND REDDISH BROWN		12																
	895.9	13	2 7 11	26	89	SS-8	4.00	-	-	-	-	-	-	-	-	17	A-7-6 (V)	
HARD, BROWN AND RED, **SILT AND CLAY**, TRACE STONE FRAGMENTS, TRACE SAND, DAMP		14	10 18 27	65	78	SS-9	4.5+	10	3	3	40	44	39	27	12	16	A-6a (9)	
	892.9	15																
		16	10 14 20	49	100	SS-10	4.5+	-	-	-	-	-	-	-	-	16	A-6a (V)	
	TR	17																
CLAYSTONE, RED AND GRAY, MODERATELY WEATHERED, VERY WEAK.		18	12 18 20	55	100	SS-11	-	-	-	-	-	-	-	-	-	13	Rock (V)	
		19	12 22 41	91	100	SS-12	-	-	-	-	-	-	-	-	-	12	Rock (V)	
		20	10 21 33	78	100	SS-13	-	-	-	-	-	-	-	-	-	11	Rock (V)	
	886.9	21	22 35 55	131	100	SS-14	-	-	-	-	-	-	-	-	-	8	Rock (V)	
CLAYSTONE, DARK REDDISH BROWN AND GREENISH GRAY, MODERATELY WEATHERED, VERY WEAK, THIN TO MEDIUM BEDDED, SLIGHTLY CALCAREOUS, JOINT, FRACTURED, NARROW, SLIGHTLY ROUGH; BLOCKY, POOR; RQD 36%, REC 62%.		22																
		23																
		24	40		60	NQ2-1											CORE	
		25																
		26																
		27																
	881.4	28																
SHALE, DARK REDDISH BROWN AND BLUEISH GRAY, MODERATELY WEATHERED, VERY WEAK, THINLY LAMINATED, PYRITIC, JOINT, FRACTURED, NARROW, SLIGHTLY ROUGH; BLOCKY FAIR; RQD 22%, REC 92%.		29																
		30	28		98	NQ2-2											CORE	
		31																
		32																
		33																
@33.2' - 35.9'; S_c = 620 psi		34																
		35	18		100	NQ2-3											CORE	
		36																
		37																
		38																
		39																
		40	17		77	NQ2-4											CORE	
@41.5'; CORE WEDGED IN CORE BARREL		41																
	866.9	42																
	EOB																	

NOTES: HOLE DRY BEFORE CORING. S_c = POINT LOAD STRENGTH VALUES AS PER ASTM D 5731. LAT/LONG FROM OGE HANDHELD GPS UNIT. ELEV FROM USGS 3DEP MAP SERVICE.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: AUGER CUTTINGS MIXED WITH 25 LB. BENTONITE CHIPS

OHIO DEPARTMENT OF TRANSPORTATION
DIVISION OF ENGINEERING

Office of Geotechnical Engineering

B-001-0-22

Run #:	Depth		Recovery		RQD	
NQ2-1	12.0’	17.0’	60/60	100%	19/60	32%
NQ2-2	17.0’	22.0’	60/60	100%	4/60	7%
NOB-147-9.93 PID 117566						

OHIO DEPARTMENT OF TRANSPORTATION
DIVISION OF ENGINEERING

Office of Geotechnical Engineering

B-001-0-22

Run #:	Depth		Recovery		RQD	
NQ2-3	22.0’	27.0’	60/60	100%	18/60	30%
NQ2-4	27.0’	32.0’	52/60	87%	27/60	45%
NOB-147-9.93 PID 117566						

OHIO DEPARTMENT OF TRANSPORTATION
DIVISION OF ENGINEERING

Office of Geotechnical Engineering

B-002-1-22

Run #:	Depth		Recovery		RQD	
NQ2-1	19.5’	24.5’	47/60	78%	15/60	25%
NQ2-2	24.5’	29.5’	55/60	92%	20/60	33%
NOB-147-9.93 PID 117566						

OHIO DEPARTMENT OF TRANSPORTATION
DIVISION OF ENGINEERING

Office of Geotechnical Engineering

B-002-1-22

Run #:	Depth		Recovery		RQD	
NQ2-3	29.5’	34.5’	54/60	90%	4/60	7%
NQ2-4	34.5’	39.5’	51/60	85%	13/60	22%
NOB-147-9.93 PID 117566						

OHIO DEPARTMENT OF TRANSPORTATION
DIVISION OF ENGINEERING

Office of Geotechnical Engineering

B-003-0-22

Run #:	Depth		Recovery		RQD	
NQ2-1	22.5’	27.5’	36/60	60%	24/60	40%
NQ2-2	27.5’	32.5’	59/60	98%	17/60	28%
NOB-147-9.93 PID 117566						

OHIO DEPARTMENT OF TRANSPORTATION
DIVISION OF ENGINEERING

Office of Geotechnical Engineering

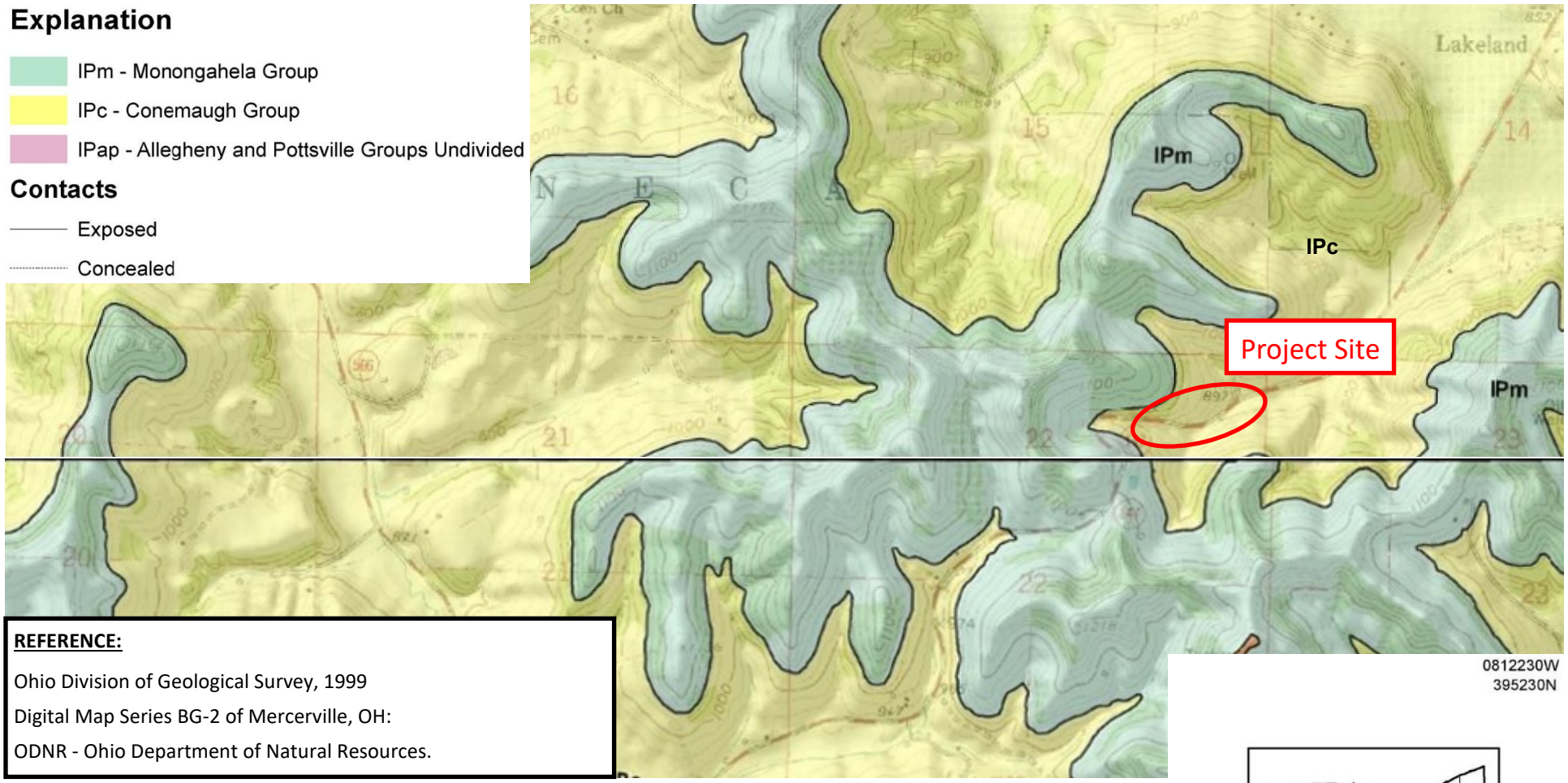
B-003-0-22

Run #:	Depth		Recovery		RQD	
NQ2-3	32.5’	37.5’	60/60	100%	11/60	18%
NQ2-4	37.5’	42.5’	46/60	77%	10/60	17%
NOB-147-9.93 PID 117566						

Bedrock Geology and Topography Maps

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

Bedrock Geology Map



REFERENCE:

Ohio Division of Geological Survey, 1999

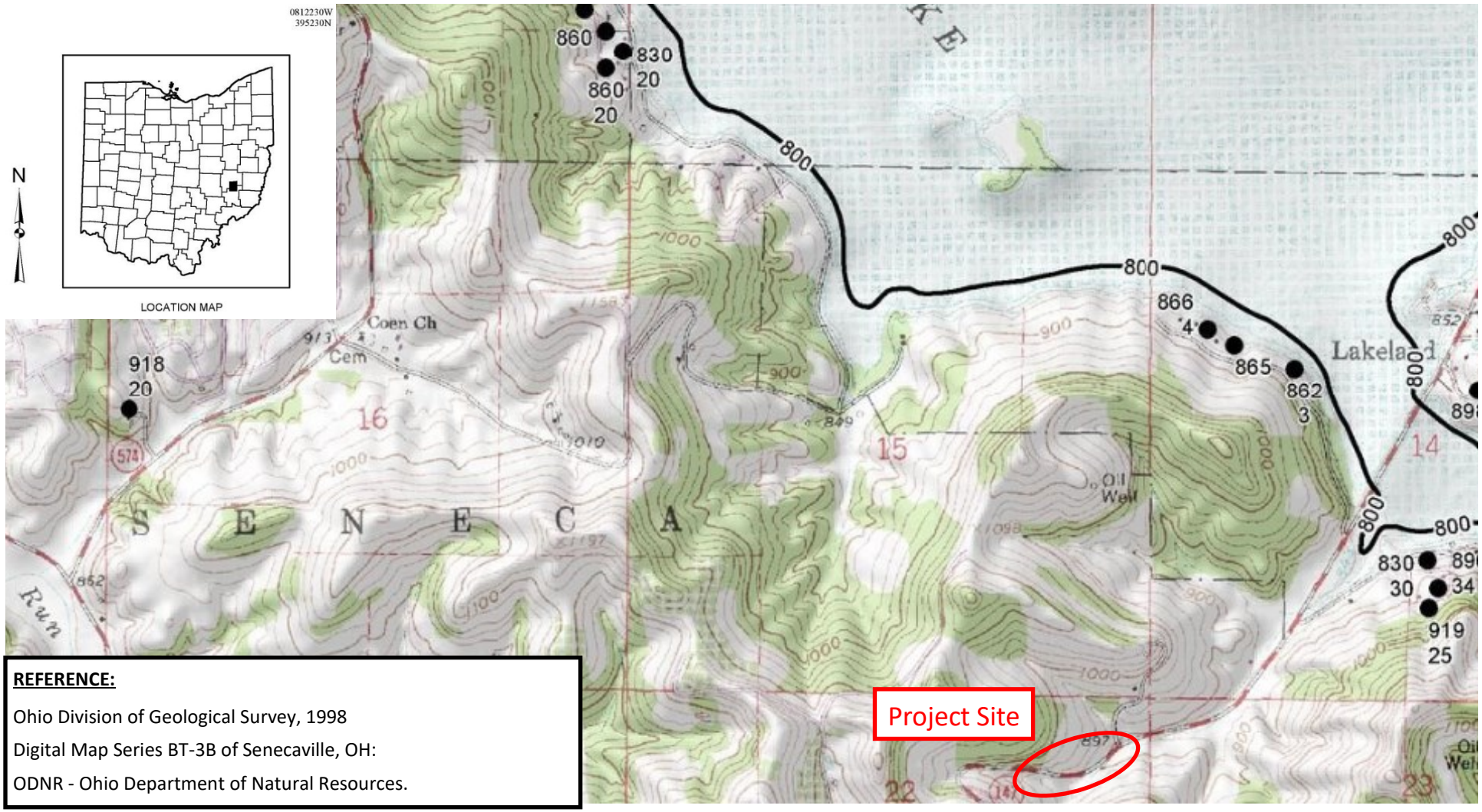
Digital Map Series BG-2 of Mercerville, OH:

ODNR - Ohio Department of Natural Resources.

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

LOCATION MAP

Bedrock Topography Map



REFERENCE:

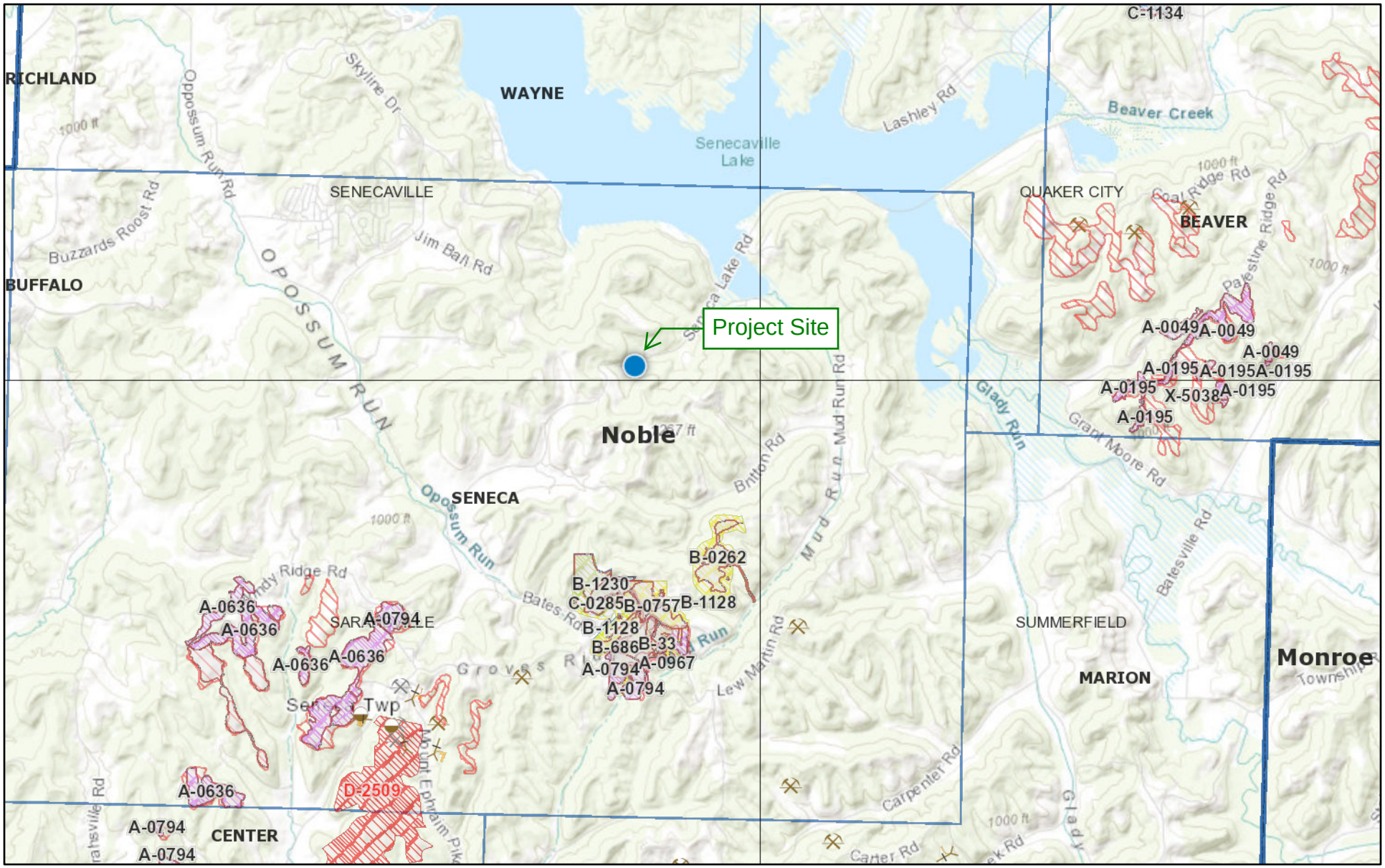
Ohio Division of Geological Survey, 1998

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

ODNR - Ohio Department of Natural Resources.

Mine Map

NOB-147-9.93 Mine Map



September 22, 2023

1:72,224

0 0.47 0.95 1.9 mi

0 0.75 1.5 3 km

West Virginia GIS, Esri, HERE, Garmin, USGS, NGA, EPA, USDA, NPS

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

Ohio Dept. of Natural Resources

FEMA Flood Map

National Flood Hazard Layer FIRMette

FEMA

81°23'43"W 39°52'49"N

81°23'5"W 39°52'21"N

Feet

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

1:6,000

Basemap Imagery Source: USGS National Map 2023

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 Cross Sections with 1% Annual Chance
- 17.5 Water Surface Elevation
- Coastal Transect
- 513 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 9/22/2023 at 10:46 AM 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
NOB-147-9.93

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							N_{60} Value	ODOT GB-7 Correlations		Tested	
			Sowers	T and P	Values	Correlation	Tested	Correlation	Tested				Cohesion (psf)	phi (deg)	Cohesion (psf)	phi (deg)
Layer 1 MEDIUM STIFF TO STIFF COHESIVE	Max	2500	2500	1596		105		125			Max	12	129	23		
	Min	1000	525	399		90		110		S_u= 1400 psf	Min	3	38	19		c' = 220 psf
	Average	1750	1434	1064		98		117		Φ = 0 deg	Average	8	94	22		Φ' = 21 deg
	Std Dev	479	675	376		5		6			Std Dev	3	29	1		
										Y_{dry} = 100 pcf						Y_{dry} = 100 pcf
	Avg + Std	2229	2109	1440		102		123		Y_{moist} = 115 pcf	Avg + Std	11	123	23		Y_{moist} = 115 pcf
	Avg - Std	1271	760	688		93		111			Avg - Std	5	65	20		
Layer 2 STIFF TO VERY STIFF COHESIVE	Max	3500	4000	2128		115		130			Max	16	153	24		
	Min	1500	2100	1596		105		125		S_u = 2500 psf	Min	12	129	23		c' = 150 psf
	Average	2650	2796	1973		108		126		Φ = 0 deg	Average	15	146	24		Φ' = 24 deg
	Std Dev	859	664	244		4		2			Std Dev	2	11	0		
										Y_{dry} = 110 pcf						Y_{dry} = 110 pcf
	Avg + Std	3509	3460	2217		112		128		Y_{moist} = 125 pcf	Avg + Std	17	157	24		Y_{moist} = 125 pcf
	Avg - Std	1791	2132	1729		104		124			Avg - Std	13	135	23		
Layer 3 VERY STIFF TO HARD COHESIVE	Max	4500	4000	4000		125		135			Max	65	250	28		
	Min	1500	4000	2926		110		125		S_u = 3500 psf	Min	22	173	25		c' = 230 psf
	Average	3313	4000	3727		117		130		Φ = 0 deg	Average	35	210	26		Φ' = 28 deg
	Std Dev	1033	0	396		6		4			Std Dev	14	31	1		
										Y_{dry} = 115 pcf						Y_{dry} = 115 pcf
	Avg + Std	4345	4000	4123		122		134		Y_{moist} = 130 pcf	Avg + Std	49	241	28		Y_{moist} = 130 pcf
	Avg - Std	2280	4000	3331		111		126			Avg - Std	21	179	25		
Layer 4 CLAYSTONE/HIGHLY WEATHERED SHALE (MODELED AS HARD CLAY)	Max	N/A	N/A	N/A		N/A		N/A			Max	131	250	28		
	Min	N/A	N/A	N/A		N/A		N/A		S_u = 6000 psf	Min	55	250	28		c' = 250 psf
	Average	N/A	N/A	N/A		N/A		N/A		Φ = 0 deg	Average	83	250	28		Φ' = 28 deg
	Std Dev	N/A	N/A	N/A		N/A		N/A			Std Dev	27	0	0		
										Y_{dry} = 145 pcf						Y_{dry} = 145 pcf
	Avg + Std	N/A	N/A	N/A		N/A		N/A		Y_{moist} = 155 pcf	Avg + Std	111	250	28		Y_{moist} = 155 pcf
	Avg - Std	N/A	N/A	N/A		N/A		N/A			Avg - Std	56	250	28		

Adjusted per Hall's thesis from c' = 120 psf and Φ' = 23 deg.

ODOT District 10
NOB-147-9.93

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 1

	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	12	67	2.5	35	9	8	34	39	47	25	22	25	Max	2500	2500	1596	129	23	10.0	922.3	105	125	0.333	2.72	0.886
Min	3	0	1.0	20	2	2	26	22	31	20	10	18	Min	1000	525	399	38	19	2.0	904.1	90	110	0.189	2.65	0.616
Average	8	40	1.8	30	4	6	28	32	39	22	17	21	Average	1750	1434	1064	94	22	5.8	912.0	98	117	0.259	2.70	0.730
Std Dev	3	22	0.5	7	3	3	4	7	7	2	6	3	Std Dev	479	675	376	29	1	2.7	6.9	5	6	0.060	0.03	0.086
Avg + Std	11	62	2.2	37	7	8	32	39	45	24	22	24	Avg + Std	2229	2109	1440	123	23	8.5	918.8	102	123	0.319	2.73	0.815
Avg - Std	5	19	1.3	23	1	3	24	25	32	20	11	19	Avg - Std	1271	760	688	65	20	3.0	905.1	93	111	0.199	2.67	0.644

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 147	926.3	B-001-0-22	3	-	4.5	SS-1	9	44	1.5	35	3	5	26	31	40	20	20	23	A-6b	Cohesive	1	1500	1575	1197	107	22	4.0	922.3	100	120	0.27	2.70	0.685
SR 147	926.3	B-001-0-22	4.5	-	6	SS-2	7	67	1	-	-	-	-	-	-	-	-	20	A-6b	Cohesive	1	1000	1225	931	88	22	5.0	921.3	95	110		2.70	0.773
SR 147	915.6	B-002-0-22	1.5	-	3	SS-1	10	33	1.75	35	9	8	26	22	31	21	10	18	A-4a	Cohesive	1	1750	750	1330	114	23	2.0	913.6	100	120	0.189	2.72	0.697
SR 147	915.6	B-002-0-22	3	-	4.5	SS-2	7	39	2.5	31	2	2	26	39	47	25	22	22	A-7-6	Cohesive	1	2500	1750	931	88	22	4.0	911.6	95	110	0.333	2.65	0.741
SR 147	915.6	B-002-0-22	4.5	-	6	SS-3	10	67	2	-	-	-	-	-	-	-	-	23	A-7-6	Cohesive	1	2000	2500	1330	114	23	5.0	910.6	100	120		2.65	0.654
SR 147	914.1	B-002-1-22	6.5	-	8	SS-1	12	44	2	20	3	7	34	36	37	23	14	22	A-6a	Cohesive	1	2000	2100	1596	129	23	7.0	907.1	105	125	0.243	2.72	0.616
SR 147	914.1	B-002-1-22	8	-	9.5	SS-2	3	0	-	-	-	-	-	-	-	-	-	25	A-6a	Cohesive	1	N/A	525	399	38	19	9.0	905.1	90	110		2.72	0.886
SR 147	914.1	B-002-1-22	9.5	-	11	SS-3	6	28	1.5	-	-	-	-	-	-	-	-	18	A-6a	Cohesive	1	1500	1050	798	75	21	10.0	904.1	95	120		2.72	0.787

ODOT District 10
NOB-147-9.93

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	16	100	3.5	45	13	23	34	35	41	23	18	24	Max	3500	4000	2128	153	24	11.0	908.6	115	130	0.279	2.72	0.616
Min	12	39	1.5	11	4	7	23	19	32	20	12	13	Min	1500	2100	1596	129	23	4.0	898.4	105	125	0.198	2.65	0.438
Average	15	74	2.7	27	7	12	29	26	35	22	14	19	Average	2650	2796	1973	146	24	8.0	903.5	108	126	0.225	2.71	0.562
Std Dev	2	27	0.9	14	4	7	5	7	4	1	3	5	Std Dev	859	664	244	11	0	2.4	4.3	4	2	0.037	0.03	0.071
Avg + Std	17	101	3.5	41	11	19	33	33	39	23	17	23	Avg + Std	3509	3460	2217	157	24	10.4	907.8	112	128	0.262	2.74	0.633
Avg - Std	13	47	1.8	12	2	5	24	20	31	20	11	14	Avg - Std	1791	2132	1729	135	23	5.6	899.1	104	124	0.188	2.68	0.491

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 147	915.6	B-002-0-22	6	-	7.5	SS-4	16	83	2.25	11	13	23	28	25	32	20	12	21	A-6a	Cohesive	2	2250	2800	2128	153	24	7.0	908.6	110	125	0.198	2.72	0.543
SR 147	915.6	B-002-0-22	7.5	-	9	SS-5	12	78	1.5	27	4	9	34	26	34	22	12	17	A-6a	Cohesive	2	1500	2100	1596	129	23	8.0	907.6	105	125	0.216	2.72	0.616
SR 147	909.4	B-003-0-22	3	-	4.5	SS-2	16	100	2.5	-	-	-	-	-	-	-	-	23	A-6a	Cohesive	2	2500	2800	2128	153	24	4.0	905.4	105	125		2.72	0.616
SR 147	909.4	B-003-0-22	7.5	-	9	SS-5	16	44	-	45	4	9	23	19	33	21	12	13	A-6a	Cohesive	2	N/A	2800	2128	153	24	8.0	901.4	110	125	0.207	2.72	0.543
SR 147	909.4	B-003-0-22	9	-	10.5	SS-6	13	39	3.5	-	-	-	-	-	-	-	-	14	A-6a	Cohesive	2	3500	2275	1729	136	23	10.0	899.4	105	125		2.72	0.616
SR 147	909.4	B-003-0-22	10.5	-	12	SS-7	16	100	3.5	23	5	7	30	35	41	23	18	24	A-7-6	Cohesive	2	3500	4000	2128	153	24	11.0	898.4	115	130	0.279	2.65	0.438

ODOT District 10
NOB-147-9.93

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 3

	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	65	100	4.5	45	4	7	40	44	47	27	27	30	Max	4500	4000	4000	250	28	16.0	919.3	125	135	0.333	2.72	0.503
Min	22	28	1.5	10	1	2	18	26	39	20	12	15	Min	1500	4000	2926	173	25	7.0	893.4	110	125	0.261	2.65	0.358
Average	35	75	3.3	30	3	4	27	36	43	24	19	20	Average	3313	4000	3727	210	26	12.0	903.4	117	130	0.297	2.67	0.432
Std Dev	14	28	1.0	18	2	3	11	9	4	4	8	5	Std Dev	1033	0	396	31	1	3.1	9.5	6	4	0.036	0.04	0.052
Avg + Std	49	103	4.3	49	4	7	39	45	47	28	26	25	Avg + Std	4345	4000	4123	241	28	15.1	912.9	122	134	0.333	2.71	0.484
Avg - Std	21	48	2.3	12	1	1	16	27	39	21	11	15	Avg - Std	2280	4000	3331	179	25	8.9	893.9	111	126	0.261	2.64	0.380

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 147	926.3	B-001-0-22	6	-	7.5	SS-3	25	100	3	36	1	2	24	37	47	20	27	22	A-7-6	Cohesive	3	3000	4000	3325	183	25	7.0	919.3	110	125	0.333	2.65	0.503
SR 147	926.3	B-001-0-22	7.5	-	9	SS-4	30	83	3	-	-	-	-	-	-	-	-	16	A-7-6	Cohesive	3	3000	4000	3990	200	26	8.0	918.3	110	125		2.65	0.503
SR 147	915.6	B-002-0-22	9	-	10.5	SS-6A	41	100	3.5	-	-	-	-	-	-	-	-	15	A-6a	Cohesive	3	3500	4000	4000	250	28	10.0	905.6	120	130		2.72	0.414
SR 147	914.1	B-002-1-22	11	-	12.5	SS-4	22	67	2.5	45	4	7	18	26	43	26	17	25	A-7-6	Cohesive	3	2500	4000	2926	173	25	12.0	902.1	115	130	0.297	2.65	0.438
SR 147	914.1	B-002-1-22	12.5	-	14	SS-5	30	33	1.5	-	-	-	-	-	-	-	-	30	A-7-6	Cohesive	3	1500	4000	3990	200	26	13.0	901.1	115	130		2.65	0.438
SR 147	914.1	B-002-1-22	14	-	15.5	SS-6	29	28	-	-	-	-	-	-	-	-	-	20	A-7-6	Cohesive	3	N/A	4000	3857	197	26	15.0	899.1	115	130		2.65	0.438
SR 147	909.4	B-003-0-22	12	-	13.5	SS-8	26	89	4	-	-	-	-	-	-	-	-	17	A-7-6	Cohesive	3	4000	4000	3458	187	25	13.0	896.4	115	130		2.65	0.438
SR 147	909.4	B-003-0-22	13.5	-	15	SS-9	65	78	4.5	10	3	3	40	44	39	27	12	16	A-6a	Cohesive	3	4500	4000	4000	250	28	14.0	895.4	125	135	0.261	2.72	0.358
SR 147	909.4	B-003-0-22	15	-	16.5	SS-10	49	100	4.5	-	-	-	-	-	-	-	-	16	A-6a	Cohesive	3	4500	4000	4000	250	28	16.0	893.4	125	135		2.72	0.358

ODOT District 10
NOB-147-9.93

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 4

	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	131	100	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	13	Max	N/A	N/A	N/A	250	28	22.0	916.3	N/A	N/A	N/A	N/A	N/A
Min	55	67	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6	Min	N/A	N/A	N/A	250	28	10.0	887.4	N/A	N/A	N/A	N/A	N/A
Average	83	94	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	10	Average	N/A	N/A	N/A	250	28	15.9	899.0	N/A	N/A	N/A	N/A	N/A
Std Dev	27	11	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2	Std Dev	N/A	N/A	N/A	0	0	4.2	9.9	N/A	N/A	N/A	N/A	N/A
Avg + Std	111	105	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	12	Avg + Std	N/A	N/A	N/A	250	28	20.1	908.9	N/A	N/A	N/A	N/A	N/A
Avg - Std	56	83	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	8	Avg - Std	N/A	N/A	N/A	250	28	11.7	889.0	N/A	N/A	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)
SR 147	926.3	B-001-0-22	9	-	10.5	SS-5	59	89	-	-	-	-	-	-	-	-	-	11	Rock		4	N/A	N/A	N/A	250	28	10.0	916.3					
SR 147	926.3	B-001-0-22	10.5	-	12	SS-6	115	100	-	-	-	-	-	-	-	-	-	7	Rock		4	N/A	N/A	N/A	250	28	11.0	915.3					
SR 147	915.6	B-002-0-22	10.5	-	11.33	SS-7	Refusal	100	-	-	-	-	-	-	-	-	-	9	Rock		4	N/A	N/A	N/A	250	28	11.0	904.6					
SR 147	915.6	B-002-0-22	11.33	-	12.08	SS-8	Refusal	100	-	-	-	-	-	-	-	-	-	6	Rock		4	N/A	N/A	N/A	250	28	12.0	903.6					
SR 147	914.1	B-002-1-22	15.5	-	17	SS-7	70	67	-	-	-	-	-	-	-	-	-	11	Rock		4	N/A	N/A	N/A	250	28	16.0	898.1					
SR 147	914.1	B-002-1-22	17	-	18.5	SS-8	68	78	-	-	-	-	-	-	-	-	-	11	Rock		4	N/A	N/A	N/A	250	28	18.0	896.1					
SR 147	914.1	B-002-1-22	18.5	-	20	SS-9	Refusal	100	-	-	-	-	-	-	-	-	-	10	Rock		4	N/A	N/A	N/A	250	28	19.0	895.1					
SR 147	909.4	B-003-0-22	16.5	-	18	SS-11	55	100	-	-	-	-	-	-	-	-	-	13	Rock		4	N/A	N/A	N/A	250	28	17.0	892.4					
SR 147	909.4	B-003-0-22	18	-	19.5	SS-12	91	100	-	-	-	-	-	-	-	-	-	12	Rock		4	N/A	N/A	N/A	250	28	19.0	890.4					
SR 147	909.4	B-003-0-22	19.5	-	21	SS-13	78	100	-	-	-	-	-	-	-	-	-	11	Rock		4	N/A	N/A	N/A	250	28	20.0	889.4					
SR 147	909.4	B-003-0-22	21	-	22.5	SS-14	131	100	-	-	-	-	-	-	-	-	-	8	Rock		4	N/A	N/A	N/A	250	28	22.0	887.4					

PROJECT: NOB-147-9.93	DRILLING FIRM / OPERATOR: ODOT / CAREY	DRILL RIG: CME 55 TRUCK	STATION / OFFSET:	EXPLORATION ID B-001-0-22
TYPE: LANDSLIDE	SAMPLING FIRM / LOGGER: ODOT / MCLEISH	HAMMER: CME AUTOMATIC	ALIGNMENT: CL SR 147	
PID: 117566 SFN:	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 4/18/22	ELEVATION: 926.3 (ft) EOB: 32.0 ft.	PAGE 1 OF 1
START: 12/7/22 END: 12/12/22	SAMPLING METHOD: SPT / NQ2	ENERGY RATIO (%): 87	LAT / LONG: 39.876313, -81.390074	

MATERIAL DESCRIPTION AND NOTES	ELEV. 926.3	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
ASPHALT (36")		1 2 3																
STIFF, BROWN, **SILTY CLAY**, SOME STONE FRAGMENTS, TRACE SAND, MOIST	923.3	3 4 5	3 3 3	9	44	SS-1	1.50	35	3	5	26	31	40	20	20	23	A-6b (8)	
@4.5'; MEDIUM STIFF Layer 1			1 2 3	7	67	SS-2	1.00	-	-	-	-	-	-	-	-	20	A-6b (V)	
VERY STIFF, REDDISH BROWN AND GRAY, **CLAY**, "AND" STONE FRAGMENTS, SOME SILT, TRACE SAND, MOIST Layer 3	920.3	6 7 8	3 7 10	25	100	SS-3	3.00	36	1	2	24	37	47	20	27	22	A-7-6 (13)	
DAMP **SHALE**, REDDISH BROWN, HIGHLY WEATHERED, VERY WEAK, LAMINATED.	917.3 TR	9 10 11	3 9 12	30	83	SS-4	3.00	-	-	-	-	-	-	-	-	16	A-7-6 (V)	
			9 17 24	59	89	SS-5	-	-	-	-	-	-	-	-	-	11	Rock (V)	
	914.3		15 25 54	115	100	SS-6	-	-	-	-	-	-	-	-	-	7	Rock (V)	
SHALE, DARK REDDISH BROWN, MODERATELY WEATHERED, VERY WEAK, LAMINATED, MICACEOUS, SLIGHTLY CALCAREOUS, JOINT, MODERATELY FRACTURED, NARROW, SLIGHTLY ROUGH; BLOCKY, POOR; RQD 15%, REC 100%.		12 13 14 15 16	32		100	NQ2-1											CORE	
@20.4' - 21.1'; HIGH ANGLE FRACTURE		17 18 19 20 21	7		100	NQ2-2											CORE	
@22.6' - 24.5'; S_c = 351 psi	901.8	22 23 24 25 26	30		100	NQ2-3											CORE	
CLAYSTONE, REDDISH BROWN, HIGHLY WEATHERED, VERY WEAK, THIN TO MEDIUM BEDDED, CALCAREOUS, JOINT, MODERATELY FRACTURED, NARROW, SLIGHTLY ROUGH; BLOCKY, POOR; RQD 50%, REC 91%. @26.7' - 26.8'; HIGH ANGLE FRACTURE		27 28 29 30 31	45		87	NQ2-4											CORE	
@31.5' - 31.6'; HIGH ANGLE FRACTURE	894.3	EOB 32																

NOTES: HOLE DRY BEFORE CORING. S_C = POINT LOAD STRENGTH VALUES AS PER ASTM D 5731. LAT/LONG FROM OGE HANDHELD GPS UNIT. ELEV FROM USGS 3DEP MAP SERVICE.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: AUGER CUTTINGS MIXED WITH 25 LB. BENTONITE CHIPS

Elevated Moisture

PROJECT: NOB-147-9.93	DRILLING FIRM / OPERATOR: ODOT / CAREY	DRILL RIG: CME 55 TRUCK	STATION / OFFSET:	EXPLORATION ID B-002-0-22
TYPE: LANDSLIDE	SAMPLING FIRM / LOGGER: ODOT / SPROUSE	HAMMER: CME AUTOMATIC	ALIGNMENT: CL SR 147	
PID: 117566 SFN:	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 4/18/22	ELEVATION: 915.6 (ft) EOB: 12.8 ft.	PAGE 1 OF 1
START: 12/15/22 END: 12/15/22	SAMPLING METHOD: SPT / NQ2	ENERGY RATIO (%): 87	LAT / LONG: 39.876495, -81.389699	

MATERIAL DESCRIPTION AND NOTES	ELEV. 915.6	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
ASPHALT (18")	914.1	1																
STIFF, OLIVE BROWN AND DARK GRAY, **SANDY SILT**, SOME STONE FRAGMENTS, SOME CLAY, DAMP	912.6	2	4 3 4	10	33	SS-1	1.75	35	9	8	26	22	31	21	10	18	A-4a (3)	
VERY STIFF, BROWN AND GRAY, **CLAY**, SOME STONE FRAGMENTS, SOME SILT, TRACE SAND, DAMP		3	1 2 3	7	39	SS-2	2.50	31	2	2	26	39	47	25	22	22	A-7-6 (12)	
@4.5'; STIFF Layer 1	909.6	4 5	1 3 4	10	67	SS-3	2.00	-	-	-	-	-	-	-	-	23	A-7-6 (V)	
VERY STIFF, BROWN AND RED, **SILT AND CLAY**, "AND" SAND, LITTLE STONE FRAGMENTS, MOIST Layer 2		6	3 7 4	16	83	SS-4	2.25	11	13	23	28	25	32	20	12	21	A-6a (4)	
@7.5'; STIFF, SOME STONE FRAGMENTS, LITTLE SAND, DAMP		7 8	1 3 5	12	78	SS-5	1.50	27	4	9	34	26	34	22	12	17	A-6a (6)	
@9.0'; VERY STIFF Layer 3	905.7	9	3 7 21	41	100	SS-6A	3.50	-	-	-	-	-	-	-	-	15	A-6a (V)	
		TR 10				SS-6B	-	-	-	-	-	-	-	-	-	9	Rock (V)	
SHALE, RED, HIGHLY WEATHERED, VERY WEAK, LAMINATED. Layer 4		11	25 55/4"	-	100	SS-7	-	-	-	-	-	-	-	-	-	7	Rock (V)	
	902.8	12 EOB	43 50/3"	-	100	SS-8	-	-	-	-	-	-	-	-	-	6	Rock (V)	

NOTES: HOLE DRY UPON COMPLETION. LAT/LONG FROM OGE HANDHELD GPS UNIT. ELEV FROM USGS 3DEP MAP SERVICE.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: BACKFILLED WITH SOIL CUTTINGS

PROJECT: NOB-147-9.93	DRILLING FIRM / OPERATOR: ODOT / CAREY	DRILL RIG: CME 55 TRUCK	STATION / OFFSET:	EXPLORATION ID B-002-1-22
TYPE: LANDSLIDE	SAMPLING FIRM / LOGGER: ODOT / MCLEISH	HAMMER: CME AUTOMATIC	ALIGNMENT: CL SR 147	
PID: 117566 SFN:	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 4/18/22	ELEVATION: 914.1 (ft) EOB: 39.5 ft.	PAGE 1 OF 1
START: 12/13/22 END: 12/14/22	SAMPLING METHOD: SPT / NQ2	ENERGY RATIO (%): 87	LAT / LONG: 39.876439, -81.389659	

Elevated Moisture

MATERIAL DESCRIPTION AND NOTES	ELEV. 914.1	DEPTHS	SPT/ RQD	N	REC	SAMPLE	HP	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
ASPHALT (72")																		
	908.1																	
STIFF, BROWN AND GRAY, **SILT AND CLAY**, LITTLE STONE FRAGMENTS, LITTLE SAND, DAMP			4 4 4	12	44	SS-1	2.00	20	3	7	34	36	37	23	14	22	A-6a (9)	
@8.0'; SOFT, NO RECOVERY, AUGER CUTTINGS TAKEN, MOIST			1 1 1	3	0	SS-2	-	-	-	-	-	-	-	-	-	25	A-6a (V)	
Layer 1																		
@9.5'; DAMP			1 2 2	6	28	SS-3	1.50	-	-	-	-	-	-	-	-	18	A-6a (V)	
	903.1																	
VERY STIFF, BROWN, GRAY AND REDDISH BROWN, **CLAY**, "AND" STONE FRAGMENTS, LITTLE SILT, LITTLE SAND, DAMP			5 8 7	22	67	SS-4	2.50	45	4	7	18	26	43	26	17	25	A-7-6 (4)	
@12.5'; STIFF, WITH TRACE WOOD FRAGMENTS, MOIST			10 14 7	30	33	SS-5	1.50	-	-	-	-	-	-	-	-	30	A-7-6 (V)	
Layer 3																		
@14.0' - 15.5'; ENCOUNTERED BOULDERS/COBBLES			9 10 10	29	28	SS-6	-	-	-	-	-	-	-	-	-	20	A-7-6 (V)	
	898.6	TR																
CLAYSTONE, GRAY AND PURPLISH GRAY, MODERATELY WEATHERED, VERY WEAK.			3 12 36	70	67	SS-7	-	-	-	-	-	-	-	-	-	11	Rock (V)	
@17.0'; REDDISH BROWN.			10 19 28	68	78	SS-8	-	-	-	-	-	-	-	-	-	11	Rock (V)	
Layer 4 (Modeled as Hard Clay)			29 56	-	100	SS-9	-	-	-	-	-	-	-	-	-	10	Rock (V)	
	894.6																	
CLAYSTONE, DARK REDDISH BROWN, MODERATELY WEATHERED, VERY WEAK, THIN TO MEDIUM BEDDED, CALCAREOUS, JOINT, FRACTURED, NARROW, SLIGHTLY ROUGH; BLOCKY, POOR; RQD 21%, REC 83%.			25		78	NQ2-1											CORE	
			33		92	NQ2-2											CORE	
			7		90	NQ2-3											CORE	
	878.9																	
SHALE, DARK RED, MODERATELY WEATHERED, VERY WEAK, THINLY LAMINATED, MICACEOUS, JOINT, MODERATELY FRACTURED TO FRACTURED, NARROW, SLIGHTLY ROUGH; BLOCKY, POOR; RQD 25%, REC 100%. @36.2' - 39.1'; S_c = 450 psi			22		85	NQ2-4											CORE	
	874.6	EOB																

NOTES: HOLE DRY BEFORE CORING. S_C = POINT LOAD STRENGTH VALUES AS PER ASTM D 5731. LAT/LONG FROM OGE HANDHELD GPS UNIT. ELEV FROM USGS 3DEP MAP SERVICE.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: AUGER CUTTINGS MIXED WITH 50 LB. BENTONITE CHIPS

PROJECT: NOB-147-9.93	DRILLING FIRM / OPERATOR: ODOT / CAREY	DRILL RIG: CME 55 TRUCK	STATION / OFFSET:
TYPE: LANDSLIDE	SAMPLING FIRM / LOGGER: ODOT / MCLEISH	HAMMER: CME AUTOMATIC	ALIGNMENT: CL SR 147
PID: 117566 SFN:	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 4/18/22	ELEVATION: 909.4 (ft) EOB: 42.5 ft.
START: 12/14/22 END: 12/14/22	SAMPLING METHOD: SPT / NQ2	ENERGY RATIO (%): 87	LAT / LONG: 39.876619, -81.389325

EXPLORATION ID B-003-0-22

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 909.4	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
ASPHALT (18")	907.9	1																
VERY STIFF, BROWN AND BLACK, **SILT AND CLAY**, SOME STONE FRAGMENTS, LITTLE SAND, DAMP		2	5 6 12	26	56	SS-1	3.50	33	3	9	30	25	38	25	13	20	A-6a (5)	
		3	2 3 8	16	100	SS-2	2.50	-	-	-	-	-	-	-	-	23	A-6a (V)	
@4.5' - 7.5'; ENCOUNTERED BOULDERS/COBBLES	904.6	4 5	50	-	100	SS-3A	2.50	-	-	-	-	-	-	-	-	15	A-6a (V)	
VERY DENSE, BROWN, **STONE FRAGMENTS WITH SAND**, LITTLE SILT, TRACE CLAY, DAMP	901.9	6 7				SS-3B									-	4	A-1-b (V)	
			41 66	-	83	SS-4	-	60	6	17	13	4	NP	NP	NP	4	A-1-b (0)	
VERY STIFF, BROWN, **SILT AND CLAY**, "AND" STONE FRAGMENTS, LITTLE SAND, DAMP		8	4 5 6	16	44	SS-5	-	45	4	9	23	19	33	21	12	13	A-6a (2)	
Layer 2	898.9	9 10	6 4 5	13	39	SS-6	3.50	-	-	-	-	-	-	-	-	14	A-6a (V)	
VERY STIFF, BROWN, **CLAY**, SOME SILT, SOME STONE FRAGMENTS, LITTLE SAND, DAMP		11 12	3 4 7	16	100	SS-7	3.50	23	5	7	30	35	41	23	18	24	A-7-6 (9)	
@12.0'; BROWN AND REDDISH BROWN	895.9	13	2 7 11	26	89	SS-8	4.00	-	-	-	-	-	-	-	-	17	A-7-6 (V)	
HARD, BROWN AND RED, **SILT AND CLAY**, TRACE STONE FRAGMENTS, TRACE SAND, DAMP		14 15	10 18 27	65	78	SS-9	4.5+	10	3	3	40	44	39	27	12	16	A-6a (9)	
Layer 3	892.9	16	10 14 20	49	100	SS-10	4.5+	-	-	-	-	-	-	-	-	16	A-6a (V)	
CLAYSTONE, RED AND GRAY, MODERATELY WEATHERED, VERY WEAK.	TR	17 18	12 18 20	55	100	SS-11	-	-	-	-	-	-	-	-	-	13	Rock (V)	
		19	12 22 41	91	100	SS-12	-	-	-	-	-	-	-	-	-	12	Rock (V)	
Layer 4 (Modeled as Hard Clay)		20 21	10 21 33	78	100	SS-13	-	-	-	-	-	-	-	-	-	11	Rock (V)	
	886.9	22	22 35 55	131	100	SS-14	-	-	-	-	-	-	-	-	-	8	Rock (V)	
CLAYSTONE, DARK REDDISH BROWN AND GREENISH GRAY, MODERATELY WEATHERED, VERY WEAK, THIN TO MEDIUM BEDDED, SLIGHTLY CALCAREOUS, JOINT, FRACTURED, NARROW, SLIGHTLY ROUGH; BLOCKY, POOR; RQD 36%, REC 62%.		23 24 25 26 27	40		60	NQ2-1											CORE	
	881.4	28																
SHALE, DARK REDDISH BROWN AND BLUEISH GRAY, MODERATELY WEATHERED, VERY WEAK, THINLY LAMINATED, PYRITIC, JOINT, FRACTURED, NARROW, SLIGHTLY ROUGH; BLOCKY FAIR; RQD 22%, REC 92%.		29 30 31 32	28		98	NQ2-2											CORE	
@33.2' - 35.9'; S_c = 620 psi		33 34 35 36 37	18		100	NQ2-3											CORE	
@41.5'; CORE WEDGED IN CORE BARREL	866.9	38 39 40 41 42	17		77	NQ2-4											CORE	
	EOB																	

Omitted as outliers

NOTES: HOLE DRY BEFORE CORING. S_c = POINT LOAD STRENGTH VALUES AS PER ASTM D 5731. LAT/LONG FROM OGE HANDHELD GPS UNIT. ELEV FROM USGS 3DEP MAP SERVICE.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: AUGER CUTTINGS MIXED WITH 25 LB. BENTONITE CHIPS

STANDARD ODOT SOIL BORING LOG (11 X 17) - OH DOT.GDT - 2/13/23 15:14 - X:\GINT\PROJECTS\601024.GPJ

Rock Strength Parameter Determination
and
Laboratory Testing

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

ODOT District 10
NOB-147-9.93

Soil 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)	Compressive Strength (MPa)	Er Modulus (psi)	Er Modulus (MPa)	GSI Range	GSI USE	Em (Hoek & Brown) Modulus (GPa)	Em (Hoek & Brown) Modulus (psi)	Lesser of Er vs Em (psi)	Em (Yang) Modulus (MPa)	Em (Yang) Modulus (psi)
NOB-147-9.93	B-001-0-22	22.6	NQ2-3	Shale	Red-brown		351	2.4		0	20-30	25	0.4	53505	53505	0.0	0
NOB-147-9.93	B-002-1-22	36.2	NQ2-4	Shale	Red		450	3.1		0	20-30	25	0.4	60582	60582	0.0	0
NOB-147-9.93	B-003-0-22	33.2	NQ2-3	Shale	Red-brown		620	4.3		0	25-35	30	0.7	94828	94828	0.0	0
				Shale	Maximum	0	620						Shale	Maximum	94828		
					Minimum	0	351							Minimum	53505		
					Average	N/A	474							Average	69638		
					Std Dev	N/A	136							Std Dev	22100		
					Adopted Value	155	480							Adopted Value	69000		

krm 0.0005

BEDROCK QUALITY

Project	Exploration ID	Rock Type	Depth Range (ft.) From	Depth Range (ft.) To	Thickness (ft)	Layer RQD (%)	Weighted RQD*(Length / Total Length)
NOB-147-9.93	B-001-0-22	Shale	12	24.5	12.5	15	6.0
NOB-147-9.93	B-002-1-22	Shale	35.2	39.5	4.3	25	3.4
NOB-147-9.93	B-003-0-22	Shale	28	42.5	14.5	22	10.2
				Shale	31.3	RQD SUM	20
				Maximum	14.5	25	
				Minimum	4.3	15	
				Average	10.4	20.7	
				Adopted Value			20

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.		

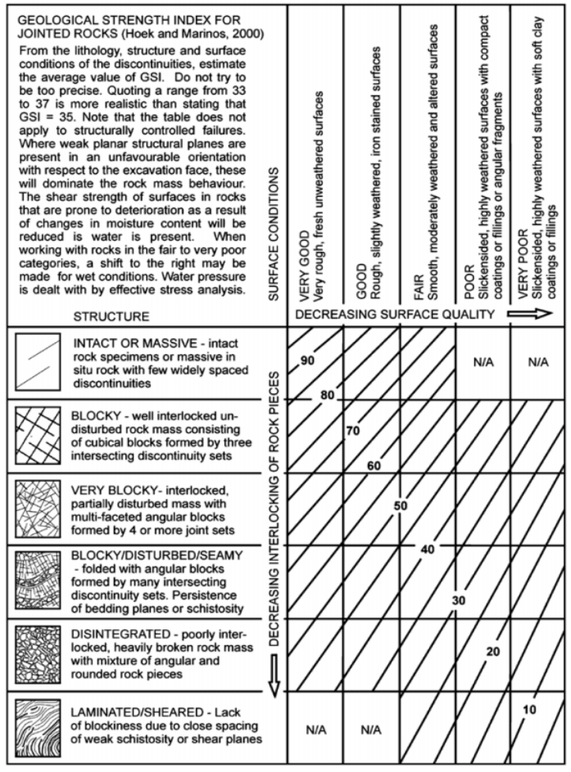


Figure 10.4.6.4-1—Determination of *GSI* for Jointed Rock Mass (Hoek and Marinos, 2000)

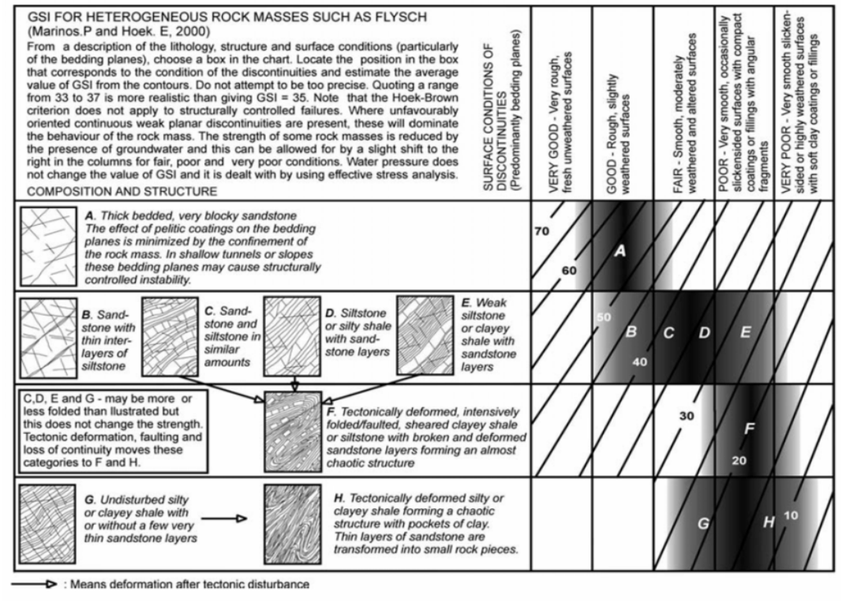


Figure 10.4.6.4-2—Determination of *GSI* for Tectonically Deformed Heterogeneous Rock Masses (Marinos and Hoek 2000)

The Ohio Department of Transportation
Office of Geotechnical Engineering

PROJECT: NOB-147-9.33 **DISTRICT No.:** 10 **PID No.** 117566 **Tech:** PPP

Point Load Strength Calc*: $Is = P / (D_e^2)$ $D_e^2 = 4A/\pi$ $A = (WD)$ Stregnth = Is * K K = 12

Boring #	Sample Depth (ft)	Material Type	W (in)	W (mm)	D (in)	D (mm) Initial	D (mm) Final	D (mm) Avg	L/D	Failure Load (kN)	Is_{50} (MPa)	Is_{50} (psi)	Strength S_c (MPa)	Strength S_c (psi)
B-001-0-22	22.6-24.5	Shale	1.968	50.00	0.63897	19.46	13.00	16.23	0.325	1.164	1.13	163	27	~~1960~~
			1.968	50.00	1.24252	33.12	30.00	31.56	0.631	1.029	0.51	74	12	~~891~~
			1.968	50.00	0.74606	19.90	18.00	18.95	0.379	0.484	0.40	58	10	698
			1.968	50.00	1.1811	31.00	29.00	30.00	0.600	0.087	0.05	7	1	79
			1.968	50.00	1.00393	26.00	25.00	25.50	0.510	0.014	0.01	1	0	~~15~~
			1.968	50.00	0.82677	24.00	18.00	21.00	0.420	0.474	0.35	51	9	617
			1.968	50.00	1.61417	45.00	37.00	41.00	0.820	0.511	0.20	28	5	341
			1.968	50.00	0.96456	26.00	23.00	24.50	0.490	0.245	0.16	23	4	273
			1.968	50.00	0.80708	21.00	20.00	20.50	0.410	0.052	0.04	6	1	~~69~~
			1.968	50.00	1.24015	33.00	30.00	31.50	0.630	0.115	0.06	8	1	100
												Average Strength (Sc) =		351

Comments:

The Ohio Department of Transportation
Office of Geotechnical Engineering

PROJECT: NOB-147-9.33 **DISTRICT No.:** 10 **PID No.** 117566 **Tech:** PPP

Point Load Strength Calc*: $Is = P / (D_e^2)$ $D_e^2 = 4A/\pi$ $A = (WD)$ Stregnth = Is * K K = 12

Boring #	Sample Depth (ft)	Material Type	W (in)	W (mm)	D (in)	D (mm) Initial	D (mm) Final	D (mm) Avg	L/D	Failure Load (kN)	Is_{50} (MPa)	Is_{50} (psi)	Strength S_c (MPa)	Strength S_c (psi)
B-002-1-22	36.2-39.1	Shale	1.968	50.00	0.98425	27.00	23.00	25.00	0.500	1.099	0.69	100	17	~~1202~~
			1.968	50.00	1.00393	26.00	25.00	25.50	0.510	0.585	0.36	52	9	627
			1.968	50.00	1.14173	32.00	26.00	29.00	0.580	1.495	0.81	117	19	~~1409~~
			1.968	50.00	0.92519	27.00	20.00	23.50	0.470	0.674	0.45	65	11	784
			1.968	50.00	1.10236	30.00	26.00	28.00	0.560	0.014	0.01	1	0	~~14~~
			1.968	50.00	0.84645	24.00	19.00	21.50	0.430	0.251	0.18	27	4	319
			1.968	50.00	1.39763	39.00	32.00	35.50	0.710	0.486	0.22	31	5	374
			1.968	50.00	1.63385	43.00	40.00	41.50	0.830	0.055	0.02	3	0	36
			1.968	50.00	0.88582	25.00	20.00	22.50	0.450	0.463	0.32	47	8	562
			1.968	50.00	0.61023	16.00	15.00	15.50	0.310	0.005	0.01	1	0	~~9~~
												Average Strength (Sc) =		450

Comments:

The Ohio Department of Transportation
Office of Geotechnical Engineering

PROJECT: NOB-147-9.33 **DISTRICT No.:** 10 **PID No.** 117566 **Tech:** PPP

Point Load Strength Calc*: $Is = P / (D_e^2)$ $D_e^2 = 4A/\pi$ $A = (WD)$ Stregnth = Is * K K = 12

Boring #	Sample Depth (ft)	Material Type	W (in)	W (mm)	D (in)	D (mm) Initial	D (mm) Final	D (mm) Avg	L/D	Failure Load (kN)	Is_{50} (MPa)	Is_{50} (psi)	Strength S_c (MPa)	Strength S_c (psi)
B-003-0-22	33.2-35.9	Shale	1.968	50.00	1.25984	43.00	21.00	32.00	0.640	1.084	0.53	77	13	926
			1.968	50.00	1.02362	32.00	20.00	26.00	0.520	0.688	0.42	60	10	723
			1.968	50.00	0.74803	22.00	16.00	19.00	0.380	0.826	0.68	99	16	~~1188~~
			1.968	50.00	0.72834	23.00	14.00	18.50	0.370	0.819	0.70	101	17	~~1210~~
			1.968	50.00	0.80708	22.00	19.00	20.50	0.410	0.177	0.14	20	3	236
			1.968	50.00	1.27952	40.00	25.00	32.50	0.650	1.200	0.58	84	14	1009
			1.968	50.00	0.70866	19.00	17.00	18.00	0.360	0.050	0.04	6	1	~~76~~
			1.968	50.00	1.22047	36.00	26.00	31.00	0.620	0.301	0.15	22	4	265
			1.968	50.00	0.7874	21.00	19.00	20.00	0.400	0.060	0.05	7	1	~~82~~
			1.968	50.00	0.92519	25.00	22.00	23.50	0.470	0.483	0.32	47	8	562
												Average Strength (Sc) =		620

Comments:

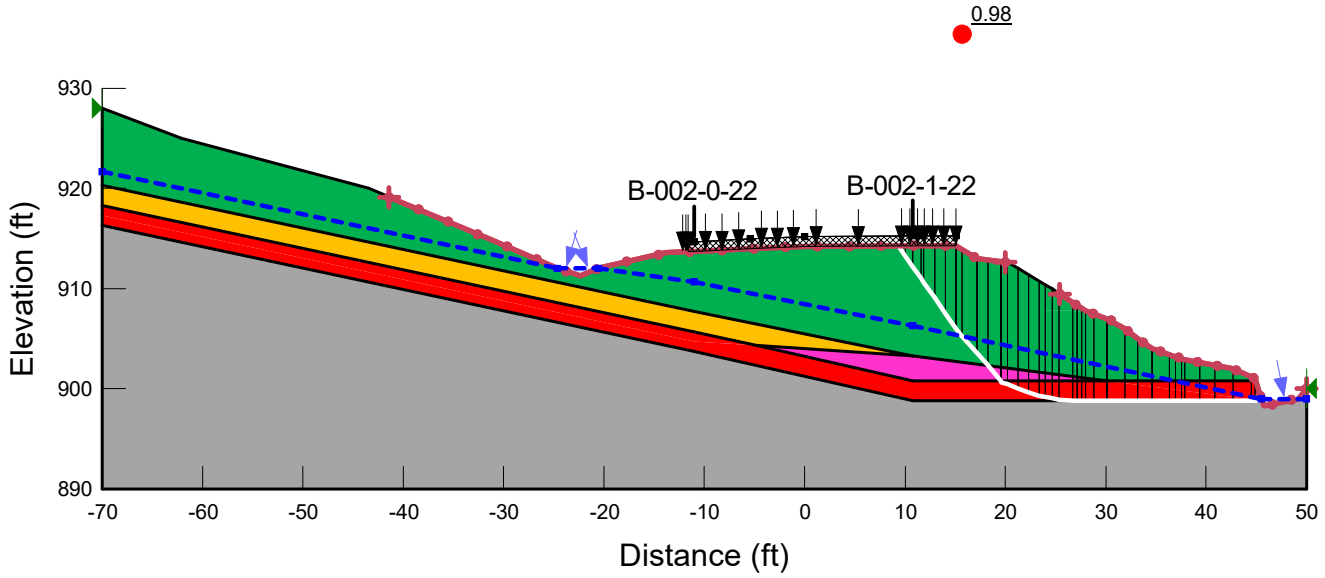
Slope Stability Analyses

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

Station 525+25
Existing Conditions

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

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	1. Medium Stiff to Stiff Cohesive	Mohr-Coulomb	115	220	21
	2. Stiff to Very Stiff Cohesive	Mohr-Coulomb	125	150	24
	3. Very Stiff to Hard Cohesive	Mohr-Coulomb	130	230	28
	Bedrock	Bedrock (Impenetrable)			
	Weak Rock	Mohr-Coulomb	140	0	12

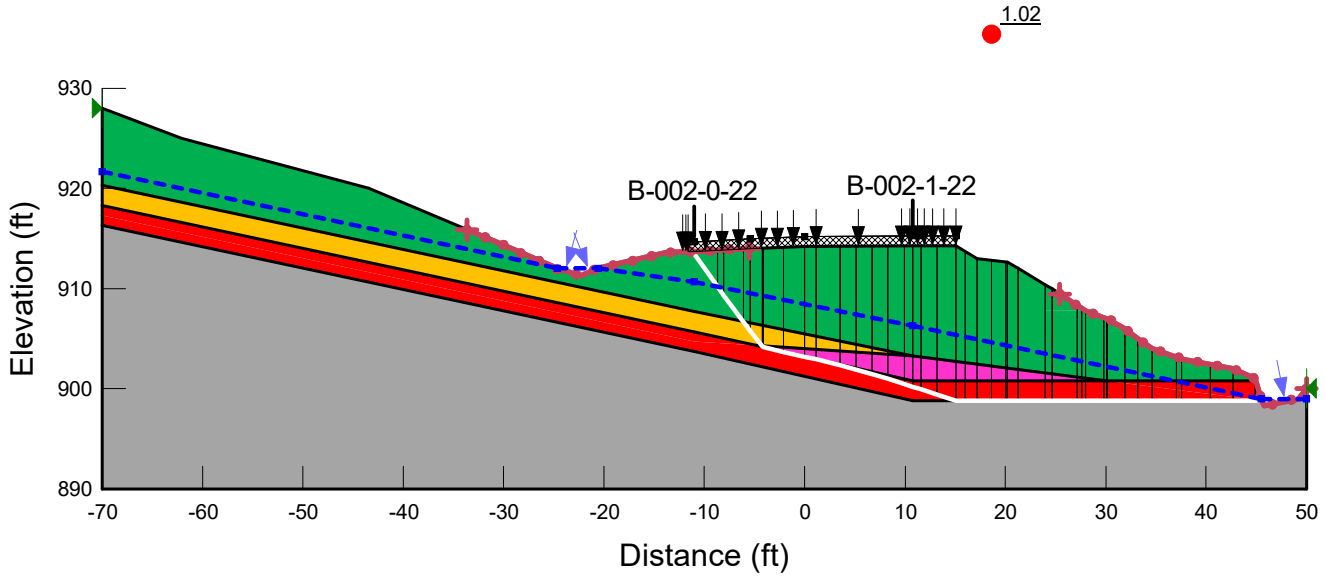


1. Existing Condition (Overall)

NOB-147-9.93.gsz

09/21/2023 1:230

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	1. Medium Stiff to Stiff Cohesive	Mohr-Coulomb	115	220	21
	2. Stiff to Very Stiff Cohesive	Mohr-Coulomb	125	150	24
	3. Very Stiff to Hard Cohesive	Mohr-Coulomb	130	230	28
	Bedrock	Bedrock (Impenetrable)			
	Weak Rock	Mohr-Coulomb	140	0	12



2. Existing Condition (Upslope)

NOB-147-9.93.gsz

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UA Slope Analyses

Station 525+25
Existing Conditions

UA Slope Program Version 2.3 - J:\ODOT-District 5-10_GES\2021\Task Order 10-LL NOB-147-9.93\Working\Slope Stability\NOB-147-9.93 Existing Overall.ua3*

File Run Options Help

Calculated Results

Factor of Safety: 0.98

Force per Shaft: 0.000 lb

Acting Point X: 0.000 ft Y: 0.000 ft

Analysis Unit System

(•) English ( ) Metric

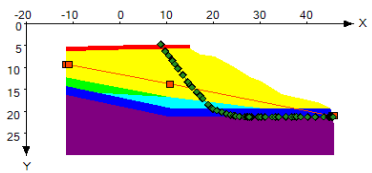
Number of Vertical Sections and Soil Layers

Vertical Section Num: 18 Soil Layer Num: 7

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	210.0	21.0	115.0
Layer4	150.0	24.0	125.0
Layer5	230.0	28.0	130.0
Layer6	0.0	12.0	140.0
Layer7	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)	-11.60	-11.00	-4.80	10.80	15.10	15.10	17.20	20.20	24.00	24.00	27.60	28.00	30.10	34.60
Y1 (ft)	5.30	5.30	5.00	4.70	4.70	5.70	7.00	7.40	9.60	9.60	12.00	12.20	13.00	16.00
▸ Y2 (ft)	6.30	6.30	6.00	5.70	5.70	5.70	7.00	7.40	9.60	9.60	12.00	12.20	13.00	16.00
Y3 (ft)	6.30	6.30	6.00	5.70	5.70	5.70	7.00	7.40	9.60	9.60	12.00	12.20	13.00	16.00
Y4 (ft)	12.20	12.30	13.60	16.70	17.30	17.30	17.50	17.90	18.40	18.40	18.90	18.90	19.20	19.20
Y5 (ft)	14.20	14.30	15.70	16.70	17.30	17.30	17.50	17.90	18.40	18.40	18.90	18.90	19.20	19.20
Y6 (ft)	14.20	14.30	15.70	19.20	19.20	19.20	19.20	19.20	19.20	19.20	19.20	19.20	19.20	19.20
Y7 (ft)	16.20	16.30	17.70	21.20	21.20	21.20	21.20	21.20	21.20	21.20	21.20	21.20	21.20	21.20
Y8 (ft)	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00

Coordinates of Crest X: 15.10 ft Y: 5.70 ft Coordinates of Toe X: 44.90 ft Y: 19.00 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)

[ ] Auto Save Data

Xmin 0.00 Diameter: 0.30 ft

Xmax 0.00 CTC Spacing: 3.00 ft

XDelta 0.00 X Coordinate: 0.00 ft

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
▸ X (ft)	-11.60	-11.00	10.80	45.50	45.80
Y (ft)	9.20	9.30	13.70	21.00	21.00

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)	8.70	9.70	10.43	11.20	11.74	12.41	13.47	14.53	15.08	15.40	16.44	17.19	17.72	18.89	19.60	19.92	20.75	21.3
▸ Y (ft)	4.70	6.23	7.28	8.40	9.19	10.16	11.70	13.23	14.02	14.39	15.56	16.41	17.05	18.43	19.26	19.43	19.74	20.1

UA Slope Program Version 2.3 - J:\ODOT-District 5-10_GES\2021\Task Order 10-LL NOB-147-9.93\Working\Slope Stability\NOB-147-9.93 Existing Upslope.ua3*

File Run Options Help

Calculated Results

Factor of Safety: 1.02

Force per Shaft: 0.000 lb

Acting Point X: 0.000 ft Y: 0.000 ft

Analysis Unit System

(•) English ( ) Metric

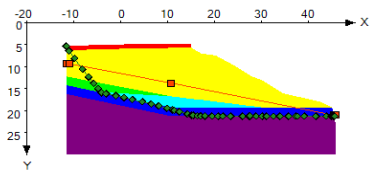
Number of Vertical Sections and Soil Layers

Vertical Section Num: 18 Soil Layer Num: 7

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	130.0	21.0	115.0
Layer4	150.0	24.0	125.0
Layer5	230.0	28.0	130.0
Layer6	0.0	12.0	140.0
Layer7	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)	-11.60	-11.00	-4.80	10.80	15.10	15.10	17.20	20.20	24.00	24.00	27.60	28.00	30.10	34.60
Y1 (ft)	5.30	5.30	5.00	4.70	4.70	5.70	7.00	7.40	9.60	9.60	12.00	12.20	13.00	16.00
▸ Y2 (ft)	6.30	6.30	6.00	5.70	5.70	5.70	7.00	7.40	9.60	9.60	12.00	12.20	13.00	16.00
Y3 (ft)	6.30	6.30	6.00	5.70	5.70	5.70	7.00	7.40	9.60	9.60	12.00	12.20	13.00	16.00
Y4 (ft)	12.20	12.30	13.60	16.70	17.30	17.30	17.50	17.90	18.40	18.40	18.90	18.90	19.20	19.20
Y5 (ft)	14.20	14.30	15.70	16.70	17.30	17.30	17.50	17.90	18.40	18.40	18.90	18.90	19.20	19.20
Y6 (ft)	14.20	14.30	15.70	19.20	19.20	19.20	19.20	19.20	19.20	19.20	19.20	19.20	19.20	19.20
Y7 (ft)	16.20	16.30	17.70	21.20	21.20	21.20	21.20	21.20	21.20	21.20	21.20	21.20	21.20	21.20
Y8 (ft)	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00

Coordinates of Crest X: 15.10 ft Y: 5.70 ft Coordinates of Toe X: 44.90 ft Y: 19.00 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: 3.00 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
▸ X (ft)	-11.60	-11.00	10.80	45.50	45.80
Y (ft)	9.20	9.30	13.70	21.00	21.00

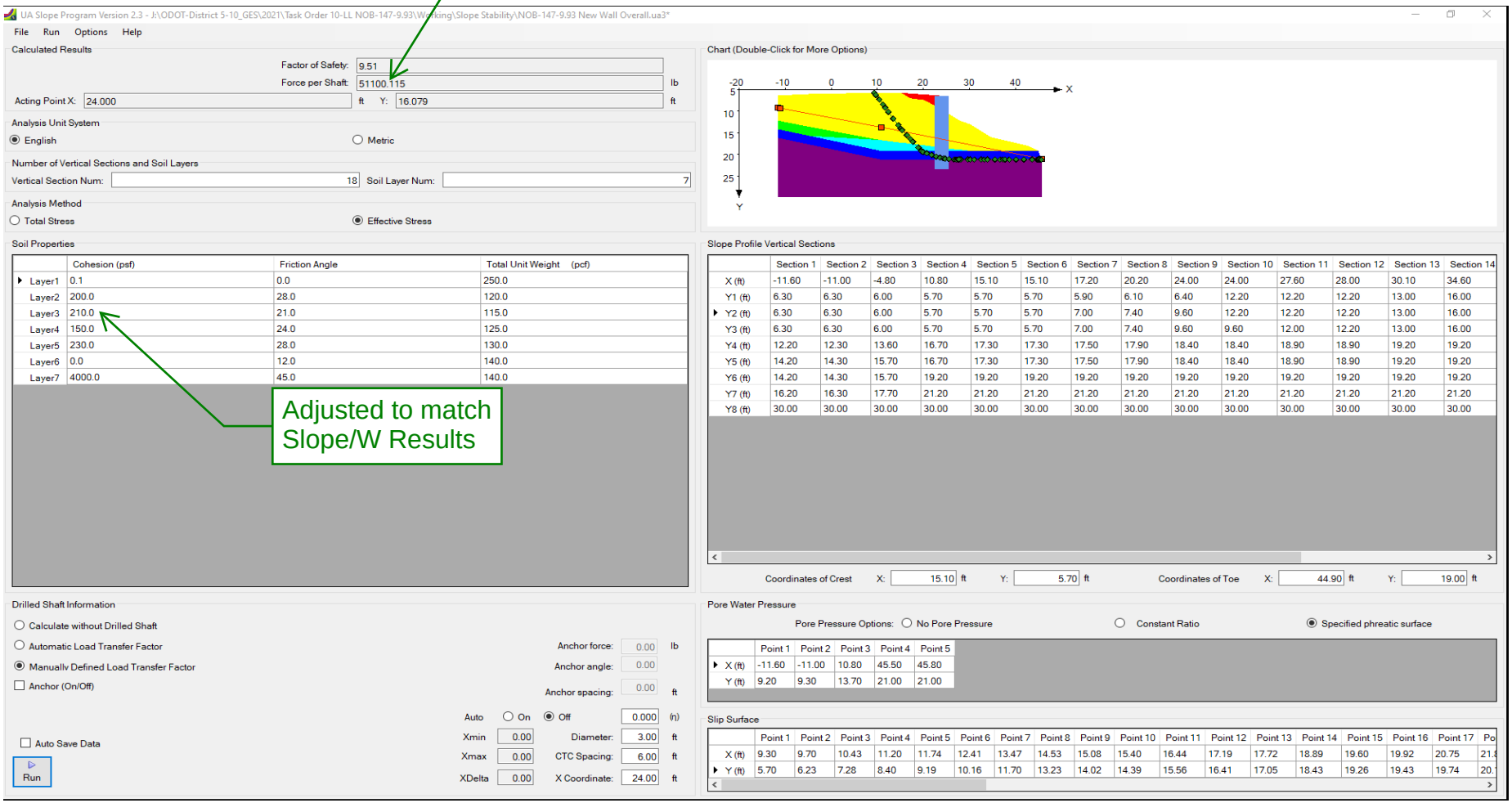
Slip Surface

	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)	-11.60	-11.04	-9.83	-8.14	-6.85	-5.74	-4.80	-4.16	-4.10	-3.07	-1.02	0.73	2.50	4.60	6.48	8.12	9.87	10.9
▸ Y (ft)	5.30	6.36	8.10	10.52	12.28	13.73	14.96	15.80	15.87	16.12	16.58	16.98	17.41	17.94	18.43	18.89	19.41	19.7

Station 525+25
Post-Construction Conditions

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

Controlling load carried forward for design.



Load did not control.

UA Slope Program Version 2.3 - J:\ODOT-District 5-10_GES\2021\Task Order 10-LL NOB-147-9.93\Working\Slope Stability\NOB-147-9.93 New Wall Upslope.ua3*

File Run Options Help

Calculated Results

Factor of Safety: 0.00

Force per Shaft: 44319.883 lb

Acting Point X: 24.000 ft Y: 16.316 ft

Analysis Unit System

(•) English ( ) Metric

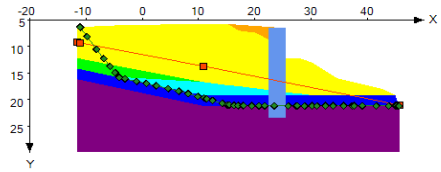
Number of Vertical Sections and Soil Layers

Vertical Section Num: 18 Soil Layer Num: 7

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	130.0	21.0	115.0
Layer4	150.0	24.0	125.0
Layer5	230.0	28.0	130.0
Layer6	0.0	12.0	140.0
Layer7	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)	-11.60	-11.00	-4.80	10.80	15.10	15.10	17.20	20.20	24.00	24.00	27.60	28.00	30.10	34.60
Y1 (ft)	6.30	6.30	6.00	5.70	5.70	5.70	5.90	6.10	6.40	12.20	12.20	12.20	13.00	16.00
Y2 (ft)	6.30	6.30	6.00	5.70	5.70	5.70	5.90	6.10	6.40	12.20	12.20	12.20	13.00	16.00
Y3 (ft)	6.30	6.30	6.00	5.70	5.70	5.70	7.00	7.40	9.60	12.20	12.20	12.20	13.00	16.00
Y4 (ft)	12.20	12.30	13.60	16.70	17.30	17.30	17.50	17.90	18.40	18.40	18.90	18.90	19.20	19.20
Y5 (ft)	14.20	14.30	15.70	16.70	17.30	17.30	17.50	17.90	18.40	18.40	18.90	18.90	19.20	19.20
Y6 (ft)	14.20	14.30	15.70	19.20	19.20	19.20	19.20	19.20	19.20	19.20	19.20	19.20	19.20	19.20
Y7 (ft)	16.20	16.30	17.70	21.20	21.20	21.20	21.20	21.20	21.20	21.20	21.20	21.20	21.20	21.20
Y8 (ft)	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00

Coordinates of Crest X: 15.10 ft Y: 5.70 ft Coordinates of Toe X: 44.90 ft Y: 19.00 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: 3.00 ft

Xmax 0.00 CTC Spacing: 6.00 ft

XDelta 0.00 X Coordinate: 24.00 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
X (ft)	-11.60	-11.00	10.80	45.50	45.80
Y (ft)	9.20	9.30	13.70	21.00	21.00

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)	-11.10	-11.04	-9.83	-8.14	-6.85	-5.74	-4.80	-4.16	-4.10	-3.07	-1.02	0.73	2.50	4.60	6.48	8.12	9.87	10.
Y (ft)	6.30	6.36	8.10	10.52	12.28	13.73	14.96	15.80	15.87	16.12	16.58	16.98	17.41	17.94	18.43	18.89	19.41	19.

Wall Calculations

Geometry

	Elevation (ft)	
Top of Backfill =	914.3	*at Outside Edge of Shoulder*
Top of Wall =	913.6	*at C/L of Wall*
Existing Ground Surface =	910.4	*at C/L of Wall*
Maintenance Bench =	907.8	*at C/L of Wall*
Slip Plane =	898.8	*at C/L of Wall*

	Horiz. Distance from C/L (ft)	
Start of Wall Backfill =	15.1	*at Outside Edge of Shoulder*
Wall =	24.0	*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	913.6	3.2	200	28	120
Medium Stiff to Stiff Fill/Colluvium	910.4	2.6	220	21	115
Bottom of Wall/Maintenance Bench	907.8				
Weighted Value		5.8	210	25	120

Earth Pressure Coefficients

	Deg		
Shear Resistance, Φ =	28		
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.	8.9	feet	*(C/L of Wall - Edge of Shoulder)*
Wall Height (H)	5.8	feet	*(Top of Wall - Maintenance Bench)*
Slope Height (h)	0.7	feet	*(Top of Backfill - Top of Wall)*
I =	3.45	degrees	

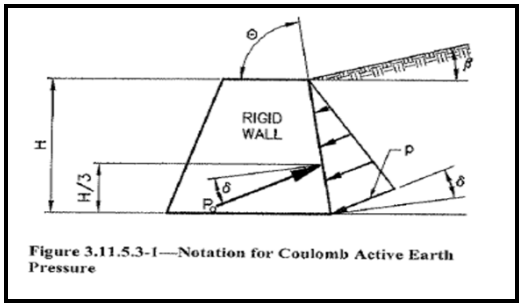


Figure 3.11.5.3-1—Notation for Coulomb Active Earth Pressure

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 = 0.383

At-Rest Earth Coefficient

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

K_o = 0.577

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' = 210 psf and φ' = 25°, per backcalculated UA Slope Values). The parameters were converted to equivalent soil strength parameters c' = 0 psf and φ'= 28° 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).*

Per direction from ODOT, soil loss in front of the wall to the top of bedrock due to erosion/scour has been assumed.

Soil Lateral Design Profile

	Top Elev	Depth (ft)	Cohesion (psf)	Phi (deg)	Unit Wt (pcf)	ε50	k
4. Claystone (Modeled as Clay)	898.8	14.8	6000	0	155	0.004	N/A

Bedrock Lateral Design Profile

	Top Elev	Depth (ft)	qu (psi)	Em (psi)	Unit Wt (pcf)	RQD (%)	krm
Shale	878.9	34.7	480	69000	155	20	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 = 120 pcf *Weighted Average Along Cantilevered Wall Height*

2) Determine Coefficient of Earth Pressure (K)

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

Ka = 0.383

3) Determine Equivalent Fluid Weight (G_H)

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

G_H = 46 *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

Assumed lowered ground surface as erosion of all soil to top of bedrock (per guidance from ODOT District 10)

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

D = 3 feet *(shaft diameter or pile flange width)*

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

p-multiplier does not apply, as erosion of all soil to top of bedrock is being considered

6) Determine Lateral Thrust

Conventional Earth Pressure Theory | *UA SLOPE*

Exposed Wall Height (H) = 5.8 feet | Depth from T/Wall to Slip Plane = 14.8 feet

Wall Height (H) + GS_{AL} = 14.8

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

P = 5031 lbs/foot

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

P_{SH} = 30184 lbs/shaft | Force Per Shaft = 51100 lbs/shaft

From "Overall" failure surface

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

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

w =	4079	lbs/foot per shaft (Earth - Service Limit)	6905 lbs/foot per shaft
w =	340	lbs/inch per shaft (Earth - Service Limit)	575 lbs/inch per shaft
γ_E =	1.5	*Earth Load Factor*	
w =	$(2*P_{SH}/H)*\gamma_E$		
w =	510	lbs/inch per shaft (Earth - Strength Limit)	863 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 =	1416	lbs/foot *(surcharge resolved to distributed load)*	1416 lbs/foot
P_s =	8498	lbs/shaft	8498 lbs/shaft

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

w = P_S/H

w =	574	lbs/foot per shaft (surcharge - unfactored)	574 lbs/foot per shaft
w =	48	lbs/inch per shaft (surcharge - unfactored)	48 lbs/inch per shaft
γ_S =	1.75	*Surcharge Load Factor - Strength I*	
w =	$(P_S/L)*\gamma_S$		
w =	84	lbs/inch per shaft (Surcharge - Strength I)	84 lbs/inch per shaft

Distributed Lateral Loads for LPILE

CONVENTIONAL

Depth (ft.)	Service (lb/in)	Strength-I (lb/in)
0	48	84
14.8	388	594

Assumes scour of soil to top of rock.

Distributed Lateral Loads for LPILE

UA SLOPE

Depth (ft.)	Service (lb/in)	Strength-I (lb/in)
0	48	84
14.8	623	947

Assumes scour of soil to top of rock.

Steel Beam and Cross-Section Properties

Assumed Pile Shape W 21x101

Pile Availability

AISC Member Producers	2
Non-Member Producers	0

Shaft Geometry

Shaft Diameter	36	in
Longest Beam Dimension	24.68299	in
Clear Distance	5.658505	in

Steel Beam Geometry

Beam Depth (D)	21.4	in
Web Thickness (t_w)	0.5	in
Flange Width (B_f)	12.3	in
Flange Thickness (t_f)	0.8	in
Area of Steel (A_s)	29.8	in^2

Steel Properties

Yield Strength of Steel	50	ksi
Moment of Inertia (I_{xx}) of Steel	2420	in^4
Modulus of Elasticity of Steel (E)	29000	ksi
Modulus of Elasticity of Steel (E)	29000000	psi
EI (Steel Only)	7.018E+10	$lb*in^2$
Section Modulus (S_x)	227	in^3
Section Modulus (Z_x)	253	in^3
Shear-Buckling Coefficient (k)	5	
Ratio of Shear-Buckling Resistance (C)	1	
D/t_w	42.8	
$1.12\sqrt{Ek/F_{yw}}$	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 * 21.4 * 0.5

$V_p =$ 310.3 kips

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

$\phi V_{cr} =$ 1 * 1 * 310.3

$\phi V_{cr =}$ 310.3 kips

$V_u =$ 106.39 kips *(from LPILE)*

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 * 227

$\phi M_n =$ 11350 in*kips

$M_u =$ 7531 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 =	14.8	ft	
Minimum Pile Length Below Slip Plane =	10	ft	*ODOT Minimum Required Length*
Minimum Required Pile Length =	24.8	ft	

Deflection Criteria

Pile Length Above Rock = 14.8 ft — Exposed Wall Height = 5.8 ft

Pile Length Above Rock = 177.6 in — Exposed Wall Height = 69.6 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

1% Wall Height **OR** 2 inches- LPILE 2 in $\delta =$ 1.518 in *(from LPILE)*

1.5% Wall Height - PYWALL in $\delta =$ in *(from PYWALL)*

Drilled Shafts Located Within 10 feet of Edge of Pavement YES

LPILE Analyses
(W 21 x 101)

9999 Carver Road, Suite 210, Cincinnati, OH 45242-5583 **hdrinc.com**
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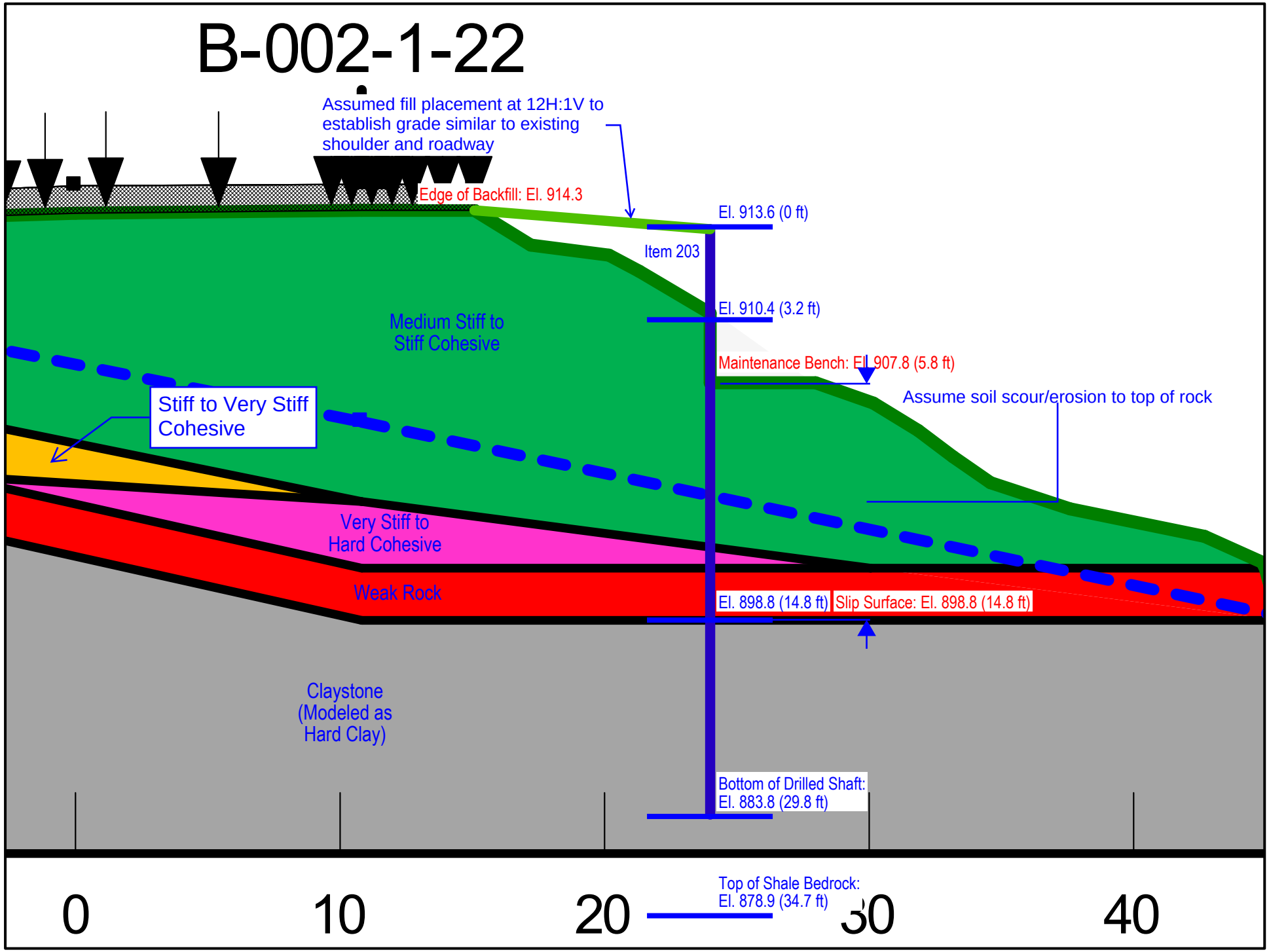
B-002-1-22
Assumed fill placement at 12H:1V to establish grade similar to existing shoulder and roadway
Edge of Backfill: El. 914.3
El. 913.6 (0 ft)
Item 203
El. 910.4 (3.2 ft)
Medium Stiff to Stiff Cohesive
Maintenance Bench: El. 907.8 (5.8 ft)
Assume soil scour/erosion to top of rock
Stiff to Very Stiff Cohesive
Very Stiff to Hard Cohesive
Weak Rock
El. 898.8 (14.8 ft)
Slip Surface: El. 898.8 (14.8 ft)
Claystone (Modeled as Hard Clay)
Bottom of Drilled Shaft: El. 883.8 (29.8 ft)
Top of Shale Bedrock: El. 878.9 (34.7 ft)
0
10
20
30
40

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
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================================================================================

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

Path to file locations:
\ODOT-District 5-10_GES\2021\Task Order 10-LL NOB-147-9.93\Working\Wall Design\

Name of input data file:
NOB-147-9.93 Service Case.lp11

Name of output report file:
NOB-147-9.93 Service Case.lp11

Name of plot output file:
NOB-147-9.93 Service Case.lp11

Name of runtime message file:
```

NOB-147-9.93 Service Case.lp11

Date and Time of Analysis

Date: September 21, 2023 Time: 13:17:01

Problem Title

Project Name: NOB-147-9.93

Job Number:

Client: ODOT

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

 - Use of p-y modification factors for p-y curves not selected
 - 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 = 29.800 ft
Depth of ground surface below top of pile = 14.8000 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	36.0000
2	29.800	36.0000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is an elastic pile

Cross-sectional Shape	=	Circular Pile
Length of section	=	29.800000 ft
Width of top of section	=	36.000000 in
Width of bottom of section	=	36.000000 in
Top Area	=	29.800000 sq. in
Bottom Area	=	29.800000 sq. in
Moment of Inertia at Top	=	2420. in^4
Moment of Inertia at Bottom	=	2420. 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 2 layers

Layer 1 is stiff clay without free water

Distance from top of pile to top of layer	=	14.800000 ft
Distance from top of pile to bottom of layer	=	34.700000 ft
Effective unit weight at top of layer	=	155.000000 pcf
Effective unit weight at bottom of layer	=	155.000000 pcf
Undrained cohesion at top of layer	=	6000. psf
Undrained cohesion at bottom of layer	=	6000. psf
Epsilon-50 at top of layer	=	0.004000
Epsilon-50 at bottom of layer	=	0.004000

Layer 2 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer	=	34.700000 ft
Distance from top of pile to bottom of layer	=	39.000000 ft
Effective unit weight at top of layer	=	155.000000 pcf
Effective unit weight at bottom of layer	=	155.000000 pcf
Uniaxial compressive strength at top of layer	=	480.000000 psi
Uniaxial compressive strength at bottom of layer	=	480.000000 psi
Initial modulus of rock at top of layer	=	69000. psi
Initial modulus of rock at bottom of layer	=	69000. psi
RQD of rock at top of layer	=	20.000000 %
RQD of rock at bottom of layer	=	20.000000 %
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 9.200 ft below the pile tip)

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

Values entered for effective unit weights of soil were outside the limits of
20 pcf to 140 pcf.

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

This data may be erroneous. Please check your data.

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

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

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

This data may be erroneous. Please check your data.

Summary of Input Soil Properties

Layer Num.	Soil Type Name (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Undrained Cohesion psf	Uniaxial qu psi	RQD %	E50 or krm	Rock Mass Modulus psi
1	Stiff Clay	14.8000	155.0000	6000.	--	--	0.00400	--
	w/o Free Water	34.7000	155.0000	6000.	--	--	0.00400	--
2	Weak	34.7000	155.0000	--	480.0000	20.0000	5.00E-04	69000.
	Rock	39.0000	155.0000	--	480.0000	20.0000	5.00E-04	69000.

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	48.000
2	177.600	623.000

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	14.8000	0.00	N.A.	No	0.00	1199812.
2	34.7000	19.9000	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	1.5178	2.07E-05	1.70E-07	-0.00782	1.54E-07	7.02E+10	0.00	0.00	50.8944
0.2980	1.4899	325.4133	197.5242	-0.00782	2.4204	7.02E+10	0.00	0.00	59.5777
0.5960	1.4619	1413.	431.2750	-0.00782	10.5076	7.02E+10	0.00	0.00	71.1554
0.8940	1.4340	3410.	706.4276	-0.00782	25.3628	7.02E+10	0.00	0.00	82.7331
1.1920	1.4060	6465.	1023.	-0.00782	48.0872	7.02E+10	0.00	0.00	94.3108
1.4900	1.3781	10726.	1381.	-0.00782	79.7821	7.02E+10	0.00	0.00	105.8885
1.7880	1.3501	16342.	1780.	-0.00781	121.5486	7.02E+10	0.00	0.00	117.4662
2.0860	1.3222	23459.	2221.	-0.00781	174.4880	7.02E+10	0.00	0.00	129.0439
2.3840	1.2943	32227.	2703.	-0.00781	239.7015	7.02E+10	0.00	0.00	140.6216
2.6820	1.2663	42792.	3227.	-0.00781	318.2903	7.02E+10	0.00	0.00	152.1993
2.9800	1.2384	55304.	3792.	-0.00781	411.3557	7.02E+10	0.00	0.00	163.7770
3.2780	1.2105	69911.	4398.	-0.00780	519.9988	7.02E+10	0.00	0.00	175.3547
3.5760	1.1826	86760.	5046.	-0.00780	645.3209	7.02E+10	0.00	0.00	186.9324
3.8740	1.1547	105999.	5735.	-0.00780	788.4232	7.02E+10	0.00	0.00	198.5101
4.1720	1.1268	127777.	6466.	-0.00779	950.4070	7.02E+10	0.00	0.00	210.0878
4.4700	1.0990	152241.	7238.	-0.00778	1132.	7.02E+10	0.00	0.00	221.6655
4.7680	1.0712	179540.	8051.	-0.00777	1335.	7.02E+10	0.00	0.00	233.2432
5.0660	1.0434	209822.	8906.	-0.00776	1561.	7.02E+10	0.00	0.00	244.8209
5.3640	1.0156	243234.	9802.	-0.00775	1809.	7.02E+10	0.00	0.00	256.3986
5.6620	0.9879	279925.	10740.	-0.00774	2082.	7.02E+10	0.00	0.00	267.9764
5.9600	0.9603	320043.	11719.	-0.00772	2380.	7.02E+10	0.00	0.00	279.5541
6.2580	0.9327	363736.	12739.	-0.00771	2705.	7.02E+10	0.00	0.00	291.1318
6.5560	0.9052	411152.	13801.	-0.00769	3058.	7.02E+10	0.00	0.00	302.7095
6.8540	0.8777	462439.	14904.	-0.00766	3440.	7.02E+10	0.00	0.00	314.2872
7.1520	0.8503	517744.	16048.	-0.00764	3851.	7.02E+10	0.00	0.00	325.8649
7.4500	0.8231	577217.	17234.	-0.00761	4293.	7.02E+10	0.00	0.00	337.4426
7.7480	0.7959	641005.	18462.	-0.00758	4768.	7.02E+10	0.00	0.00	349.0203
8.0460	0.7688	709256.	19731.	-0.00755	5275.	7.02E+10	0.00	0.00	360.5980
8.3440	0.7419	782119.	21041.	-0.00751	5817.	7.02E+10	0.00	0.00	372.1757
8.6420	0.7151	859741.	22392.	-0.00747	6395.	7.02E+10	0.00	0.00	383.7534
8.9400	0.6885	942270.	23785.	-0.00742	7009.	7.02E+10	0.00	0.00	395.3311
9.2380	0.6621	1029854.	25220.	-0.00737	7660.	7.02E+10	0.00	0.00	406.9088
9.5360	0.6358	1122642.	26696.	-0.00732	8350.	7.02E+10	0.00	0.00	418.4865
9.8340	0.6097	1220782.	28213.	-0.00726	9080.	7.02E+10	0.00	0.00	430.0642
10.1320	0.5839	1324421.	29771.	-0.00719	9851.	7.02E+10	0.00	0.00	441.6419
10.4300	0.5583	1433707.	31371.	-0.00712	10664.	7.02E+10	0.00	0.00	453.2196

10.7280	0.5330	1548790.	33013.	-0.00704	11520.	7.02E+10	0.00	0.00	464.7973
11.0260	0.5079	1669816.	34696.	-0.00696	12420.	7.02E+10	0.00	0.00	476.3750
11.3240	0.4832	1796933.	36420.	-0.00687	13366.	7.02E+10	0.00	0.00	487.9527
11.6220	0.4588	1930291.	38186.	-0.00678	14358.	7.02E+10	0.00	0.00	499.5304
11.9200	0.4347	2070037.	39993.	-0.00668	15397.	7.02E+10	0.00	0.00	511.1081
12.2180	0.4110	2216318.	41841.	-0.00657	16485.	7.02E+10	0.00	0.00	522.6858
12.5160	0.3877	2369283.	43731.	-0.00645	17623.	7.02E+10	0.00	0.00	534.2635
12.8140	0.3649	2529081.	45662.	-0.00633	18811.	7.02E+10	0.00	0.00	545.8412
13.1120	0.3425	2695859.	47635.	-0.00619	20052.	7.02E+10	0.00	0.00	557.4189
13.4100	0.3206	2869764.	49649.	-0.00605	21345.	7.02E+10	0.00	0.00	568.9966
13.7080	0.2992	3050946.	51704.	-0.00590	22693.	7.02E+10	0.00	0.00	580.5743
14.0060	0.2784	3239552.	53801.	-0.00574	24096.	7.02E+10	0.00	0.00	592.1520
14.3040	0.2581	3435731.	55939.	-0.00557	25555.	7.02E+10	0.00	0.00	603.7297
14.6020	0.2385	3639630.	58119.	-0.00539	27072.	7.02E+10	0.00	0.00	615.3074
14.9000	0.2196	3851397.	55824.	-0.00520	28647.	7.02E+10	-2001.	32592.	102.2831
15.1980	0.2013	4038882.	48861.	-0.00500	30041.	7.02E+10	-1995.	35444.	0.00
15.4960	0.1838	4200849.	41740.	-0.00479	31246.	7.02E+10	-1987.	38654.	0.00
15.7940	0.1671	4337408.	34655.	-0.00457	32262.	7.02E+10	-1976.	42284.	0.00
16.0920	0.1511	4448704.	27616.	-0.00435	33090.	7.02E+10	-1961.	46409.	0.00
16.3900	0.1360	4534919.	20634.	-0.00412	33731.	7.02E+10	-1944.	51120.	0.00
16.6880	0.1217	4596277.	13719.	-0.00389	34187.	7.02E+10	-1923.	56532.	0.00
16.9860	0.1082	4633037.	6883.	-0.00365	34461.	7.02E+10	-1900.	62788.	0.00
17.2840	0.09556	4645506.	138.7668	-0.00341	34553.	7.02E+10	-1872.	70071.	0.00
17.5820	0.08377	4634030.	-6502.	-0.00318	34468.	7.02E+10	-1842.	78618.	0.00
17.8800	0.07283	4599002.	-13027.	-0.00294	34207.	7.02E+10	-1807.	88737.	0.00
18.1780	0.06273	4540863.	-19421.	-0.00271	33775.	7.02E+10	-1769.	100840.	0.00
18.4760	0.05345	4460105.	-25670.	-0.00248	33174.	7.02E+10	-1726.	115487.	0.00
18.7740	0.04499	4357272.	-31758.	-0.00226	32409.	7.02E+10	-1679.	133461.	0.00
19.0720	0.03732	4232970.	-37669.	-0.00204	31485.	7.02E+10	-1627.	155887.	0.00
19.3700	0.03042	4087865.	-43383.	-0.00182	30406.	7.02E+10	-1569.	184443.	0.00
19.6680	0.02426	3922698.	-48878.	-0.00162	29177.	7.02E+10	-1505.	221750.	0.00
19.9660	0.01883	3738289.	-54130.	-0.00143	27805.	7.02E+10	-1433.	272158.	0.00
20.2640	0.01407	3535559.	-59108.	-0.00124	26298.	7.02E+10	-1351.	343492.	0.00
20.5620	0.00995	3315549.	-63771.	-0.00107	24661.	7.02E+10	-1257.	451549.	0.00
20.8600	0.00644	3079466.	-68063.	-9.03E-04	22905.	7.02E+10	-1143.	634391.	0.00
21.1580	0.00350	2828763.	-71886.	-7.52E-04	21040.	7.02E+10	-994.9003	1017549.	0.00
21.4560	0.00106	2565337.	-75005.	-6.15E-04	19081.	7.02E+10	-749.5350	2520143.	0.00
21.7540	-9.02E-04	2292327.	-75045.	-4.91E-04	17050.	7.02E+10	726.9712	2882622.	0.00
22.0520	-0.00245	2028612.	-72053.	-3.81E-04	15089.	7.02E+10	946.4661	1381713.	0.00
22.3500	-0.00363	1777001.	-68470.	-2.84E-04	13217.	7.02E+10	1058.	1042854.	0.00
22.6480	-0.00448	1538918.	-64558.	-2.00E-04	11446.	7.02E+10	1130.	901434.	0.00
22.9460	-0.00506	1315282.	-60430.	-1.27E-04	9783.	7.02E+10	1179.	834058.	0.00

23.2440	-0.00539	1106726.	-56152.	-6.53E-05	8232.	7.02E+10	1213.	804966.	0.00
23.5420	-0.00552	913685.	-51773.	-1.38E-05	6796.	7.02E+10	1236.	800249.	0.00
23.8400	-0.00549	736447.	-47330.	2.83E-05	5478.	7.02E+10	1249.	813816.	0.00
24.1380	-0.00532	575183.	-42854.	6.17E-05	4278.	7.02E+10	1254.	843118.	0.00
24.4360	-0.00505	429959.	-38371.	8.73E-05	3198.	7.02E+10	1253.	887578.	0.00
24.7340	-0.00470	300755.	-33905.	1.06E-04	2237.	7.02E+10	1245.	947996.	0.00
25.0320	-0.00429	187471.	-29477.	1.18E-04	1394.	7.02E+10	1231.	1026381.	0.00
25.3300	-0.00385	89934.	-25108.	1.25E-04	668.9290	7.02E+10	1212.	1126061.	0.00
25.6280	-0.00339	7898.	-20816.	1.28E-04	58.7483	7.02E+10	1188.	1252031.	0.00
25.9260	-0.00294	-58945.	-16621.	1.27E-04	438.4343	7.02E+10	1159.	1411645.	0.00
26.2240	-0.00249	-110972.	-12539.	1.22E-04	825.4132	7.02E+10	1124.	1615863.	0.00
26.5220	-0.00206	-148625.	-8591.	1.16E-04	1105.	7.02E+10	1084.	1881588.	0.00
26.8200	-0.00166	-172412.	-4795.	1.07E-04	1282.	7.02E+10	1038.	2236354.	0.00
27.1180	-0.00129	-182920.	-1176.	9.84E-05	1361.	7.02E+10	985.8329	2728736.	0.00
27.4160	-9.57E-04	-180821.	2239.	8.92E-05	1345.	7.02E+10	924.2528	3454938.	0.00
27.7140	-6.54E-04	-166903.	5306.	8.03E-05	1241.	7.02E+10	790.6988	4321507.	0.00
28.0120	-3.82E-04	-142874.	7554.	7.24E-05	1063.	7.02E+10	466.9074	4366696.	0.00
28.3100	-1.36E-04	-112874.	8690.	6.59E-05	839.5563	7.02E+10	168.3622	4411885.	0.00
28.6080	8.89E-05	-80721.	8793.	6.10E-05	600.4020	7.02E+10	-110.7631	4457073.	0.00
28.9060	2.99E-04	-49984.	7921.	5.76E-05	371.7830	7.02E+10	-377.0649	4502262.	0.00
29.2040	5.01E-04	-24069.	6108.	5.57E-05	179.0287	7.02E+10	-637.1079	4547451.	0.00
29.5020	6.98E-04	-6302.	3365.	5.50E-05	46.8735	7.02E+10	-896.6113	4592640.	0.00
29.8000	8.94E-04	0.00	0.00	5.48E-05	0.00	7.02E+10	-985.6096	1970964.	0.00

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

Output Summary for Load Case No. 1:

```
Pile-head deflection             =     1.51784014 inches
Computed slope at pile head      =    -0.00781639 radians
Maximum bending moment           =       4645506. inch-lbs
Maximum shear force              =        -75045. lbs
Depth of maximum bending moment  =    17.28400000 feet below pile head
Depth of maximum shear force     =    21.75400000 feet below pile head
Number of iterations             =             28
Number of zero deflection points =              2
```

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
29.80000	1.51784014	4645506.	-75045.
28.31000	1.55532182	4714493.	-75268.
26.82000	1.56781079	4727648.	-76070.
25.33000	1.71894975	4634630.	-83972.
23.84000	2.88211709	4543991.	-96200.
22.35000	7.81745357	4358882.	-107413.
20.86000	30.30443719	4109080.	-119903.

Summary of Pile-head Responses for Conventional Analyses

Definitions of Pile-head Loading Conditions:

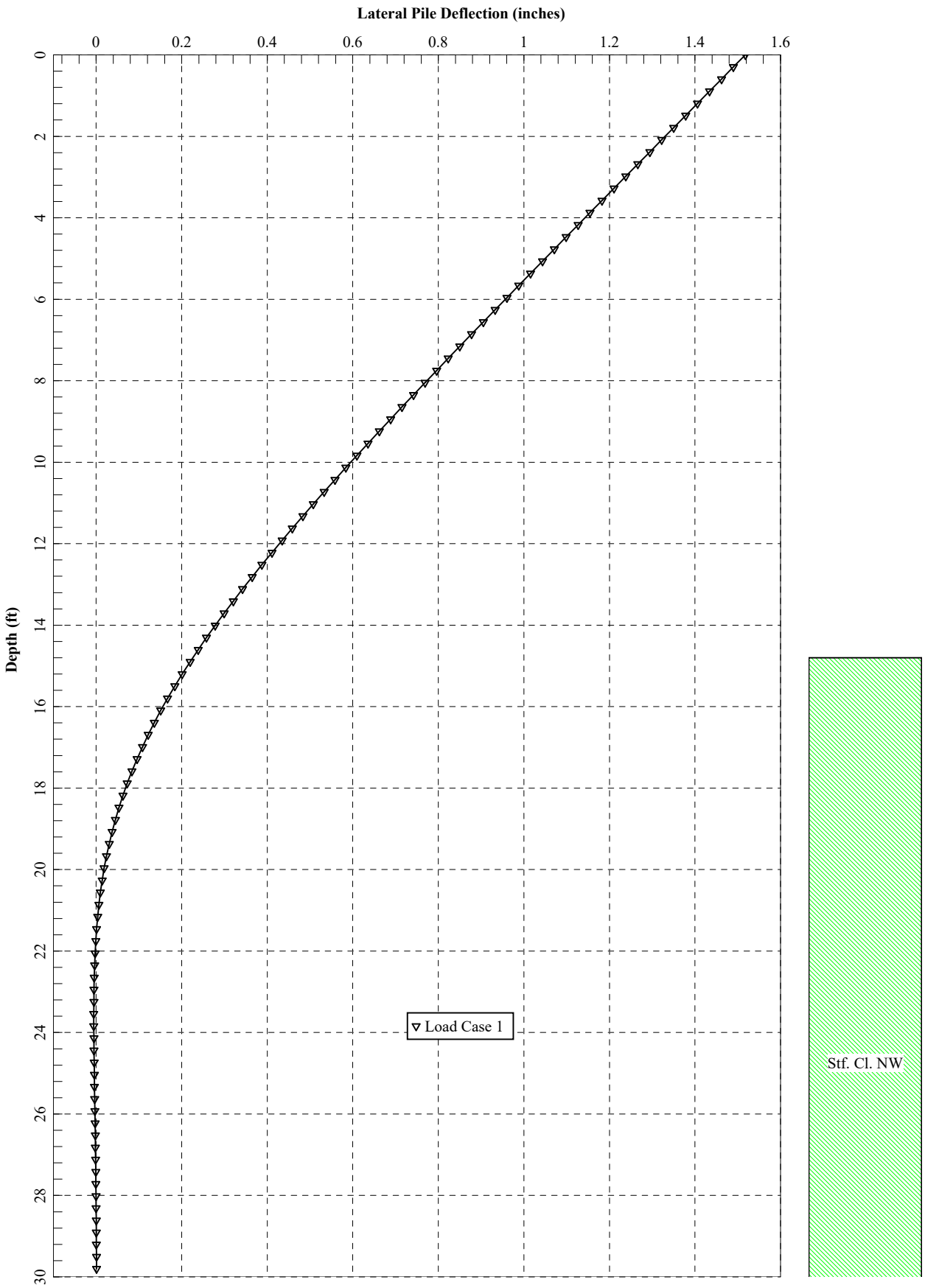
Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load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

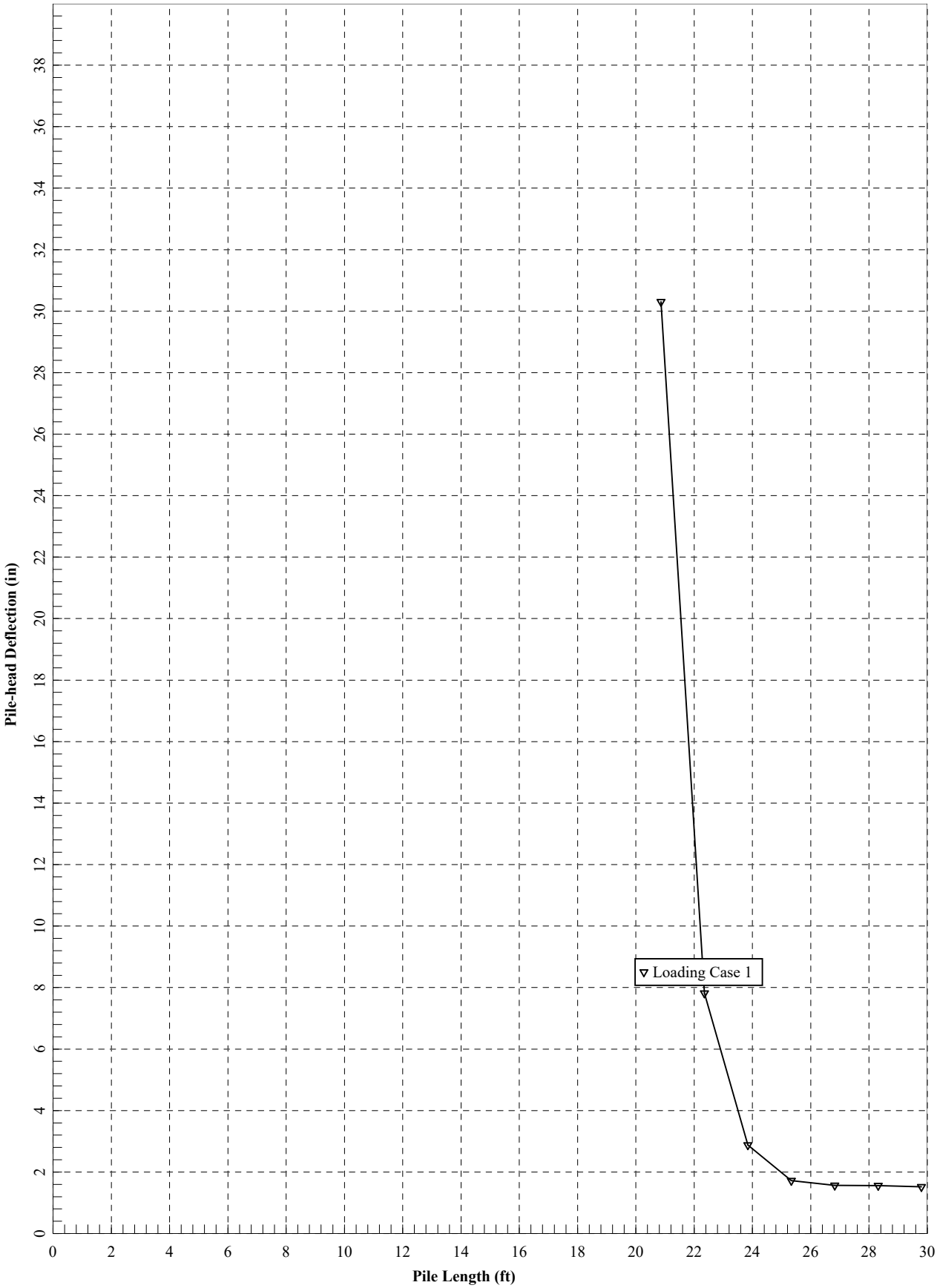
Load Case No.	Load Type 1	Pile-head Load 1	Load Type 2	Pile-head Load 2	Axial Loading lbs	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
1	V, lb	0.00	M, in-lb	0.00	0.00	1.5178	-0.00782	-75045.	4645506.

Maximum pile-head deflection = 1.5178401405 inches

Maximum pile-head rotation   = -0.0078163882 radians = -0.447846 deg.

The analysis ended normally.


Lateral Pile Deflection (inches)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
Depth (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
Load Case 1
Stf. Cl. NW


Pile-head Deflection (in)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
Pile Length (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
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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--------------------------------------------------------------------------------
                              Files Used for Analysis
--------------------------------------------------------------------------------

Path to file locations:
\ODOT-District 5-10_GES\2021\Task Order 10-LL NOB-147-9.93\Working\Wall Design\

Name of input data file:
NOB-147-9.93 Strength Case.lp11

Name of output report file:
NOB-147-9.93 Strength Case.lp11

Name of plot output file:
NOB-147-9.93 Strength Case.lp11

Name of runtime message file:
```

NOB-147-9.93 Strength Case.lp11

Date and Time of Analysis

Date: September 21, 2023 Time: 13:37:32

Problem Title

Project Name: NOB-147-9.93

Job Number:

Client: ODOT

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

 - Use of p-y modification factors for p-y curves not selected
 - 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 = 29.800 ft
Depth of ground surface below top of pile = 14.8000 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	36.0000
2	29.800	36.0000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is an elastic pile

Cross-sectional Shape	=	Circular Pile
Length of section	=	29.800000 ft
Width of top of section	=	36.000000 in
Width of bottom of section	=	36.000000 in
Top Area	=	29.800000 sq. in
Bottom Area	=	29.800000 sq. in
Moment of Inertia at Top	=	2420. in^4
Moment of Inertia at Bottom	=	2420. 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 2 layers

Layer 1 is stiff clay without free water

Distance from top of pile to top of layer	=	14.800000 ft
Distance from top of pile to bottom of layer	=	34.700000 ft
Effective unit weight at top of layer	=	155.000000 pcf
Effective unit weight at bottom of layer	=	155.000000 pcf
Undrained cohesion at top of layer	=	6000. psf
Undrained cohesion at bottom of layer	=	6000. psf
Epsilon-50 at top of layer	=	0.004000
Epsilon-50 at bottom of layer	=	0.004000

Layer 2 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer	=	34.700000 ft
Distance from top of pile to bottom of layer	=	39.000000 ft
Effective unit weight at top of layer	=	155.000000 pcf
Effective unit weight at bottom of layer	=	155.000000 pcf
Uniaxial compressive strength at top of layer	=	480.000000 psi
Uniaxial compressive strength at bottom of layer	=	480.000000 psi
Initial modulus of rock at top of layer	=	69000. psi
Initial modulus of rock at bottom of layer	=	69000. psi
RQD of rock at top of layer	=	20.000000 %
RQD of rock at bottom of layer	=	20.000000 %
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 9.200 ft below the pile tip)

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

Values entered for effective unit weights of soil were outside the limits of
20 pcf to 140 pcf.

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

This data may be erroneous. Please check your data.

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

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

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

This data may be erroneous. Please check your data.

Summary of Input Soil Properties

Layer Num.	Soil Type Name (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Undrained Cohesion psf	Uniaxial qu psi	RQD %	E50 or krm	Rock Mass Modulus psi
1	Stiff Clay	14.8000	155.0000	6000.	--	--	0.00400	--
	w/o Free Water	34.7000	155.0000	6000.	--	--	0.00400	--
2	Weak	34.7000	155.0000	--	480.0000	20.0000	5.00E-04	69000.
	Rock	39.0000	155.0000	--	480.0000	20.0000	5.00E-04	69000.

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	84.000
2	177.600	947.000

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	14.8000	0.00	N.A.	No	0.00	1199812.
2	34.7000	19.9000	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	2.8393	-3.41E-05	-3.41E-07	-0.01399	2.54E-07	7.02E+10	0.00	0.00	88.3442
0.2980	2.7893	564.8626	339.2207	-0.01399	4.2015	7.02E+10	0.00	0.00	101.3766
0.5960	2.7392	2426.	732.8129	-0.01399	18.0454	7.02E+10	0.00	0.00	118.7532
0.8940	2.6892	5806.	1189.	-0.01399	43.1847	7.02E+10	0.00	0.00	136.1299
1.1920	2.6392	10927.	1706.	-0.01399	81.2720	7.02E+10	0.00	0.00	153.5065
1.4900	2.5891	18010.	2286.	-0.01399	133.9603	7.02E+10	0.00	0.00	170.8831
1.7880	2.5391	27279.	2929.	-0.01399	202.9021	7.02E+10	0.00	0.00	188.2597
2.0860	2.4891	38955.	3633.	-0.01399	289.7505	7.02E+10	0.00	0.00	205.6364
2.3840	2.4391	53261.	4399.	-0.01398	396.1581	7.02E+10	0.00	0.00	223.0130
2.6820	2.3891	70419.	5228.	-0.01398	523.7777	7.02E+10	0.00	0.00	240.3896
2.9800	2.3391	90651.	6119.	-0.01398	674.2621	7.02E+10	0.00	0.00	257.7662
3.2780	2.2891	114179.	7071.	-0.01397	849.2642	7.02E+10	0.00	0.00	275.1428
3.5760	2.2392	141225.	8086.	-0.01396	1050.	7.02E+10	0.00	0.00	292.5195
3.8740	2.1893	172013.	9163.	-0.01396	1279.	7.02E+10	0.00	0.00	309.8961
4.1720	2.1394	206763.	10303.	-0.01395	1538.	7.02E+10	0.00	0.00	327.2727
4.4700	2.0895	245698.	11504.	-0.01394	1828.	7.02E+10	0.00	0.00	344.6493
4.7680	2.0397	289040.	12768.	-0.01392	2150.	7.02E+10	0.00	0.00	362.0259
5.0660	1.9899	337012.	14093.	-0.01391	2507.	7.02E+10	0.00	0.00	379.4026
5.3640	1.9402	389836.	15481.	-0.01389	2900.	7.02E+10	0.00	0.00	396.7792
5.6620	1.8906	447734.	16931.	-0.01387	3330.	7.02E+10	0.00	0.00	414.1558
5.9600	1.8411	510927.	18443.	-0.01384	3800.	7.02E+10	0.00	0.00	431.5324
6.2580	1.7916	579639.	20017.	-0.01381	4311.	7.02E+10	0.00	0.00	448.9091
6.5560	1.7423	654092.	21654.	-0.01378	4865.	7.02E+10	0.00	0.00	466.2857
6.8540	1.6930	734507.	23352.	-0.01375	5463.	7.02E+10	0.00	0.00	483.6623
7.1520	1.6439	821108.	25113.	-0.01371	6107.	7.02E+10	0.00	0.00	501.0389
7.4500	1.5950	914115.	26936.	-0.01366	6799.	7.02E+10	0.00	0.00	518.4155
7.7480	1.5462	1013752.	28821.	-0.01361	7540.	7.02E+10	0.00	0.00	535.7922
8.0460	1.4976	1120241.	30768.	-0.01356	8332.	7.02E+10	0.00	0.00	553.1688
8.3440	1.4492	1233803.	32777.	-0.01350	9177.	7.02E+10	0.00	0.00	570.5454
8.6420	1.4011	1354661.	34848.	-0.01343	10076.	7.02E+10	0.00	0.00	587.9220
8.9400	1.3532	1483038.	36982.	-0.01336	11031.	7.02E+10	0.00	0.00	605.2986
9.2380	1.3055	1619155.	39177.	-0.01328	12043.	7.02E+10	0.00	0.00	622.6753
9.5360	1.2582	1763234.	41435.	-0.01320	13115.	7.02E+10	0.00	0.00	640.0519
9.8340	1.2111	1915499.	43755.	-0.01310	14248.	7.02E+10	0.00	0.00	657.4285
10.1320	1.1645	2076170.	46137.	-0.01300	15443.	7.02E+10	0.00	0.00	674.8051
10.4300	1.1182	2245471.	48581.	-0.01289	16702.	7.02E+10	0.00	0.00	692.1818

10.7280	1.0723	2423623.	51088.	-0.01277	18027.	7.02E+10	0.00	0.00	709.5584
11.0260	1.0268	2610849.	53656.	-0.01264	19420.	7.02E+10	0.00	0.00	726.9350
11.3240	0.9818	2807371.	56287.	-0.01251	20881.	7.02E+10	0.00	0.00	744.3116
11.6220	0.9374	3013410.	58979.	-0.01236	22414.	7.02E+10	0.00	0.00	761.6882
11.9200	0.8935	3229191.	61734.	-0.01220	24019.	7.02E+10	0.00	0.00	779.0649
12.2180	0.8501	3454933.	64551.	-0.01203	25698.	7.02E+10	0.00	0.00	796.4415
12.5160	0.8074	3690861.	67430.	-0.01185	27453.	7.02E+10	0.00	0.00	813.8181
12.8140	0.7654	3937195.	70372.	-0.01165	29285.	7.02E+10	0.00	0.00	831.1947
13.1120	0.7241	4194158.	73375.	-0.01144	31196.	7.02E+10	0.00	0.00	848.5714
13.4100	0.6836	4461973.	76441.	-0.01122	33188.	7.02E+10	0.00	0.00	865.9480
13.7080	0.6438	4740861.	79568.	-0.01099	35263.	7.02E+10	0.00	0.00	883.3246
14.0060	0.6050	5031045.	82758.	-0.01074	37421.	7.02E+10	0.00	0.00	900.7012
14.3040	0.5670	5332747.	86010.	-0.01048	39665.	7.02E+10	0.00	0.00	918.0778
14.6020	0.5300	5646189.	89324.	-0.01020	41996.	7.02E+10	0.00	0.00	935.4545
14.9000	0.4941	5971594.	86892.	-0.00990	44417.	7.02E+10	-2451.	17739.	155.4799
15.1980	0.4592	6267644.	78403.	-0.00959	46619.	7.02E+10	-2452.	19096.	0.00
15.4960	0.4255	6532336.	69637.	-0.00926	48588.	7.02E+10	-2451.	20597.	0.00
15.7940	0.3930	6765686.	60880.	-0.00892	50323.	7.02E+10	-2447.	22263.	0.00
16.0920	0.3617	6967751.	52144.	-0.00857	51826.	7.02E+10	-2439.	24119.	0.00
16.3900	0.3317	7138621.	43439.	-0.00821	53097.	7.02E+10	-2429.	26193.	0.00
16.6880	0.3029	7278426.	34776.	-0.00785	54137.	7.02E+10	-2416.	28521.	0.00
16.9860	0.2755	7387336.	26165.	-0.00747	54947.	7.02E+10	-2400.	31145.	0.00
17.2840	0.2495	7465558.	17618.	-0.00710	55529.	7.02E+10	-2380.	34116.	0.00
17.5820	0.2248	7513343.	9148.	-0.00671	55884.	7.02E+10	-2357.	37499.	0.00
17.8800	0.2015	7530986.	766.3434	-0.00633	56016.	7.02E+10	-2331.	41370.	0.00
18.1780	0.1795	7518824.	-7514.	-0.00595	55925.	7.02E+10	-2301.	45829.	0.00
18.4760	0.1589	7477243.	-15681.	-0.00556	55616.	7.02E+10	-2267.	51001.	0.00
18.7740	0.1397	7406676.	-23719.	-0.00519	55091.	7.02E+10	-2229.	57047.	0.00
19.0720	0.1218	7307608.	-31613.	-0.00481	54354.	7.02E+10	-2187.	64176.	0.00
19.3700	0.1053	7180577.	-39349.	-0.00444	53409.	7.02E+10	-2140.	72670.	0.00
19.6680	0.09008	7026182.	-46910.	-0.00408	52261.	7.02E+10	-2088.	82911.	0.00
19.9660	0.07613	6845079.	-54276.	-0.00373	50914.	7.02E+10	-2032.	95434.	0.00
20.2640	0.06342	6637997.	-61429.	-0.00338	49374.	7.02E+10	-1969.	111008.	0.00
20.5620	0.05193	6405738.	-68346.	-0.00305	47646.	7.02E+10	-1899.	130791.	0.00
20.8600	0.04161	6149189.	-75000.	-0.00273	45738.	7.02E+10	-1822.	156604.	0.00
21.1580	0.03240	5869340.	-81360.	-0.00242	43656.	7.02E+10	-1735.	191508.	0.00
21.4560	0.02427	5567300.	-87389.	-0.00213	41410.	7.02E+10	-1636.	241111.	0.00
21.7540	0.01715	5244336.	-93033.	-0.00186	39007.	7.02E+10	-1520.	317057.	0.00
22.0520	0.01098	4901931.	-98215.	-0.00160	36461.	7.02E+10	-1378.	448740.	0.00
22.3500	0.00571	4541903.	-102799.	-0.00136	33783.	7.02E+10	-1186.	742514.	0.00
22.6480	0.00127	4166713.	-106394.	-0.00114	30992.	7.02E+10	-824.8400	2329924.	0.00
22.9460	-0.00242	3780975.	-106116.	-9.34E-04	28123.	7.02E+10	980.3209	1449178.	0.00

23.2440	-0.00542	3407773.	-102191.	-7.51E-04	25347.	7.02E+10	1215.	802085.	0.00
23.5420	-0.00779	3050103.	-97611.	-5.86E-04	22687.	7.02E+10	1347.	618236.	0.00
23.8400	-0.00961	2709656.	-92634.	-4.40E-04	20154.	7.02E+10	1437.	534679.	0.00
24.1380	-0.01094	2387582.	-87380.	-3.10E-04	17759.	7.02E+10	1502.	491174.	0.00
24.4360	-0.01183	2084716.	-81923.	-1.96E-04	15506.	7.02E+10	1550.	468707.	0.00
24.7340	-0.01234	1801671.	-76317.	-9.69E-05	13401.	7.02E+10	1585.	459448.	0.00
25.0320	-0.01252	1538894.	-70606.	-1.18E-05	11446.	7.02E+10	1609.	459727.	0.00
25.3300	-0.01242	1296699.	-64823.	6.04E-05	9645.	7.02E+10	1625.	467785.	0.00
25.6280	-0.01209	1075281.	-58999.	1.21E-04	7998.	7.02E+10	1632.	482905.	0.00
25.9260	-0.01156	874735.	-53163.	1.71E-04	6506.	7.02E+10	1632.	505064.	0.00
26.2240	-0.01087	695062.	-47338.	2.11E-04	5170.	7.02E+10	1625.	534818.	0.00
26.5220	-0.01005	536171.	-41551.	2.42E-04	3988.	7.02E+10	1611.	573331.	0.00
26.8200	-0.00914	397887.	-35826.	2.66E-04	2959.	7.02E+10	1591.	622548.	0.00
27.1180	-0.00815	279943.	-30188.	2.83E-04	2082.	7.02E+10	1563.	685566.	0.00
27.4160	-0.00711	181980.	-24665.	2.95E-04	1354.	7.02E+10	1526.	767380.	0.00
27.7140	-0.00604	103536.	-19289.	3.02E-04	770.1023	7.02E+10	1481.	876416.	0.00
28.0120	-0.00495	44029.	-14095.	3.06E-04	327.4852	7.02E+10	1424.	1027993.	0.00
28.3100	-0.00386	2728.	-9133.	3.07E-04	20.2911	7.02E+10	1351.	1253303.	0.00
28.6080	-0.00276	-21294.	-4473.	3.07E-04	158.3847	7.02E+10	1255.	1628030.	0.00
28.9060	-0.00166	-29263.	-230.5629	3.05E-04	217.6623	7.02E+10	1117.	2402714.	0.00
29.2040	-5.74E-04	-22943.	3073.	3.04E-04	170.6499	7.02E+10	730.4274	4547451.	0.00
29.5020	5.10E-04	-7282.	3208.	3.03E-04	54.1623	7.02E+10	-655.2569	4592640.	0.00
29.8000	0.00159	0.00	0.00	3.03E-04	0.00	7.02E+10	-1139.	1277900.	0.00

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

Output Summary for Load Case No. 1:

```
Pile-head deflection             =     2.83927990 inches
Computed slope at pile head      =    -0.01399038 radians
Maximum bending moment           =       7530986. inch-lbs
Maximum shear force              =       -106394. lbs
Depth of maximum bending moment  =    17.88000000 feet below pile head
Depth of maximum shear force     =    22.64800000 feet below pile head
Number of iterations             =             31
Number of zero deflection points =              2
```

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
29.80000	2.83927990	7530986.	-106394.
28.31000	2.93470442	7622295.	-110369.
26.82000	3.38509640	7532627.	-123139.
25.33000	5.01052414	7254878.	-134373.
23.84000	12.22715775	7050338.	-149765.
22.35000	56.57154699	6829462.	-173740.

Summary of Pile-head Responses for Conventional Analyses

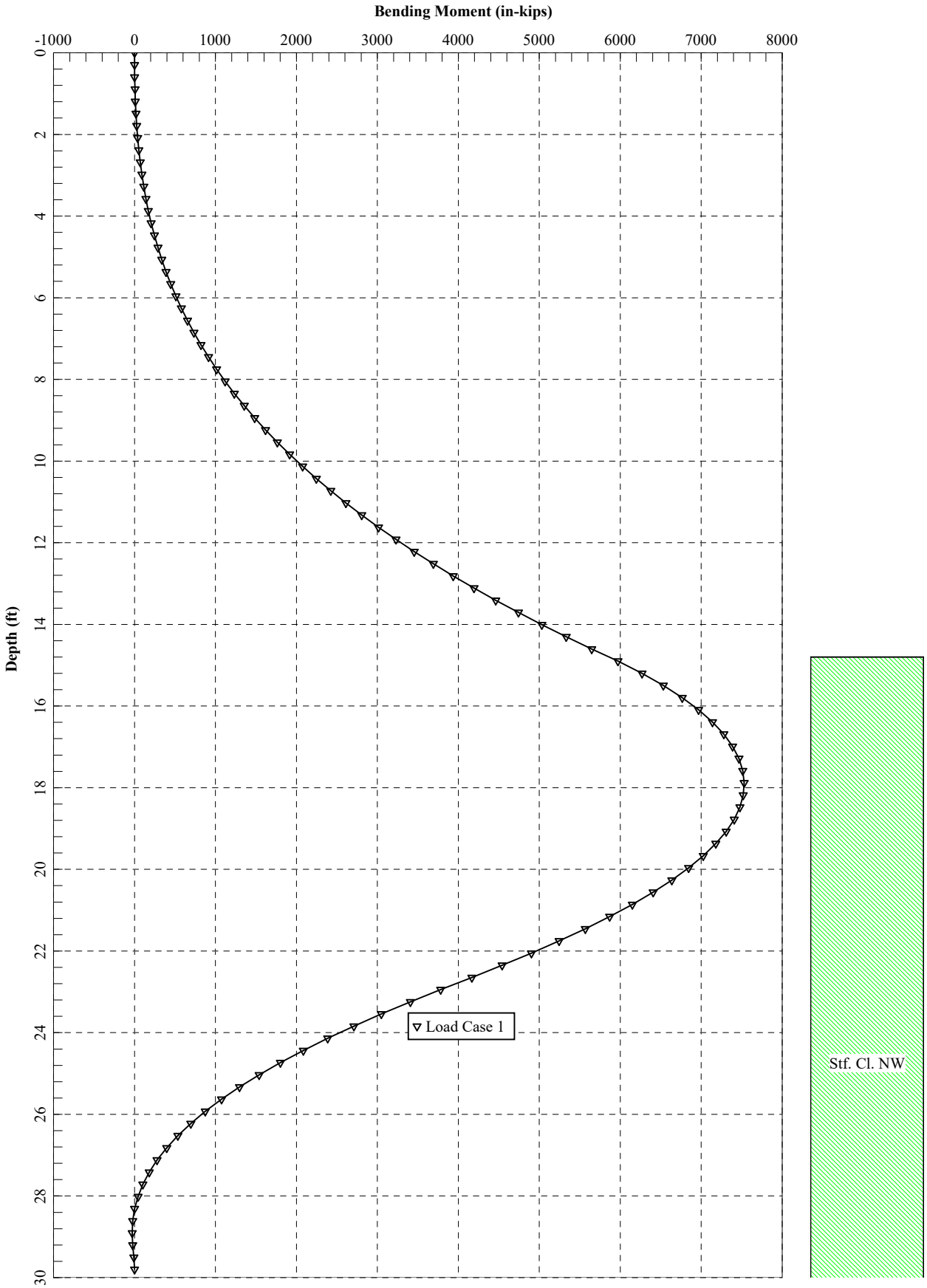
Definitions of Pile-head Loading Conditions:

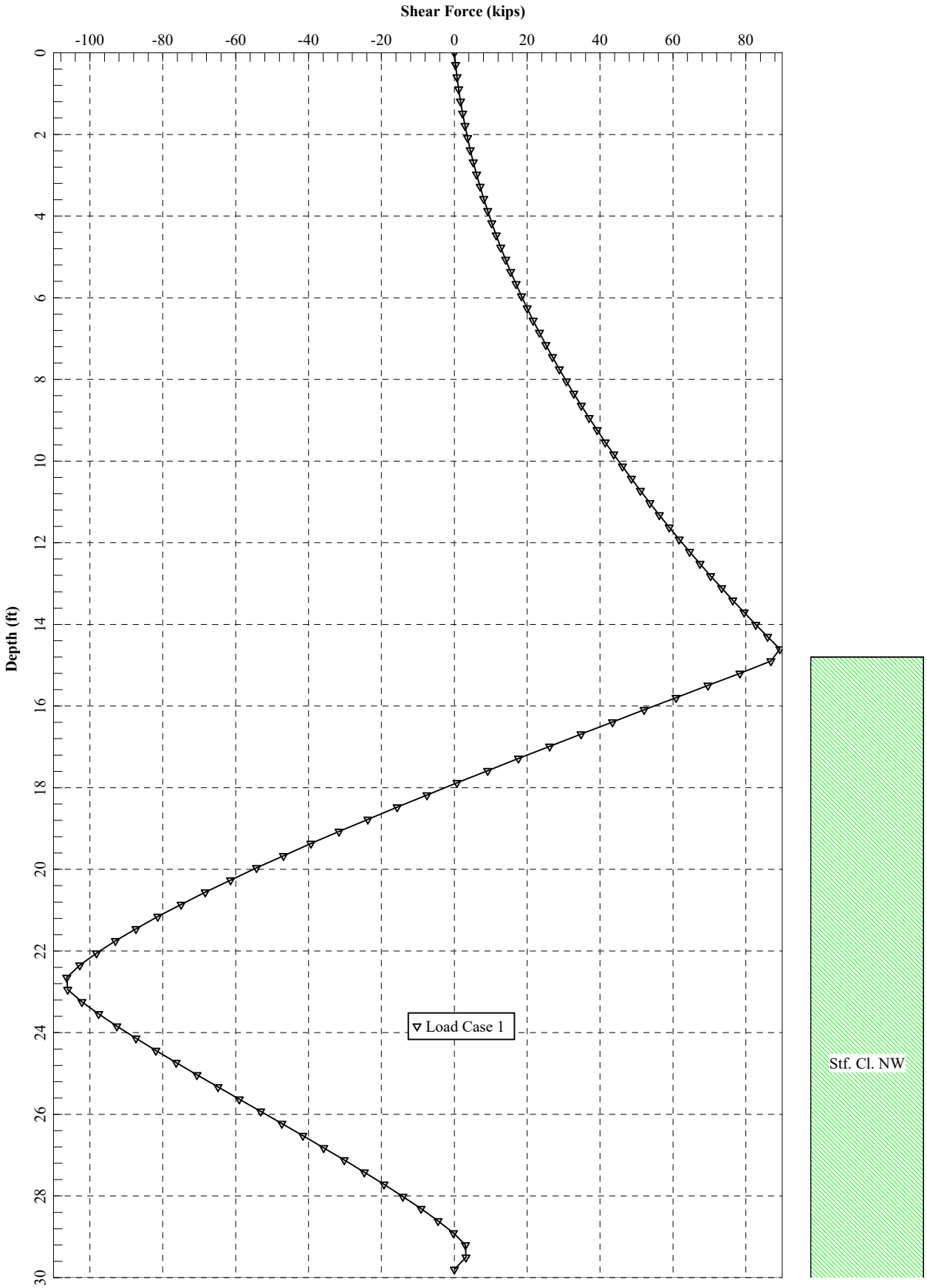
Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load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

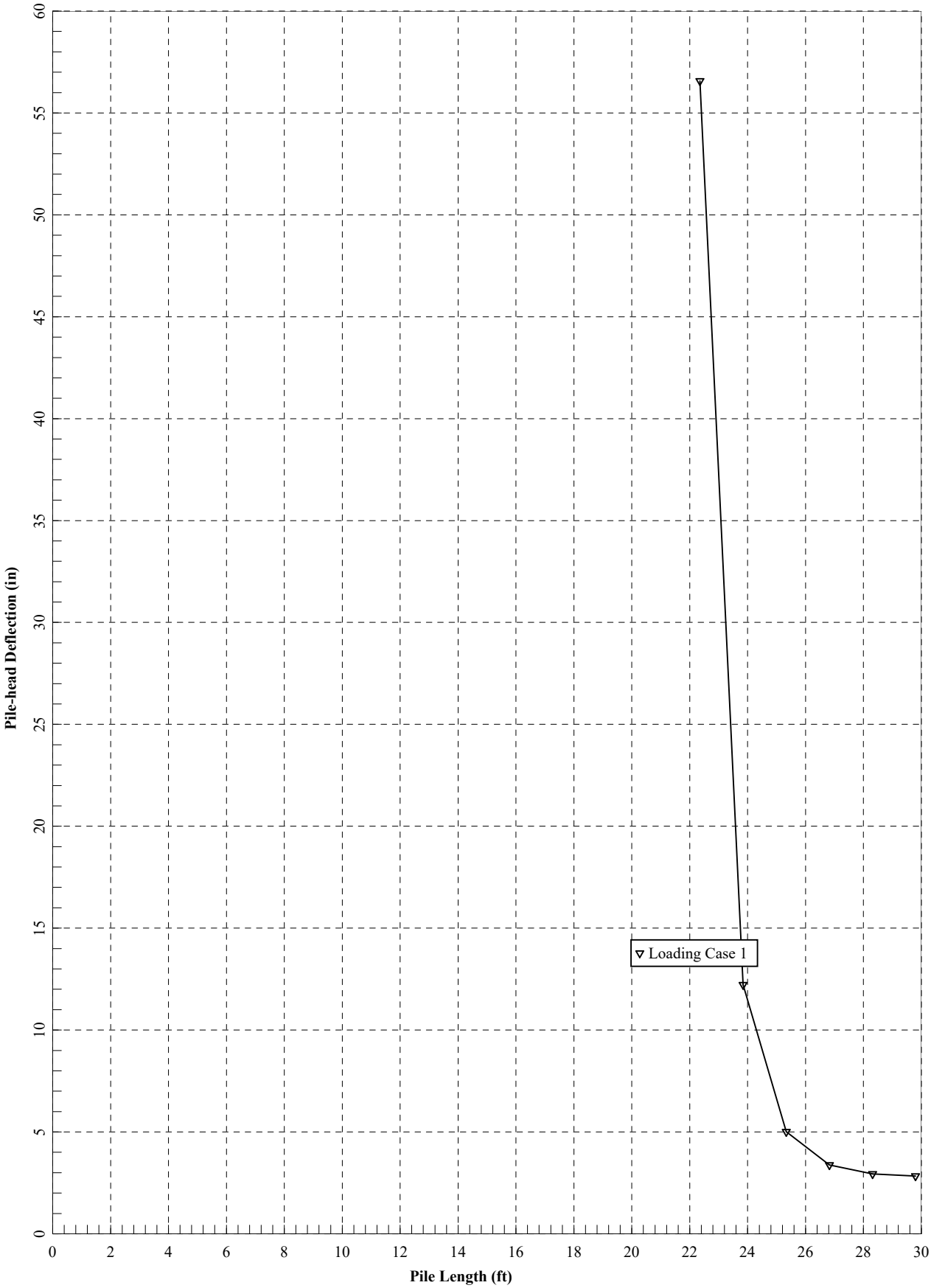
Load Case No.	Load Type 1	Pile-head Load 1	Load Type 2	Pile-head Load 2	Axial Loading lbs	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
1	V, lb	0.00	M, in-lb	0.00	0.00	2.8393	-0.01399	-106394.	7530986.

Maximum pile-head deflection = 2.8392798995 inches
Maximum pile-head rotation = -0.0139903802 radians = -0.801590 deg.

```
The analysis ended normally.
```


Bending Moment (in-kips)
-1000
0
1000
2000
3000
4000
5000
6000
7000
8000
Depth (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
Load Case 1
Stf. Cl. NW


Shear Force (kips)
-100
-80
-60
-40
-20
0
20
40
60
80
Depth (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
Load Case 1
Stf. Cl. NW


Pile-head Deflection (in)
0
5
10
15
20
25
30
35
40
45
50
55
60
Pile Length (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
Loading Case 1

Soldier Pile and Lagging Wall Detail

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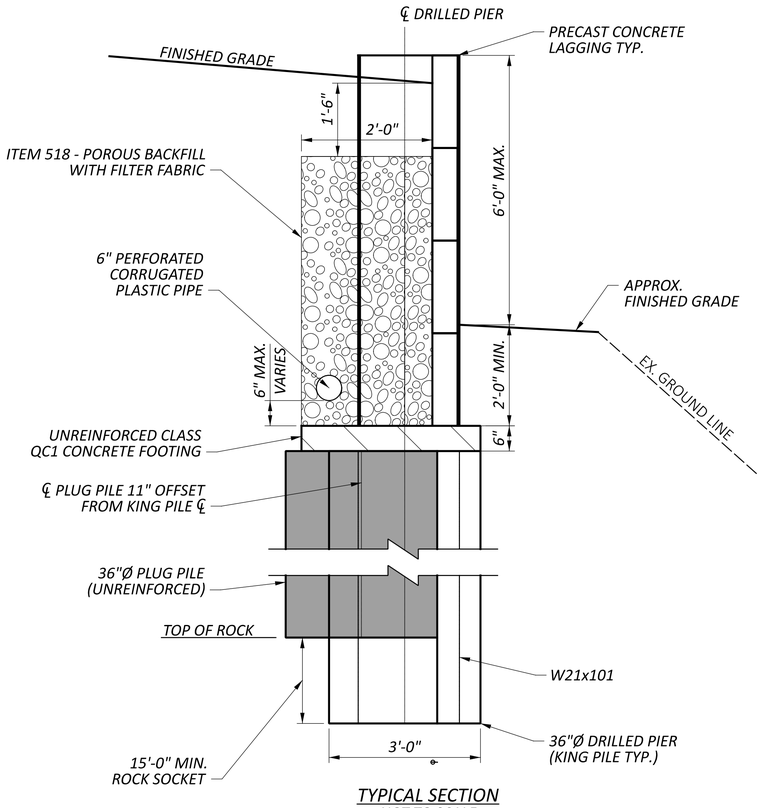
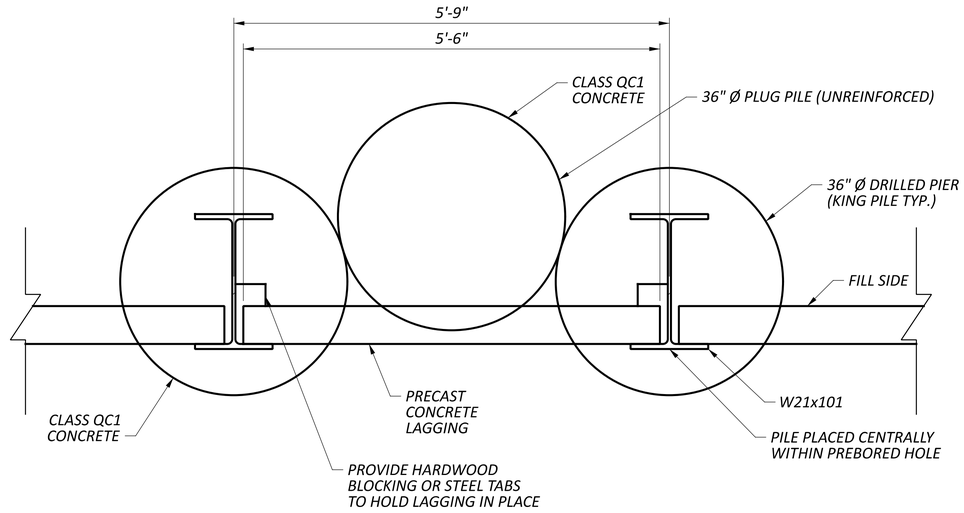
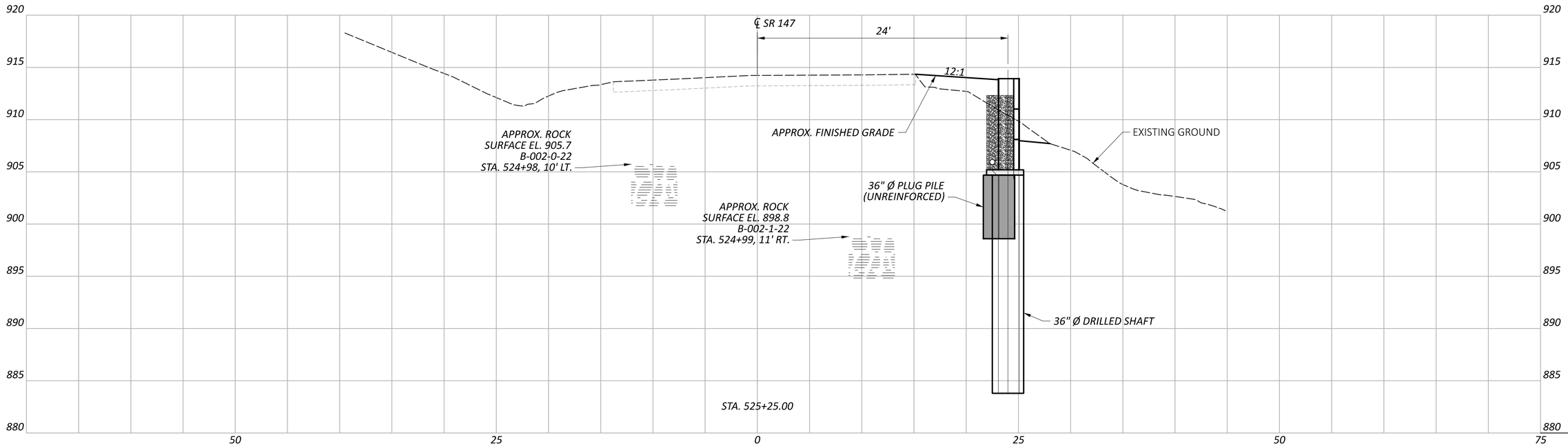


TYPICAL SECTION
NOT TO SCALE



PLAN - RETAINING WALL
NOT TO SCALE

BORING	STATION	OFFSET	APPROX. SURFACE ELEVATION	APPROX. ROCK SURFACE ELEVATION
B-001-0-22	523+75	10' RT	926.3	917.3
B-002-0-22	524+98	10' LT	915.6	905.7
B-002-1-22	524+99	11' RT	914.1	898.6
B-003-0-22	526+16	9' RT	909.4	892.9



HORIZONTAL SCALE IN FEET
0 2.5 5 10

SOLDIER PILE AND LAGGING WALL DETAIL
CRITICAL SECTION STA. 525+25

DESIGN AGENCY
HDR

DESIGNER AKB
REVIEWER DMV 09/29/23
PROJECT ID 117566
SHEET 1 TOTAL 1

NOB-147-9.93

MODEL: Sheet PAPERSIZE: 34x22 (in.) DATE: 9/29/2023 TIME: 11:47:03 AM USER: SKIRK
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