

# ATTACHMENT K

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## Geotechnical Engineering Memorandum for King Street & Commonwealth Avenue Bridge Replacements

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*Addendum No. 8*





# Geotechnical Engineering Memorandum:

Date: Friday, December 29, 2023

Project: King Street & Commonwealth Avenue Bridge Replacements

HDR No.: 10331846

Prepared for: CSX Transportation, Inc.

Prepared By: HDR Engineering, Inc., Vienna, VA

## Purpose

The purpose of this memorandum is to provide geotechnical design information for new abutment foundations for King Street and Commonwealth Avenue Bridge Replacements project in City of Alexandria, Virginia. The work was completed as part of HDR's Memorandum of Agreement for General Engineering Services dated January 01, 2021.

HDR previously submitted a geotechnical engineering report (GER) dated November 29, 2023, to support design of Alexandria Fourth Track project from CSX milepost (MP) 104 to MP 110, excluding King Street and Commonwealth Avenue bridges. HDR recommends also reviewing that GER as it includes additional geotechnical information that may also be useful for King Street and Commonwealth Avenue bridge sites.



## Table of Contents

**Geotechnical Engineering Memorandum: .....I**

**Purpose .....I**

**Table of Contents .....II**

    Appendices .....II

**Project Description .....1**

**Subsurface Explorations .....1**

**Laboratory Testing .....2**

**Subsurface Summary .....3**

    Geology .....3

    Generalized Subsurface Strata.....3

    Subsurface Water .....4

**Seismic Consideration.....4**

**Soil Corrosion Potential .....5**

**Micropile Foundations .....5**

**Limitations .....7**

**References .....7**

### ***Appendices***

- Appendix A – Figures & Tables
- Appendix B – Subsurface Exploration Logs
- Appendix C – Laboratory Test Results
- Appendix D – Calculations

## Project Description

The project consists of improving the capacity and replacing the existing King Street and Commonwealth Avenue bridges in City of Alexandria to accommodate an additional track. A project location map is provided as Figure 1 in Appendix A. The new abutments will be built behind the existing abutments to support the tracks, except for the existing Commonwealth Avenue north abutment (Abutment 1) which will be utilized for the new bridge. After considering several foundation types and their design and construction challenges, vertical micropiles were selected to support the new bridge abutments. The analysis for the existing Commonwealth Avenue Abutment 1 will be provided under a separate cover.

## Subsurface Explorations

HDR reviewed the 30% plans dated August 15, 2022, and identified boring locations to collect subsurface data for foundation design of the new abutments. The initial exploration plan consisted of four Standard Penetration Test (SPT) borings and associated laboratory testing, 22-King-BR-01 and 22-King-BR-02 for King Street bridge, and 22-CMWLTH-BR-01 and 22-CMWLTH-BR-02 for Commonwealth Avenue bridge as shown in Figure 2 of Appendix A.

During exploration, 22-King-BR-02 planned at the north abutment of King Street bridge had to be abandoned without drilling due to following field issues.

1. Presence of several underlying utilities at the planned location causing safety concerns.
2. Any possible boring relocation was within the zone of fouling distance from the tracks due to space limitation.

HDR reviewed subsurface soil information obtained from 22-King-BR-01, 22-CMWLTH-BR-01 and 22-CMWLTH-BR-02 and developed subsurface profiles, which allowed for evaluation of the extent and character of the underlying soil and disclosing important irregularities in the subsurface conditions. We determined the number and location of the borings as adequate for designing both King Street abutment foundations and the abandoned boring was not required.

Soil and Land Use Technology, Inc. (SaLUT) of Glen Burnie, Maryland drilled the test borings using track-mounted and truck-mounted drill rigs between August 1, 2022, and August 9, 2022. SaLUT advanced the test borings using mud rotary with a roller bit or hollow-stem auger drilling techniques per CSX Specifications for Test Borings. Standard Penetration Tests (SPT) with split-barrel spoon sampling of soils were conducted in the borings per ASTM D1586 using an automatic hammer. Typically, continuous sampling was performed in the upper 10 feet of each borehole and at 5-foot intervals thereafter until the boring termination depth. Corrosivity testing was performed using combined SPT samples from 28 to 35 feet depth collected from boring 22-King-BR-01.

Table A-1 in Appendix A summarizes the test boring locations, depths, and other boring information. Exploration locations are shown in Figure 2 in Appendix A and exploration logs are included in Appendix B.

Rice Associates, Inc. (Rice) of Manassas, Virginia laid out and staked the boring locations based on the geotechnical exploration plan (GEP) and performed private utility locating. SaLUT completed the Miss Utility process before drilling and HDR obtained a CSX dig permit for each boring.

HDR personnel monitored the drilling in the field, which included overall coordination of drilling activities, visual-manual classification of soil samples, preparation of field exploration logs, monitoring conformance with drilling and sampling criteria, and observation of general site conditions. Pocket penetrometer tests were typically performed on cohesive soil samples at the time of sample collection. The results of the pocket penetrometer tests are shown on the exploration logs provided in Appendix B.

Groundwater observations were typically made in open boreholes upon completion of drilling and prior to backfilling, where possible. Borings were typically backfilled with auger cuttings. After completion of drilling, SaLUT transported jar and bulk soil samples to their laboratory for testing and HDR shipped Shelby tube samples to GeoTesting Express (GTX) of Acton, MA for advanced soil testing.

The coordinate system used to calculate the absolute XY locations (latitude/longitude, northing/easting) for the explorations consisted of the Horizontal Datum: North American Datum 1983, State Plane Virginia North FIPS 4501 Feet (US). Elevation for each exploration was calculated by utilizing the Vertical Datum: North American Vertical Datum 1988 along with the USGS Digital Elevation Model (DEM) for Fairfax County (2018).

## Laboratory Testing

SaLUT and GTX performed laboratory testing on selected soil samples collected from the test borings. HDR personnel evaluated the field exploration logs and assigned specific samples for testing. Testing was performed to aid in the classification of representative soils encountered in the explorations and to support development of geotechnical engineering parameters for design. Geotechnical laboratory tests conducted on the samples include natural moisture content, Atterberg limits, sieve analysis, unconsolidated undrained triaxial shear and one-dimensional consolidation tests. Table 1 summarizes the laboratory testing completed for the project. The results of the laboratory tests are provided in Appendix C.

**Table 1: Summary of Laboratory Testing Program**

Laboratory Test	Test Specification
Moisture Content	ASTM D2216
# 200 Sieve Wash	AASHTO T 11
Grain Size Analysis	ASTM D6913
Atterberg Limits	ASTM D4318
Resistivity, pH, Sulfate, Chloride	AASHTO T 288, T 289, T 290, T 291
Incremental Consolidation	ASTM D2435
Unconsolidated Undrained Triaxial	ASTM D2850

## Subsurface Summary

### Geology

A geology map of the project area is included in Figure 3. The project site is located within the Coastal Plain Physiographic Province. Regionally, the stratigraphy of the Coastal Plain can be generalized as a wedge of sediments composed of fluvial and coastal plain sands and gravels of Quaternary and upper Tertiary age, underlain by marine, deltaic, and fluvial clays, silts, and sands of lower Tertiary age, underlain by fluvial-deltaic to shallow-shelf sands and clays of Cretaceous age, underlain by crystalline bedrock.

Fill soils (af) consisting of sand, gravel, and clay are present at the King Street and Commonwealth Avenue bridge sites. These fill soils are from previous site grading for existing railroad tracks and bridges. Below the fill, is the Quaternary period Terrace deposits belonging to Shirley formation (Qt/ Qsh) and consist of gravel, sand, silt and clay, which is present throughout the project corridor. These estuarine deposits are related to sea level change during the ice ages, while the uppermost deposits are river deltas and terraces.

The Terrace deposits are further underlain by the Potomac formation (Kp), which mostly consist of sands and fat clays. Sands are tan to yellow brown, fine to coarse-grained and consist of quartz fragments. Fat clays are mostly gray to mottled red or reddish brown and very stiff to hard. The soils of the Potomac Formation occur within the older or buried floodplains of the Coastal Plain Physiographic Province.

The high-plasticity clay deposits of the Potomac Formation (also referred to as marine clays or Potomac clays) are highly fractured and broken and contain fissures and discontinuities. They are considered “unsuitable” and are known locally to be problematic, specifically with regards to volumetric changes with moisture variation (shrinking and swelling) and being unstable in fill embankments and cut slopes. However, while the highly plastic Potomac Formation soils can be problematic for supporting shallow foundations and use in cut or fill slopes, these materials can support deep foundations.

### Generalized Subsurface Strata

HDR typically observed three strata at King Street and Commonwealth Avenue bridge sites and are discussed below. The transitions between strata may be gradual and indistinct.

- **Fill (Af):** Fill soils were identified in the field by soil type, consistency/relative density, and the partial presence of non-native materials (crushed aggregate, asphalt fragments, etc.). Additionally, fill soils were identified based on the existing topography in the vicinity of the test borings. Fill soils were encountered below the existing railroad tracks with thicknesses of approximately 16 feet and generally consist of gray and brown, mostly loose sands and firm to stiff silts and clays (SC, SM, SC-SM, CL, GP).

- **Terrace Deposit/ Shirley Formation (Qt/ Qsh):** Terrace deposits belonging to Shirley formation were encountered below the fill deposit. The thickness of this deposit varies from 4 to 55 feet in the test borings. It generally consists of gray to brown, loose to dense sand and soft to stiff silt and clay.
- **Potomac Formation (Kp):** Potomac formation was encountered below the fill and terrace deposits. The thickness of this deposit varies from 28 to 80 feet in the test borings. It generally consists of brown and gray stiff to hard fat clays (CH), gray medium dense to very dense sands (SC, SM) to brown loose to dense sand and soft to stiff silt and clay.

### **Subsurface Water**

Subsurface water was encountered in the borings from Elevation (El.) 7 to El. 20 approximately at the time of drilling. Refer to the exploration logs in Appendix B for specific observations of subsurface water at the boring locations.

Note that water was introduced into the borehole as part of the drilling process during mud rotary drilling and may have influenced water level measurements made in those borings (drilling methods are noted on the test boring logs). Additionally, subsurface water levels fluctuate due to precipitation, season, temperature, site grading, and other factors that may be different from those prevailing at the time HDR completed its subsurface explorations.

### **Seismic Consideration**

The latest recorded earthquake occurred in August 2011 near Mineral, Virginia, which is within 100 miles from the project area. It had a magnitude of 5.8. Based on which, the following seismic considerations should be made for the project area per 2019 AREMA Chapter 9, Section 1.

**Table 2: Seismicity**

<b>Earthquake Magnitude</b>	<b>Response Level</b>	<b>Ground Level</b>	<b>Motion</b>	<b>Performance Criteria Limit State</b>	<b>Average Return Period (years)</b>
5.8	II	1		Serviceability	50 to 100

Although the average return period corresponding to Ground Motion Level 1 is 50 to 100 years, HDR conservatively used a return period of 475 years for assessing the seismic hazard at the site. HDR performed seismic evaluation of the project corridor using SPT blow counts in accordance with the 2019 AREMA Chapter 9, Part 1 and has been included in Appendix D. We have conservatively identified the King Street and Commonwealth Avenue bridge sites to be Class E and estimated site adjusted peak ground acceleration for the 475-year Return Period event to be less than 10% of acceleration due to gravity.

The mapped peak horizontal ground acceleration (PGA) and mapped 1-second horizontal response spectral acceleration (S1) value for the project corridor from AREMA Vol. 2, Chapter 9 are 0.02g (2 percent of gravity) for a return period of 475 years.

Assuming Seismic Site Class E for project corridor, the site factor  $F_{pga}$  is 2.5 and the site factor  $F_v$  is 3.5 from AREMA Tables 9-1-7 and 9-1-9, respectively. Therefore, the site adjusted peak ground acceleration ( $A_s$ ) is 0.05g and the design 1-second spectral acceleration,  $SD1$ , is 0.07g, which corresponds to Seismic Zone 1 based on AASHTO Table 3.10.6-1.

AREMA Vol. 2, Chapter 9, Section 1.5.4.1 indicates evaluation for seismic performance is required only in areas where 475-yr return period PGA is greater than 0.1g. Further, AASHTO 10.5.4.2 indicates that liquefaction assessment is not required for Seismic zone 1. Therefore, no seismic factors were applied in our geotechnical design analyses and liquefaction assessment was not performed.

### Soil Corrosion Potential

Structural elements in contact with soil are subject to degradation due to corrosion, chemical attack, and/or induced electrical currents. Therefore, buried structures should be designed to resist corrosion and degradation based on accepted practices.

Corrosivity testing was performed on a composite sample collected from 25 to 35 feet depth of boring 22-King-BR-01. Corrosivity testing included tests for pH, Sulfate and Chloride content, and resistivity testing. The corrosivity laboratory testing results are provided in Appendix C and a summary of the results are listed in Table 2.

**Table 2: Summary of Corrosion Test Results**

Boring	Depth (ft) <sup>1</sup>	pH	Resistivity (ohm-cm)	Chloride Content (ppm)	Sulfate Content (ppm)
22-King-BR-01	28 to 35	4.44	2,060	15.51	62

2019 AREMA, Chapter 8, Part 4 requires protection of steel against corrosion; however, neither AREMA nor CSX guidelines provide information on soil corrosivity criteria. Therefore, HDR used VDOT Structure and Bridge Manual (S&B Manual, April 2021) criteria for analyzing the soil corrosion potential on steel piles. This criterion requires that subsurface soils shall be treated as corrosive if pH < 6, sulfate ion > 200 parts per million (ppm), chloride ion > 100 ppm, and resistivity < 3000 ohm-cm. Based on the test results, the subsurface soils at King Street and Commonwealth Avenue bridge sites are considered to be generally corrosive and a reduction in the wall thicknesses of the micropile casing is recommended to account for corrosion.

### Micropile Foundations

Based on new footing configuration, proximity to adjacent structures and construction challenges associated with other foundation types, HDR selected 12.75-inch diameter micropile with 0.5-inch-thick permanent steel casing wall for the new abutments. To perform geotechnical analysis for the micropiles, HDR prepared subsurface profiles, identified geologic strata, and interpreted the soil stratigraphy using test boring information. We analyzed and developed allowable axial capacity curves for the micropiles based on a 12.75-inch unbonded zone and 11.75-inch bond

zone using FHWA Micropile manual (2005). The axial capacity curves are provided in Appendix D.

The bridge plans show a grade increase of approximately 2 feet for the new track and the construction of the new abutment footing will require excavation to at least El. 5 and then backfilling. Given the limited fill height, the stress increase and corresponding settlements will be limited within the soil profile. Furthermore, the micropiles have at least 3D (where D is the pile diameter) center to center (CTC) spacing, and the bond zone of the micropiles is generally in stiff to very stiff, highly overconsolidated Potomac formation clays and medium dense sands below El. -15 ft at King Street and -25 ft at Commonwealth. Below these elevations (-15 ft and -25 ft), the stress increases are anticipated to be less than 5% of the existing effective stress. Therefore, we anticipate settlements will be negligible and do not consider downdrag as applicable.

We also evaluated soil response due to anticipated lateral loads on micropiles. We used the computer program LPILE (version 2019.11.02, ENSOFT) and applied an average P-multiplier of 0.5). We conservatively calculated an average of 0.5 using P-multipliers for different number of pile rows from AASHTO Table 10.7.2.4-1 considering the pile CTC spacing of 3D. We modeled the pile as a corroded section (steel loss of 0.035 inches). The lateral load analysis outputs are included in Appendix D and a summary of results are provided in Table 3 below.

**Table 3: Summary of Lateral Soil Response Analyses**

Bridge	Head Condition/ Loading	Maximum Lateral Load (kips)	Maximum Moment below Pile Top (kips-inch)	Maximum Shear below Pile Top (kips)	Depth to Point of Fixity from Pile Top (ft)
King Street	Free	21	690	12	16
	Fixed		676	4	15
Commonwealth Avenue	Free	22	1354	14	25
	Fixed		1161	4	25

We recommend a minimum of one verification load testing per bridge site to verify the micropile axial capacities. Per CSX Design and Construction Specifications, Section 070440, a resistance factor of 0.60 was applied to the ultimate axial capacities to estimate micropile tip elevation. Table 4 below provides the micropile data based on analyses included in Appendix D. Additionally, we recommend the following:

- Casing material and corrosion protection should be per 2019 AREMA, Chapter 8, Part 4.
- Before grouting, the hole should be probed using a suitable device to verify the hole length to +/- 2 inches. Debris accumulated at the hole bottom shall be flushed out before grouting. Grouting equipment should produce grout free of lumps and undispersed cement.
- The contractor should submit means and methods of micropile installation for review by the geotechnical engineer.
- The micropile verification load testing should be performed on sacrificial piles prior to installation of the production piles in accordance with Section 070440 of CSX Design and Construction Specifications. The contractor should submit the results of testing for review

by the geotechnical engineer. The ultimate and allowable bond strengths should be reassessed after testing to verify micropile lengths.

**Table 4: Micropile Data Table**

Bridge	Abutment	Maximum Axial Compression or Tension Load per Pile (Kips)	Footing Bottom Elevation (feet)	Minimum Permanent Steel Casing Length Below Footing (feet)	Minimum Permanent Steel Casing Tip Elevation (feet)	Minimum Micropile Tip Elevation (feet)
King Street	Abutment 0 (South)	135	5	20	-15	-60
	Abutment 1 (North)	102			-15	-50
	Wingwalls (all)	165			-15	-70
Commonwealth Avenue	Abutment 0 (South)	119	5	30	-25	-65
	Wingwalls (all)	158			-25	-75

### Limitations

This Geotechnical Engineering Memo has been prepared for CSX Transportation for exclusive application to King Street and Commonwealth Avenue Bridge Replacements project in City of Alexandria, Virginia. This memo has been prepared in accordance with generally accepted geotechnical engineering practices. No other warranty, express or implied, is made.

The test borings and other subsurface investigations completed for this memo are for design purposes only. Variations in both the nature and extent of the subsurface conditions could be observed during construction. Per Section 020200 of CSX Specifications, it is the obligation of the contractor to make their own investigation of subsoil condition.

Standard test methods are referenced in this memo. Other standards or documents referenced in any given standard cited in this memo, or otherwise relied upon by the authors of this memo, are only mentioned in the given standard; they are not incorporated into it or “included by reference,” as that latter term is used relative to contracts or other matters of law.

### References

AASHTO, 2017 *Bridge Design Specifications, 8th Edition*.

AREMA, 2019 *Manual for Railway Engineering*.

CSX, 2021 *Design and Construction Standard Specifications*.

FHWA, 2005 *Micropile Design and Construction*.

Virginia Department of Transportation, *Manual of the Structure and Bridge Division*, April 2021.



Virginia Polytechnic Institute and State University, Center for Geotechnical Practice and Research: *Performance and Use of the Standard Penetration Test in Geotechnical Engineering Practice*, McGregor, Jeffrey A. and Duncan, J. Michael, October 1998.

Washington Metropolitan Area Transit Authority, Office of Joint Development & Adjacent Construction, *Adjacent Construction Project Manual, latest edition*.



# Appendix A

## FIGURES & TABLES



Figure 1: Project Location Map

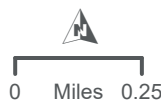
Figure 2: Subsurface Exploration Plan

Figure 3: Site Geology Map

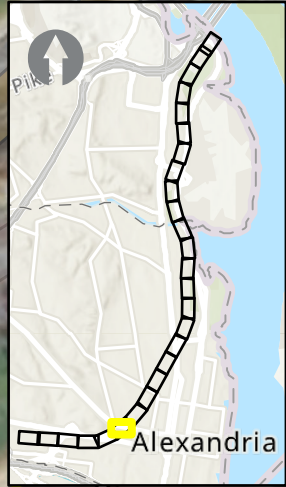
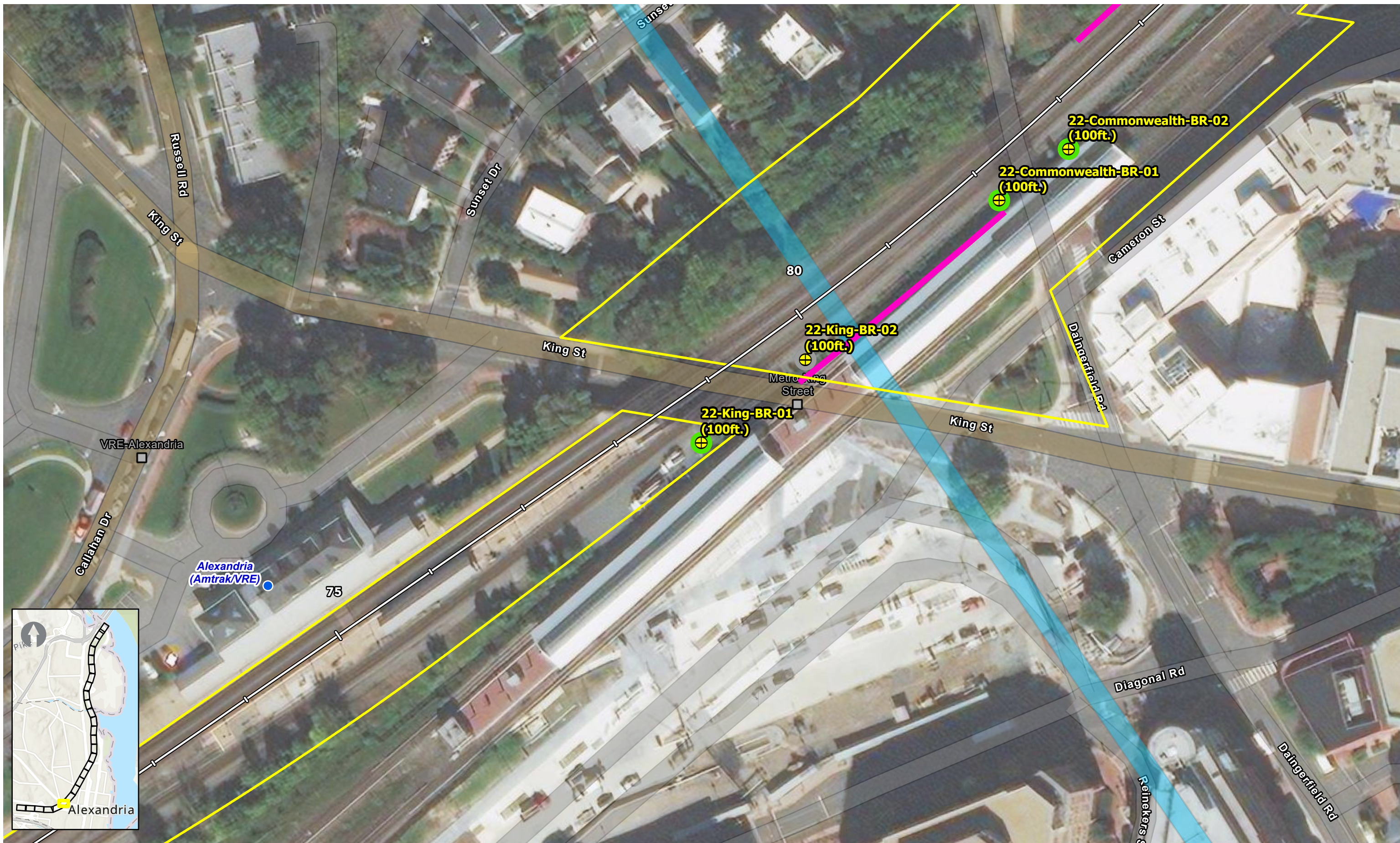
Table A-1: Summary of Subsurface Explorations



 Project Corridor



**PROJECT LOCATION MAP**  
**CSX AF-RO ALEXANDRIA 4TH TRACK**  
 FIGURE 1



**Proposed Standard Penetration Test (SPT) Borings**

- Trackbed
- Retaining Wall
- Culvert
- Slope
- Bridge
- Piezometer

**Drilling Status**

- Drilled
- Not Drilled
- Not Needed

**Legend**

- Existing Stations
- Existing CSX ROW
- Retaining Walls
- Signal Houses
- NWI Wetlands

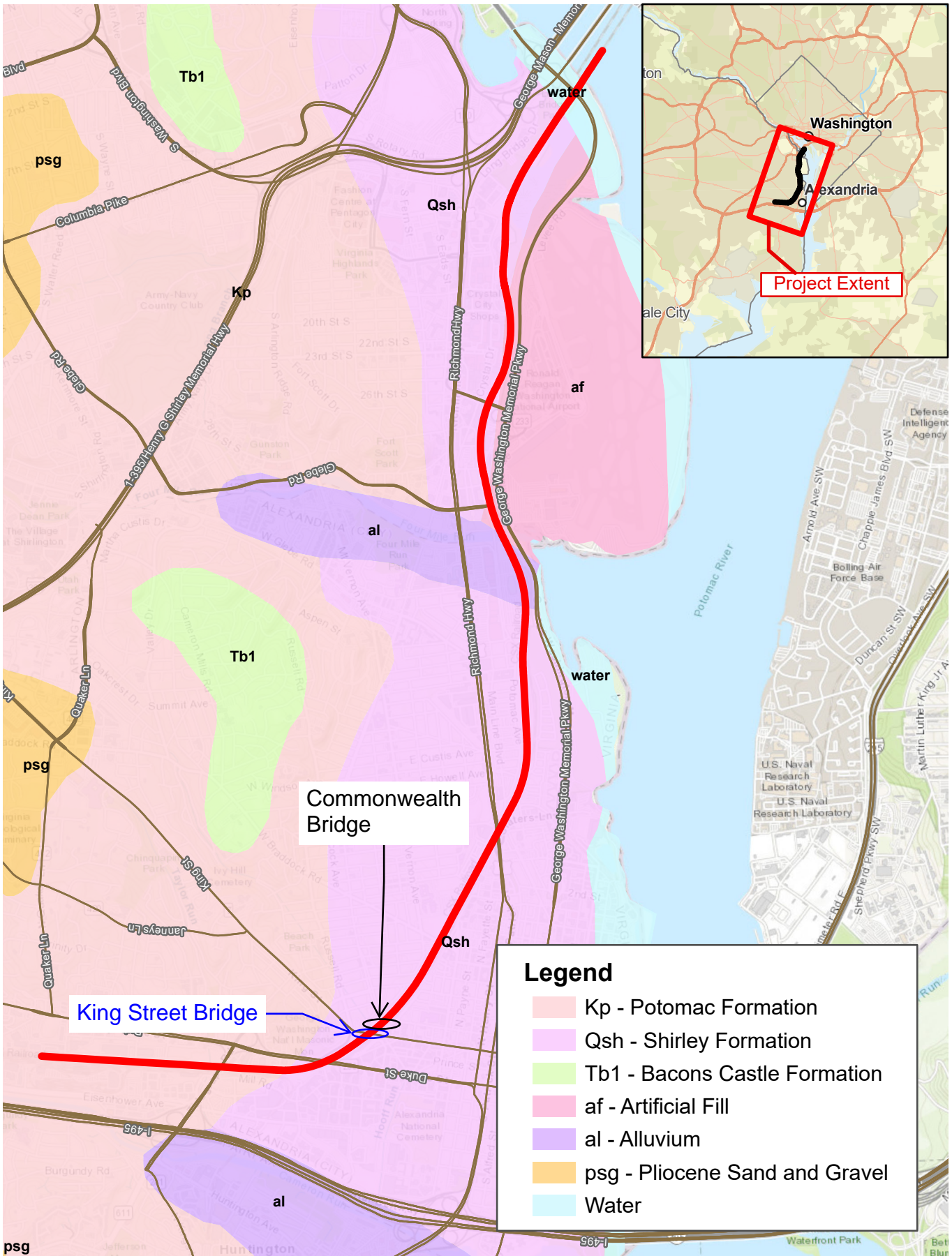


1 inch = 100 feet  
 0 Feet 100

**SUBSURFACE EXPLORATION PLAN**

CSX AF-RO 4TH TRACK

PAGE 1 OF 1 FIGURE 2



King Street Bridge

Commonwealth Bridge

**Legend**

- Kp - Potomac Formation
- Qsh - Shirley Formation
- Tb1 - Bacons Castle Formation
- af - Artificial Fill
- al - Alluvium
- psg - Pliocene Sand and Gravel
- Water



0 1 mi  
 DATA SOURCE: ESRI WORLD TOPOGRAPHIC;  
 USGS NATIONAL GEOLOGIC MAP DATABASE



Project Corridor

**CSX ALEXANDRIA 4TH TRACK  
 SITE GEOLOGY MAP  
 FIGURE 3**



# Appendix B

## SUBSURFACE EXPLORATION LOGS



Client: CSX Transportation  
 Project: DRPT CSX AF to RO Widening  
 Project Phase: --  
 Project Location: City of Alexandria and Arlington County

**22-CMWLTH-BR-01**  
 Sheet 1 of 5

Drilling Co.: SaLUT	Rig Type: Mobile Drill B-57 Truck	Start Date: 08-01-2022	End Date: 08-09-2022	Total Final Depth: 100.0 ft	Refusal Depth: --	Casing Depth: --
Soil Drilling Method(s): 3-1/4" HSA, Mud Rotary	Rock Drilling Method(s): N/A	Driller: Deante Robinson	Logger: Ertica Susanto, EIT	Elevation: 31.7 ft	Incl. from Horiz.: 90 deg.	Azimuth: 0 deg.
Hammer (Efficiency): Automatic (80%)	Core Barrel Length: N/A	Peizometer Depth (Screened Interval): N/A	Ver./Hor. Datum: NAVD 88 / NAD 1983 StatePlane Virginia North FIPS 4501 Feet	Latitude: 38.807340	Longitude: -77.060096	
Bit Type(s): --	Cave-in Depth: --	Backfill Method:	Station: 82+01	Offset: 32.0 RT	Subsurface Water Depth	
Bit Size(s): --	Soil Cuttings	Initial: <input type="checkbox"/>	18.0 ft		Stabilized: <input checked="" type="checkbox"/>	
					N/A	

Elev	Depth	Sample	Rec %	Blows / 6" or Press.	Nf (N60)	Strata Legend	MATERIAL DESCRIPTION	Sample No.	Laboratory					Su (tsf)	Remarks
									MC (%)	Y (pcf)	Fines (%)	LL	PI		
30	2						POORLY GRADED GRAVEL (GP); black, moist, fine to coarse grained [Fill]	1							
28	4						SANDY SILT (ML); black, moist [Fill]	2							
26	6		0	1 1 3	2 (3)		LEAN CLAY WITH SAND (CL); tan, soft, moist, No recovery. Description based on cuttings. [Fill]	3							
24	8		80	1 2 3 5	5 (7)		LEAN CLAY WITH SAND (CL); tan and gray, mottled, firm, moist, trace quartz fragments [Fill]	4	36.3		84.0	46	28	0.2 (P)	
22	10														
20	12														
18	14		20	6 5 5 4	10 (13)		LEAN CLAY WITH SAND (CH); tan and dark gray, mottled, stiff, moist [Fill]	5						0.2 (P)	
16	16														
14	18														
12	20		65	3 3 2 3	5 (7)		SILTY SAND (SM); gray, loose, wet, fine to medium grained [Terrace Deposits, Qt]	6	20.5		40.6	18	3		

Additional Notes: Soil relative density and consistency based on N60 values. Field SPT N-Values corrected for hammer energy (CE=1.33)



Elev	Depth	Sample	Rec %	Blows / 6" or Press.	Nf (N60)	Strata Legend	MATERIAL DESCRIPTION	Sample No.	Laboratory					Su (tsf)	Remarks
									MC (%)	γ (pcf)	Fines (%)	LL	PI		
10	-22														
8	-24	X	90	3 2 1 1	3 (4)	[Vertical lines]	<b>SANDY SILT (ML)</b> ; gray, soft, wet [Terrace Deposits, Qt]	7						0.2 (P)	
6	-26														
4	-28	X	60	7 11 13 12	24 (32)	[Vertical lines]	<b>SILTY SAND (SM)</b> ; gray to brown, dense, wet, fine to medium grained [Terrace Deposits, Qt]	8	17.9						
2	-30	X													
0	-32														
-2	-34	X	60	4 6 8 7	14 (19)	[Vertical lines]	<b>POORLY GRADED SAND WITH SILT (SP-SM)</b> ; brown, medium dense, wet, fine to coarse grained, trace rock fragments [Terrace Deposits, Qt]	9							
-4	-36														
-6	-38	X	60	7 13 8 7	21 (28)	[Vertical lines]	<b>POORLY GRADED SAND WITH SILT (SP-SM)</b> ; brown, medium dense, wet, fine to coarse grained, trace rock fragments [Terrace Deposits, Qt]	10	12.8		10.0				
-8	-40	X													
-10	-42														
-12	-44	X	0	5 7 8 3	15 (20)	[Vertical lines]	No recovery	11							



Elev	Depth	Sample	Rec %	Blows / 6" of Press.	Nf (N60)	Strata Legend	MATERIAL DESCRIPTION	Sample No.	Laboratory					Su (tsf)	Remarks
									MC (%)	γ (pcf)	Fines (%)	LL	PI		
-14	-46														
-16	-48		100	2 3 2 7	5 (7)	[Potomac Formation, Kp]	<b>SANDY FAT CLAY (CH);</b> gray, firm, wet [Potomac Formation, Kp]	12					0.4 (P) 2.2 (P)		
-18	-50														
-20	-52														
-22	-54		100	9 12 14 16	26 (35)		<b>FAT CLAY (CH);</b> brown and gray , mottled, hard, wet [Potomac Formation, Kp]	13	24.9				1.5 (P)		
-24	-56														
-26	-58		80	7 8 10 13	18 (24)	<b>FAT CLAY (CH);</b> brown, very stiff, wet [Potomac Formation, Kp]	14					1.6 (P)			
-28	-60														
-30	-62														
-32	-64		90	16 18 14 13	32 (43)	<b>FAT CLAY (CH);</b> red, hard, wet [Potomac Formation, Kp]	15	23.6		99.0	77	55	2.2 (P)		
-34	-66														
-36	-68		100	8 13 15 21	28 (37)	<b>FAT CLAY (CH);</b> red and gray , mottled, hard, wet [Potomac Formation, Kp]	16					1.0 (P)			
-38	-70														



Elev	Depth	Sample	Rec %	Blows / 6" or Press.	Nf (N60)	Strata Legend	MATERIAL DESCRIPTION	Sample No.	Laboratory					Su (tsf)	Remarks
									MC (%)	γ (pcf)	Fines (%)	LL	PI		
-40	-72														
-42	-74	X	100	9 13 17 23	30 (40)	[Diagonal Hatching]	<b>FAT CLAY (CH)</b> ; gray, hard, wet, slightly micaceous <b>[Potomac Formation, Kp]</b>	17						2.1 (P)	
-44	-76														
-46	-78	X	100	12 22 31 49	53 (70)	[Dotted Pattern]	<b>SILTY, CLAYEY SAND (SC-SM)</b> ; brown, very dense, wet, slightly micaceous <b>[Potomac Formation, Kp]</b>	18	21.9		27.0	24	4		
-48	-80														
-50	-82														
-52	-84	X	100	16 20 20 27	40 (53)	[Diagonal Hatching]	<b>FAT CLAY WITH SAND (CH)</b> ; brown and gray, mottled, hard, wet, slightly micaceous <b>[Potomac Formation, Kp]</b>	19						2.1 (P)	
-54	-86														
-56	-88	X	100	11 14 20 29	34 (45)	[Diagonal Hatching]	<b>SANDY FAT CLAY (CH)</b> ; brown and gray, mottled, hard, wet, slightly micaceous <b>[Potomac Formation, Kp]</b>	20						0.4 (P)	
-58	-90														
-60	-92														
-62	-94	X	100	15 21 26 25	47 (63)	[Diagonal Hatching]	<b>SANDY FAT CLAY (CH)</b> ; brown and gray, mottled, very hard, wet, slightly micaceous <b>[Potomac Formation, Kp]</b>	21	22.6					1.4 (P)	



Elev	Depth	Sample	Rec %	Blows / 6" or Press.	Nf (N60)	Strata Legend	MATERIAL DESCRIPTION	Sample No.	Laboratory					Su (tsf)	Remarks
									MC (%)	Y (pcf)	Fines (%)	LL	PI		
-64	-96														
-66	-98						<b>FAT CLAY (CH);</b> red and gray , mottled, very hard, wet <b>[Potomac Formation, Kp]</b>	22						2.2 (P)	
-68	-100		100	14 26 29 40	55 (73)		Boring Terminated at 100.0 ft depth.								
-70	-102														
-72	-104														
-74	-106														
-76	-108														
-78	-110														
-80	-112														
-82	-114														
-84	-116														
-86	-118														
-88	-120														



Client: CSX Transportation  
 Project: DRPT CSX AF to RO Widening  
 Project Phase: --  
 Project Location: City of Alexandria and Arlington County

22-CMWLTH-BR-02

Sheet 1 of 5

Drilling Co.: SaLUT	Rig Type: Acker XLS Track	Start Date: 08-02-2022	End Date: 08-03-2022	Total Final Depth: 100.0 ft	Refusal Depth: --	Casing Depth: --
Soil Drilling Method(s): Mud Rotary, 3-1/4" HSA	Rock Drilling Method(s): N/A	Driller: Blake Strawderman	Logger: Nick Miller, PE	Elevation: 29.6 ft	Incl. from Horiz.: 90 deg.	Azimuth: 0 deg.
Hammer (Efficiency): Automatic (80%)	Core Barrel Length: N/A	Peizometer Depth (Screened Interval): N/A	Ver./Hor. Datum: NAVD 88 / NAD 1983 StatePlane Virginia North FIPS 4501 Feet	Latitude: 38.807465	Longitude: -77.059879	
Bit Type(s): --	Cave-in Depth: --	Backfill Method: Bentonite Powder, Soil Cuttings	Station: 82+76	Subsurface Water Depth		
Bit Size(s): --	Initial: <input type="checkbox"/>	23.0 ft		Stabilized: <input checked="" type="checkbox"/>		
			N/A			

Elev	Depth	Sample	Rec %	Blows / 6" or Press.	Nf (N60)	Strata Legend	MATERIAL DESCRIPTION	Sample No.	Laboratory					Su (tsf)	Remarks
									MC (%)	Y (pcf)	Fines (%)	LL	PI		
28	2		40	7 11 12 15	23 (31)		POORLY GRADED GRAVEL (GP); dark gray, dense, moist [Fill]	1							
26	2		35	4 4 3 4	7 (9)		SILTY SAND (SM); dark gray, loose, moist, fine to coarse grained [Fill]	2							
24	4		25	1 2 1 1	3 (4)		CLAYEY SAND (SC); brown, loose, moist, fine to coarse grained [Fill]	3	10.4		13.6				
22	6		75	WOH WOH 2 2	2 (3)		SANDY LEAN CLAY (CL); gray, soft, moist [Fill]	4	25.0		69.0			0.2 (P)	
20	8		0	2 2 4 2	6 (8)		LEAN CLAY (CL); brown, firm, moist, No recovery, root mass in shoe. Description is based on cuttings. [Fill]	5							
16	10		60	4 1 2 3	3 (4)		LEAN CLAY (CL); brown, soft, moist [Fill]	6						0.4 (P)	Switched to Mud Rotary at 15'
12	18		65	1 2 4 6	6 (8)		LEAN CLAY (CL); brown, firm, moist [Terrace Deposits, Qt]	7						0.2 (P)	

Additional Notes: Soil relative density and consistency based on N60 values. Field SPT N-Values corrected for hammer energy (CE=1.33)



Elev	Depth	Sample	Rec %	Blows / 6" or Press.	Nf (N60)	Strata Legend	MATERIAL DESCRIPTION	Sample No.	Laboratory					Su (tsf)	Remarks
									MC (%)	γ (pcf)	Fines (%)	LL	PI		
8	-22														
6	-24		75	1 1 1 2	2 (3)		<b>SILTY, CLAYEY SAND (SC-SM);</b> gray, very loose, wet, fine to medium grained, trace organics [Terrace Deposits, Qt]	8	28.8		47.0	23	4	0.1 (P)	
4	-26														
2	-28		75	1 2 5 10	7 (9)		<b>SILTY, CLAYEY SAND (SC-SM);</b> gray, loose, wet, fine to medium grained, trace organics [Terrace Deposit, Qt]	9						0.2 (P)	
0	-30														
-2	-32														
-4	-34		50	4 4 6 11	10 (13)		<b>SILTY, CLAYEY SAND (SC-SM);</b> gray, medium dense, wet, coarse grained [Terrace Deposits, Qt]	10	23.8						
-6	-36														
-8	-38		85	1 1 1 1	2 (3)		<b>LEAN CLAY WITH SAND (CL);</b> gray, soft, wet [Terrace Deposits, Qt]	11	29.9		77.0			0.2 (P)	
-10	-40														
-12	-42														
-14	-44		55	3 3 5 5	8 (11)		<b>SILTY SAND (SM);</b> gray, medium dense, wet, coarse grained [Terrace Deposits, Qt]	12							



Elev	Depth	Sample	Rec %	Blows / 6" or Press.	Nf (N60)	Strata Legend	MATERIAL DESCRIPTION	Sample No.	Laboratory					Su (tsf)	Remarks
									MC (%)	γ (pcf)	Fines (%)	LL	PI		
-16	-46														
-18	-48	X	90	3 4 7 7	11 (15)	[Diagonal Hatching]	LEAN CLAY (CL); gray, stiff, wet [Terrace Deposits, Qt]	13	36.2						
-20	-50	X													
-22	-52														
-24	-54	X	100	1 1 5 3	6 (8)	[Diagonal Hatching]	LEAN CLAY (CL); gray, firm, wet [Terrace Deposits, Qt]	14					0.4 (P)		
-26	-56														
-28	-58	X	30	16 7 3 7	10 (13)	[Dotted Pattern]	POORLY GRADED SAND WITH CLAY AND GRAVEL (SP-SC); gray, medium dense, wet, fine to coarse grained [Terrace Deposits, Qt]	15							
-30	-60	X													
-32	-62														
-34	-64	X	60	7 9 6 9	15 (20)	[Dotted Pattern]	POORLY GRADED SAND WITH CLAY AND GRAVEL (SP-SC); gray, medium dense, wet, fine to coarse grained [Terrace Deposits, Qt]	16	16.7		7.6				
-36	-66														
-38	-68	X	50	3 1 2 7	3 (4)	[Dotted Pattern]	POORLY GRADED SAND WITH CLAY AND GRAVEL (SP-SC); gray, loose, wet, fine to coarse grained [Terrace Deposits, Qt]	17							
-40	-70	X													



Elev	Depth	Sample	Rec %	Blows / 6" or Press.	Nf (N60)	Strata Legend	MATERIAL DESCRIPTION	Sample No.	Laboratory					Su (tsf)	Remarks
									MC (%)	γ (pcf)	Fines (%)	LL	PI		
-42	-72														
-44	-74	X	55	3 18 34 28	52 (69)	[Potomac Formation, Kp]	LEAN CLAY (CL); brown, very hard, wet [Potomac Formation, Kp]	18	21.2					2.0 (P)	
-46	-76														
-48	-78	X	55	12 23 30 30	53 (70)	[Potomac Formation, Kp]	FAT CLAY (CH); gray, very hard, wet [Potomac Formation, Kp]	19							
-50	-80	X													
-52	-82														
-54	-84	X	100	14 20 30 36	50 (66)	[Potomac Formation, Kp]	FAT CLAY (CH); gray, very hard, wet [Potomac Formation, Kp]	20	26.3		96.0	78	57		
-56	-86														
-58	-88	X	100	13 17 21 31	38 (51)	[Potomac Formation, Kp]	LEAN CLAY (CL); green brown, hard, wet [Potomac Formation, Kp]	21						1.6 (P)	
-60	-90	X													
-62	-92														
-64	-94	X	100	15 22 29 44	51 (68)	[Potomac Formation, Kp]	LEAN CLAY (CL); green brown, very hard, wet [Potomac Formation, Kp]	22						1.2 (P)	



Elev	Depth	Sample	Rec %	Blows / 6" or Press.	Nf (N60)	Strata Legend	MATERIAL DESCRIPTION	Sample No.	Laboratory					Su (tsf)	Remarks
									MC (%)	γ (pcf)	Fines (%)	LL	PI		
-66	-96														
-68	-98		90	17 22 37 37	59 (78)		<b>CLAYEY SAND (SC)</b> ; gray, very dense, wet, fine to coarse grained [Potomac Formation, Kp]	23						1.2 (P)	
-70	-100						Boring Terminated at 100.0 ft depth.								
-72	-102														
-74	-104														
-76	-106														
-78	-108														
-80	-110														
-82	-112														
-84	-114														
-86	-116														
-88	-118														
-90															
-120															



Client: CSX Transportation  
 Project: DRPT CSX AF to RO Widening  
 Project Phase: --  
 Project Location: City of Alexandria and Arlington County

22-King-BR-01

Sheet 1 of 5

Drilling Co.: SaLUT	Rig Type: Mobile Drill B-57 Truck	Start Date: 08-02-2022	End Date: 08-03-2022	Total Final Depth: 100.0 ft	Refusal Depth: --	Casing Depth: --
Soil Drilling Method(s): 3-1/4" HSA, Mud Rotary	Rock Drilling Method(s): N/A	Driller: Deante Robinson	Logger: Harsh Patel, EIT	Elevation: 31.7 ft	Incl. from Horiz.: 90 deg.	Azimuth: 0 deg.
Hammer (Efficiency): Automatic (80%)	Core Barrel Length: N/A	Peizometer Depth (Screened Interval): N/A	Ver./Hor. Datum: NAVD 88 / NAD 1983 StatePlane Virginia North FIPS 4501 Feet	Latitude: 38.806749	Longitude: -77.061028	
Bit Type(s): --	Cave-in Depth: 26.3 ft	Backfill Method: Auger Cuttings, Bentonite Powder	Station: 78+63	Offset: 43.0 RT	Subsurface Water Depth	
Bit Size(s): --			Initial: <input type="checkbox"/>	18.0 ft		
			Stabilized: <input checked="" type="checkbox"/>	12.3 ft		

Elev	Depth	Sample	Rec %	Blows / 6" or Press.	Nf (N60)	Strata Legend	MATERIAL DESCRIPTION	Sample No.	Laboratory					Su (tsf)	Remarks
									MC (%)	Y (pcf)	Fines (%)	LL	PI		
							POORLY GRADED GRAVEL (GP); gray, dry, fine to coarse grained [Fill]	1							
30	2						CLAYEY SAND (SC); brown, moist, fine to medium grained, trace asphalt fragments [Fill]	2							
							SILTY SAND WITH GRAVEL (SM); black, moist, fine to medium grained [Fill]	3							
28	4						SANDY LEAN CLAY (CL); brown to red, moist [Fill]	4							
26	6		75	2 3 3 5	6 (8)		SANDY LEAN CLAY (CL); brown red and gray, mottled, firm, moist [Fill]	5						0.5 (P)	
24	8		75	4 4 4 6	8 (11)		SANDY LEAN CLAY (CL); brown red and gray, mottled, stiff, moist [Fill]	6	20.0		68.0	29	14	0.5 (P)	
22	10														
20	12														
18	14		100	2 4 3 3	7 (9)		SANDY LEAN CLAY (CL); gray, stiff, moist [Fill]	7						0.2 (P)	
16	16														
14	18		100	2 1 1 1	2 (3)		FAT CLAY (CH); gray, soft, wet [Terrace Deposits, Qt]	8	21.3					0.2 (P)	
12	20						SILTY SAND (SM); yellow brown, moist, fine to medium grained [Potomac Formation, Kp]								Switched to Mud

Additional Notes: Soil relative density and consistency based on N60 values. Field SPT N-Values corrected for hammer energy (CE=1.33)



Elev	Depth	Sample	Rec %	Blows / 6" or Press.	Nf (N60)	Strata Legend	MATERIAL DESCRIPTION	Sample No.	Laboratory					Su (tsf)	Remarks
									MC (%)	γ (pcf)	Fines (%)	LL	PI		
10	-22		100						18.4		13.2	NP	NP		Rotary at 20'
8	-24		54	5 15 12 17	27 (36)		<b>SILTY SAND (SM)</b> ; tan, dense, wet, fine to coarse grained, trace quartz fragments <b>[Potomac Formation, Kp]</b>	9							
6	-26														
4	-28		100	5 6 9 10	15 (20)		<b>SANDY FAT CLAY (CH)</b> ; dark gray, very stiff, wet, slickensides <b>[Potomac Formation, Kp]</b>	10						1.5 (P)	
2	-30														
0	-32														
-2	-34		100	7 8 10 12	18 (24)		<b>FAT CLAY (CH)</b> ; gray blue, very stiff, wet, slickensides <b>[Potomac Formation, Kp]</b>	11	34.5					2.0 (P)	
-4	-36														
-6	-38		100	6 8 11 12	19 (25)		<b>FAT CLAY (CH)</b> ; blue gray and red, very stiff, wet, slickensides <b>[Potomac Formation, Kp]</b>	12	32.9		96.0	84	58	2.2 (P)	
-8	-40														
-10	-42														
-12	-44		100	6 10 11 13	21 (28)		<b>FAT CLAY (CH)</b> ; blue gray and red, very stiff, wet <b>[Potomac Formation, Kp]</b>	13						2.2 (P)	



Elev	Depth	Sample	Rec %	Blows / 6" or Press.	Nf (N60)	Strata Legend	MATERIAL DESCRIPTION	Sample No.	Laboratory					Su (tsf)	Remarks
									MC (%)	Y (pcf)	Fines (%)	LL	PI		
-14	-46														
-16	-48	X	100	7 13 16 20	29 (39)		<b>FAT CLAY (CH);</b> blue gray, hard, wet, slickensides <b>[Potomac Formation, Kp]</b>	14						2.1 (P)	
-20	-52														
-22	-54	X	100	8 13 18 23	31 (41)		<b>FAT CLAY WITH SAND (CH);</b> blue gray, hard, wet <b>[Potomac Formation, Kp]</b>	15	21.2		81.0	67	49	2.2 (P)	
-24	-56														
-26	-58	X	100	14 22 22 28	44 (59)		<b>FAT CLAY (CH);</b> blue gray, hard, wet <b>[Potomac Formation, Kp]</b>	16						2.2 (P)	
-30	-62														
-32	-64	X	100	10 23 28 28	51 (68)		<b>FAT CLAY WITH SAND (CH);</b> brown, red and gray, mottled, very hard, wet <b>[Potomac Formation, Kp]</b>	17						2.2 (P)	
-34	-66														
-36	-68	X	100	6 12 16 20	28 (37)		<b>FAT CLAY (CH);</b> red and gray, mottled, hard, wet <b>[Potomac Formation, Kp]</b>	18						2.0 (P)	
-38	-70														



Elev	Depth	Sample	Rec %	Blows / 6" or Press.	Nf (N60)	Strata Legend	MATERIAL DESCRIPTION	Sample No.	Laboratory					Su (tsf)	Remarks
									MC (%)	γ (pcf)	Fines (%)	LL	PI		
-40	-72														
-42	-74	X	100	10 15 16 21	31 (41)		<b>FAT CLAY (CH);</b> red and gray , mottled, hard, wet <b>[Potomac Formation, Kp]</b>	19	22.5	100.0			2.2 (P)		
-44	-76														
-46	-78	X	100	10 13 16 22	29 (39)			20					2.2 (P)		
-48	-80														
-50	-82														
-52	-84	X	100	7 9 13 18	22 (29)		<b>FAT CLAY (CH);</b> gray, very stiff, wet, trace organics <b>[Potomac Formation, Kp]</b>	21					2.2 (P)		
-54	-86														
-56	-88	X	100	13 18 23 26	41 (55)		<b>FAT CLAY WITH SAND (CH);</b> gray and brown , mottled, hard, wet, slightly micaceous <b>[Potomac Formation, Kp]</b>	22	26.7				2.2 (P)		
-58	-90														
-60	-92														
-62	-94	X	100	12 17 26 35	43 (57)		<b>FAT CLAY WITH SAND (CH);</b> gray and brown , mottled, hard, wet <b>[Potomac Formation, Kp]</b>	23					2.2 (P)		



Elev	Depth	Sample	Rec %	Blows / 6" or Press.	Nf (N60)	Strata Legend	MATERIAL DESCRIPTION	Sample No.	Laboratory					Su (tsf)	Remarks
									MC (%)	γ (pcf)	Fines (%)	LL	PI		
-64	-96														
-66	-98						<b>FAT CLAY WITH SAND (CH);</b> gray and brown, very hard, wet <b>[Potomac Formation, Kp]</b>  Boring Terminated at 100.0 ft depth.	24						1.9 (P)	
-68	-100		100	17 22 26 43	48 (64)										
-70	-102														
-72	-104														
-74	-106														
-76	-108														
-78	-110														
-80	-112														
-82	-114														
-84	-116														
-86	-118														
-88	-120														



**TABLE A-1: SUMMARY OF SUBSURFACE EXPLORATIONS**

Exploration Designation	Primary Design Element Purpose	Mile Post	Station <sup>4</sup>	Offset (ft) <sup>4</sup>		Surface Elevation (ft)	Latitude	Longitude	Depth Drilled (ft)
22-King-BR-01 <sup>1</sup>	Bridge	105.29	78+63	44	RT	31.7	38.806736	-77.061054	100.0
22-CMWLTH-BR-01	Bridge	105.36	82+01	32	RT	31.7	38.807340	-77.060096	100.0
22-CMWLTH-BR-02	Bridge	105.38	82+76	39	RT	29.6	38.807465	-77.059879	100.0

<sup>1</sup> Shelby tube samples were collected/attempted in the boring

<sup>2</sup> Bulk samples were collected in the boring



# Appendix C

## LABORATORY TEST RESULTS



Table C-1: Summary of Laboratory Testing

Moisture Content Results

Atterberg Limits Results

Grain Size Analysis Results

Corrosion Test Results (pH, Resistivity, Chloride, Sulfate)

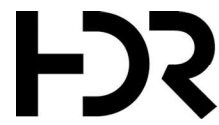
Shelby Tube Extraction Logs

1-D Consolidation Results

UU Triaxial Test Results



**Table C-1: Summary of Laboratory Testing**



**Table C-1: SUMMARY OF LABORATORY TESTING RESULTS**

Exploration Designation	Sample Type	Depth, feet	w (%)	Atterberg Limits			Grain Size Analysis			USCS Symbol	Modified Proctor		Corrosion			
				LL (%)	PL (%)	PI (%)	% Gravel <sup>1</sup>	% Sand <sup>2</sup>	% Silt/Clay <sup>3</sup>		Y <sub>d max</sub> (pcf)	W <sub>opt</sub> (%)	pH	Resistivity (ohm-cm)	Sulfates (ppm)	Chlorides (ppm)
22-CMWLTH-BR-01	Jar	8.0 to 10.0	36.3	46	18	28			84.0	CL						
22-CMWLTH-BR-01	Jar	18.0 to 20.0	20.5	18	15	3	0.0	59.4	40.6	SM						
22-CMWLTH-BR-01	Jar	28.0 to 30.0	17.9													
22-CMWLTH-BR-01	Jar	38.0 to 40.0	12.8						10.0							
22-CMWLTH-BR-01	Jar	53.0 to 55.0	24.9													
22-CMWLTH-BR-01	Jar	63.0 to 65.0	23.6	77	22	55			99.0	CH						
22-CMWLTH-BR-01	Jar	78.0 to 80.0	21.9	24	20	4			27.0							
22-CMWLTH-BR-01	Jar	93.0 to 95.0	22.6													
22-CMWLTH-BR-02	Jar	4.0 to 6.0	10.4				36.8	49.7	13.6							
22-CMWLTH-BR-02	Jar	6.0 to 8.0	25.0						69.0							
22-CMWLTH-BR-02	Jar	23.0 to 25.0	28.8	23	19	4			47.0							
22-CMWLTH-BR-02	Jar	33.0 to 35.0	23.8													
22-CMWLTH-BR-02	Jar	38.0 to 40.0	29.9						77.0							
22-CMWLTH-BR-02	Jar	48.0 to 50.0	36.2													
22-CMWLTH-BR-02	Jar	63.0 to 65.0	16.7				16.4	76.0	7.6							
22-CMWLTH-BR-02	Jar	73.0 to 75.0	21.2													
22-CMWLTH-BR-02	Jar	83.0 to 85.0	26.3	78	21	57			96.0	CH						
22-King-BR-01	Jar	8.0 to 10.0	20.0	29	15	14			68.0	CL						
22-King-BR-01	Jar	18.0 to 20.0	21.3													
22-King-BR-01	Jar	33.0 to 35.0	34.5													
22-King-BR-01	Jar	38.0 to 40.0	32.9	84	26	58			96.0	CH						
22-King-BR-01	Jar	53.0 to 55.0	21.2	67	18	49			81.0	CH						
22-King-BR-01	Jar	73.0 to 75.0	22.5						100.0							
22-King-BR-01	Jar	88.0 to 90.0	26.7													
22-King-BR-01	Shelby Tube	20.0 to 22.0	18.4	NP	NP	NP	0.0	86.8	13.2	SM						
22-King-BR-01	Composite	28.0 to 35.0										4.4	1,000	62	16	

1 Particle Diameter > Sieve No. 4  
 2 Sieve No. 4 < Particle Diameter <= Sieve No. 200  
 3 Particle Diameter < Sieve No. 200



## Moisture Content Results

T.B. LAB SUMMARY - BASIC - PROC. AF-RO ALEXANDRIA 4TH TRACK G&J PROJECT GDT 9/31/22

Boring	Depth (ft)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	% < #4 Sieve	% < #200 Sieve	Classification	Water Content (%)	Dry Density (pcf)	Optimum Water Content (%)
22-Cmwealth-BR-01	8.0 - 10.0	46	18	28		84	CL	36.3		
22-Cmwealth-BR-01	18.0 - 20.0	18	15	3	100	41	SM	20.5		
22-Cmwealth-BR-01	28.0 - 30.0							17.9		
22-Cmwealth-BR-01	38.0 - 40.0					10		12.8		
22-Cmwealth-BR-01	53.0 - 55.0							24.9		
22-Cmwealth-BR-01	63.0 - 65.0	77	22	55		99	CH	23.6		
22-Cmwealth-BR-01	78.0 - 80.0	24	20	4		27		21.9		
22-Cmwealth-BR-01	93.0 - 95.0							22.6		
22-Cmwealth-BR-02	4.0 - 6.0				63	14		10.4		
22-Cmwealth-BR-02	6.0 - 8.0					69		25.0		



**Summary of Laboratory Results**  
AF-RO Alexandria 4th Track

Alexandria, VA  
Project Number: 22-026.01

TLB LAB SUMMARY - BASIC - PROC AF-RO ALEXANDRIA 4TH TRACK GPJ PROJECT GDT 9/31/22

Boring	Depth (ft)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	% < #4 Sieve	% < #200 Sieve	Classification	Water Content (%)	Dry Density (pcf)	Optimum Water Content (%)
22-Cmwealth-BR-02	23.0 - 25.0	23	19	4		47		28.8		
22-Cmwealth-BR-02	33.0 - 35.0							23.8		
22-Cmwealth-BR-02	38.0 - 40.0					77		29.9		
22-Cmwealth-BR-02	48.0 - 50.0							36.2		
22-Cmwealth-BR-02	63.0 - 65.0				84	8		16.7		
22-Cmwealth-BR-02	73.0 - 75.0							21.2		
22-Cmwealth-BR-02	83.0 - 85.0	78	21	57		96	CH	26.3		




**Summary of Laboratory Results**  
AF-RO Alexandria 4th Track

Alexandria, VA  
Project Number: 22-026.01

TLB LAB SUMMARY - BASIC - PROC AF-RO ALEXANDRIA 4TH TRACK GPJ PROJECT GDT 9/31/22

Boring	Depth (ft)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	% < #4 Sieve	% < #200 Sieve	Classification	Water Content (%)	Dry Density (pcf)	Optimum Water Content (%)
22-King-BR-01	8.0 - 10.0	29	15	14		68	CL	20.0		
22-King-BR-01	18.0 - 20.0							21.3		
22-King-BR-01	33.0 - 35.0							34.5		
22-King-BR-01	38.0 - 40.0	84	26	58		96	CH	32.9		
22-King-BR-01	53.0 - 55.0	67	18	49		81	CH	21.2		
22-King-BR-01	73.0 - 75.0					100		22.5		
22-King-BR-01	88.0 - 90.0							26.7		

	<p><b>Summary of Laboratory Results</b> AF-RO Alexandria 4th Track</p>	<p>Alexandria, VA Project Number: 22-026.01</p>
--	--	---



Client:	HDR Engineering, Inc.		
Project:	AF-RO Alexandria 4th Track		
Location:	Alexandria, VA	Project No:	GTX-315798
Boring ID:	---	Sample Type:	---
Sample ID:	---	Test Date:	09/23/22
Depth :	---	Test Id:	685418
		Tested By:	ckg
		Checked By:	jsc

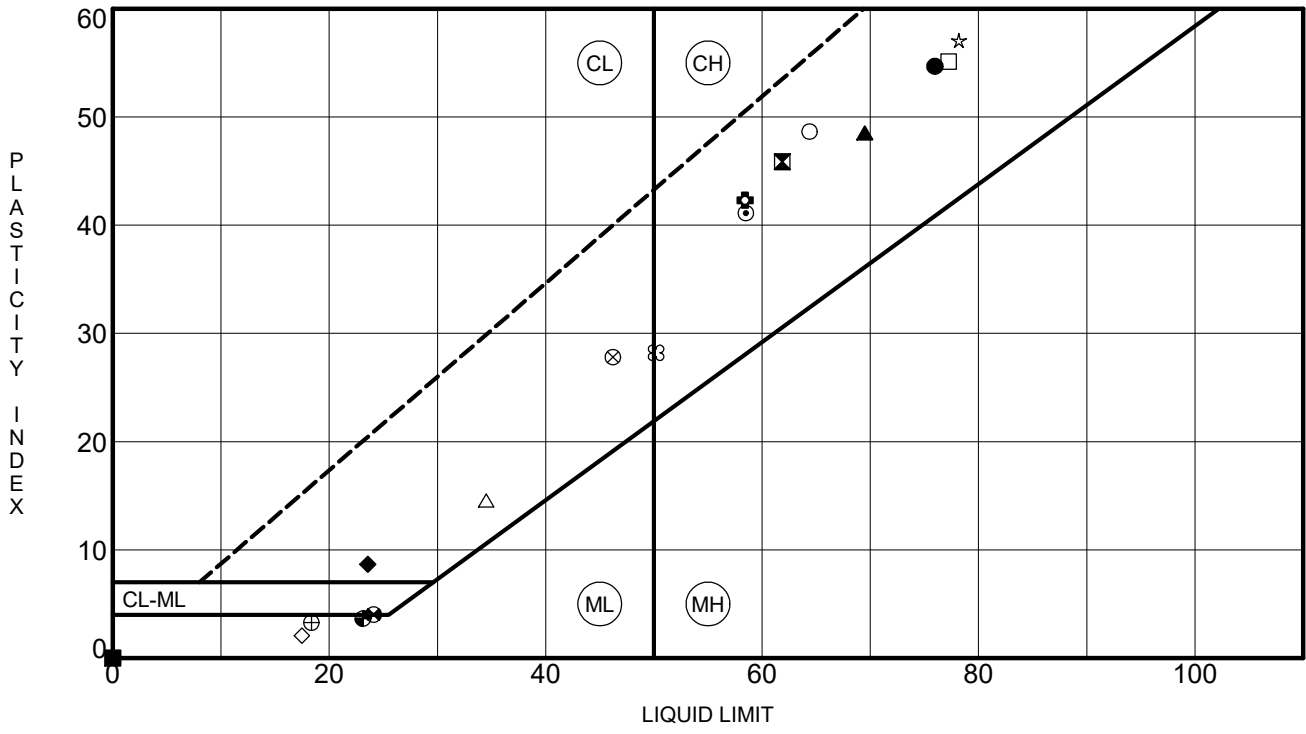
## Moisture Content of Soil and Rock - ASTM D2216

Boring ID	Sample ID	Depth	Description	Moisture Content, %
22-King-BR-01	ST- 1	20-22	Moist, yellowish brown silty sand	18.4

Notes: Temperature of Drying : 110° Celsius



## **Atterberg Limits Results**



⊗	22-Cmwealth-BR-01	8.0 - 10.0	46	18	28	84	LEAN CLAY with SAND(CL)
⊕	22-Cmwealth-BR-01	18.0 - 20.0	18	15	3	41	SILTY SAND(SM)
□	22-Cmwealth-BR-01	63.0 - 65.0	77	22	55	99	FAT CLAY(CH)
⊗	22-Cmwealth-BR-01	78.0 - 80.0	24	20	4	27	
⊕	22-Cmwealth-BR-02	23.0 - 25.0	23	19	4	47	
☆	22-Cmwealth-BR-02	83.0 - 85.0	78	21	57	96	FAT CLAY(CH)

Test Method: **ASTM D4318**

Tested By: SM

Date: 8/25/2022

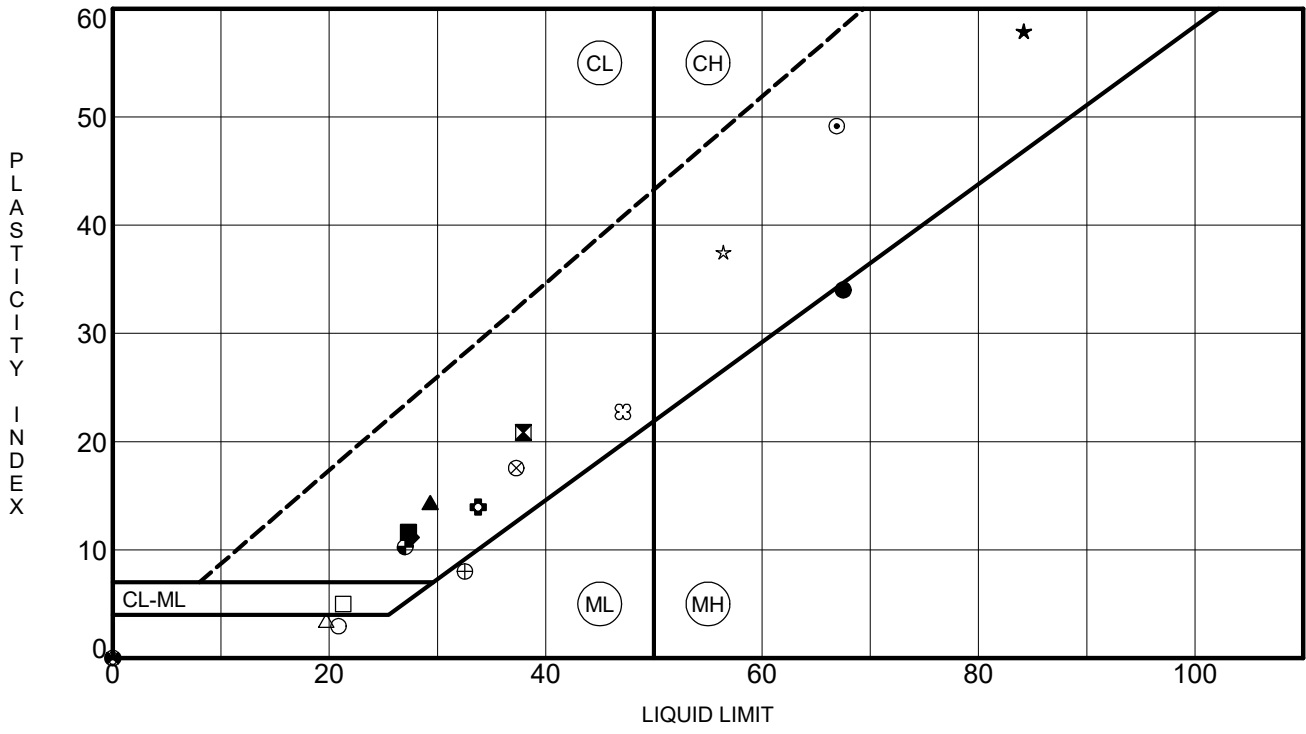


### ATTERBERG LIMITS' RESULTS

Project: AF-RO Alexandria 4th Track

Location: Alexandria, VA

Project Number: 22-026.01



Boring	Depth	LL	PL	PI	Fines	Classification
▲ 22-King-BR-01	8.0 - 10.0	29	15	14	68	SANDY LEAN CLAY(CL)
★ 22-King-BR-01	38.0 - 40.0	84	26	58	96	FAT CLAY(CH)
⊙ 22-King-BR-01	53.0 - 55.0	67	18	49	81	FAT CLAY with SAND(CH)

TUB-ATTERBERG LIMITS AF-RO ALEXANDRIA 4TH TRACK GPJ TLB2008.GDT 8/31/22

Test Method: ASTM D4318

Tested By: SM Date: 8/25/2022



**ATTERBERG LIMITS' RESULTS**

Project: AF-RO Alexandria 4th Track  
 Location: Alexandria, VA  
 Project Number: 22-026.01



Client:	HDR Engineering, Inc.		
Project:	AF-RO Alexandria 4th Track		
Location:	Alexandria, VA	Project No:	GTX-315798
Boring ID:	22-King-BR-01	Sample Type:	tube
Sample ID:	ST-1	Test Date:	09/22/22
Depth :	20-22	Test Id:	685398
Test Comment:	---		
Visual Description:	Moist, yellowish brown silty sand		
Sample Comment:	---		

## Atterberg Limits - ASTM D4318

Sample Determined to be non-plastic

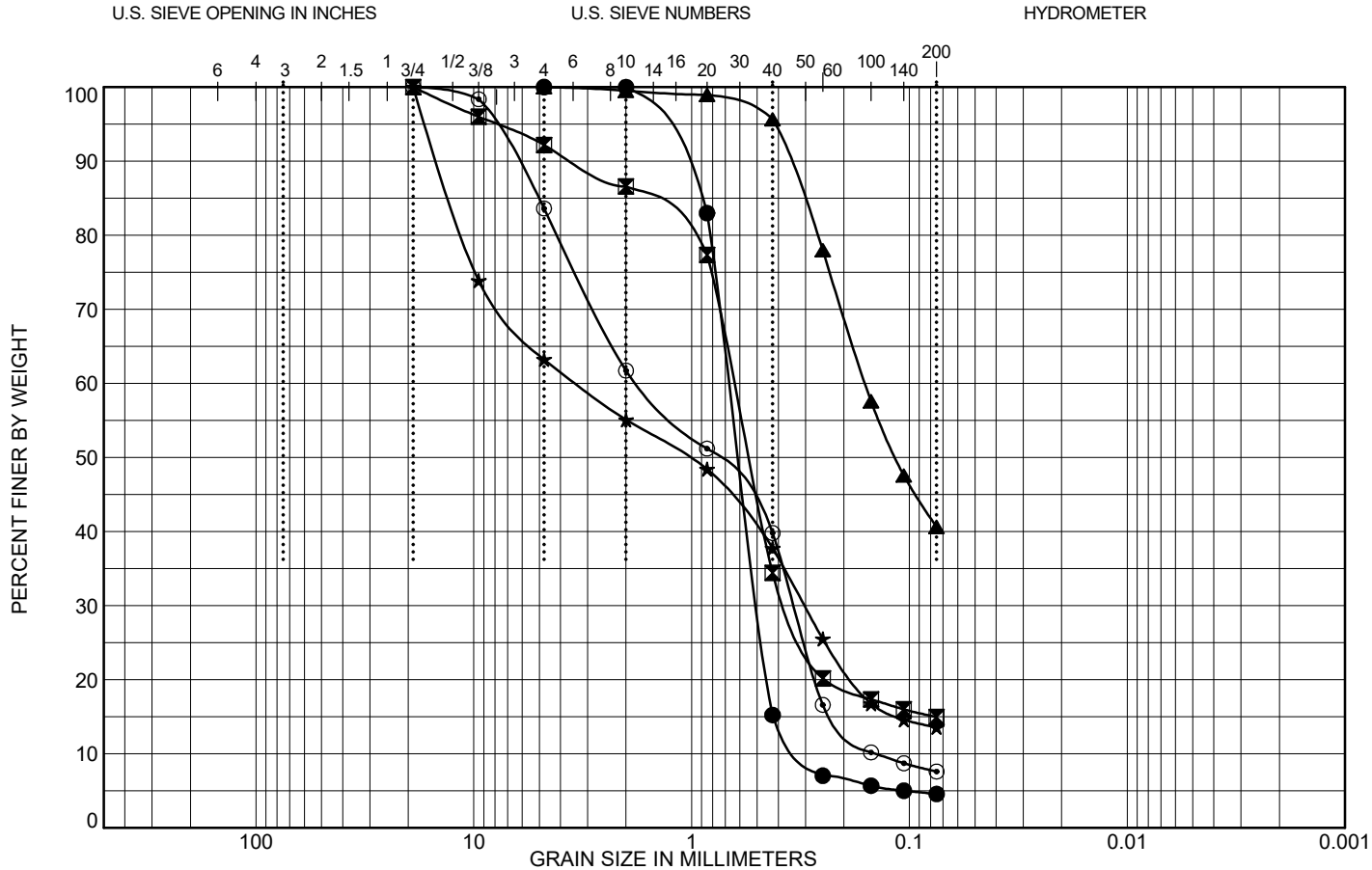
Symbol	Sample ID	Boring	Depth	Natural Moisture Content, %	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index	Soil Classification
◆	ST-1	King-BR-	20-22	18	n/a	n/a	n/a	n/a	Silty SAND (SM)

0% Retained on #40 Sieve  
 Dry Strength: LOW  
 Dilatancy: RAPID  
 Toughness: n/a  
 The sample was determined to be Non-Plastic



## **Grain Size Analysis Results**

T.B. GRAIN SIZE LANDSCAPE USGS AF-RO ALEXANDRIA 4TH TRACK GRU SA/LUT/2614.GDT 8/21/22



	D10	D30	D60	D100
●	0.303	0.494	0.672	4.76
⊠		0.361	0.643	19
▲			0.159	4.76
★		0.304	3.376	19
⊙	0.144	0.34	1.739	19

Test Method: ASTM D422

Tested By: CL Date: 8/26/2022

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

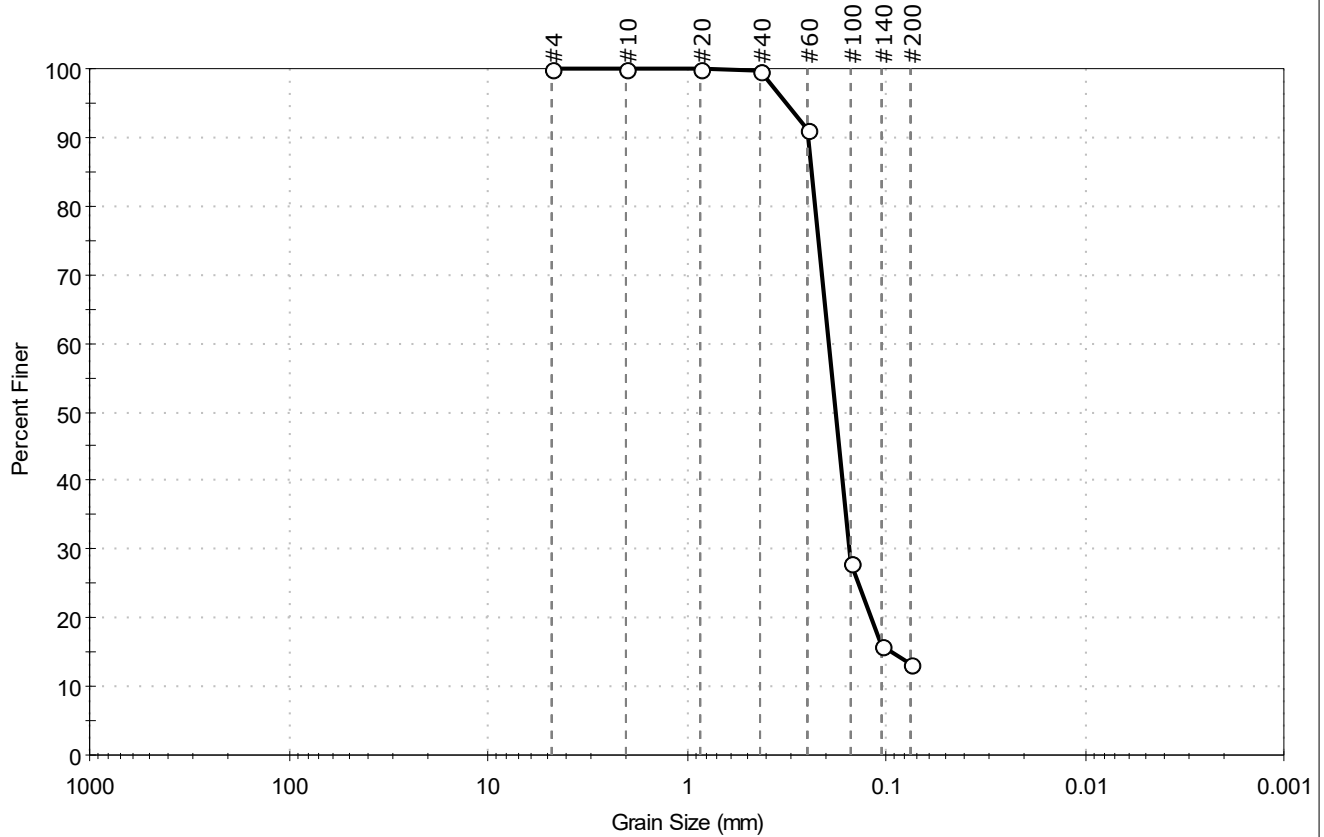
Boring	S No.	Depth	%Gravel	%Sand	%Silt	%Clay	LL	PI	MC(%)	Classification
▲ 22-CMWLTH-BR-01	SS-4	18.0 - 20.0	0.0	59.4	40.6	18	3	20.5		SILTY SAND(SM)
★ 22-CMWLTH-BR-02	SS-3	4.0 - 6.0	36.8	49.7	13.6			10.4		
⊙ 22-CMWLTH-BR-02	SS-16	63.0 - 65.0	16.4	76.0	7.6			16.7		

	<h3>GRAIN SIZE DISTRIBUTION</h3> <p>AF-RO Alexandria 4th Track</p>	<p>Alexandria, VA</p> <p>Project Number: 22-026.01</p>	<p>Sheet 1 of 5</p>
--	--	--	---------------------



Client: HDR Engineering, Inc.	Project: AF-RO Alexandria 4th Track	Location: Alexandria, VA	Project No: GTX-315798
Boring ID: 22-King-BR-01	Sample Type: tube	Tested By: ckg	Checked By: jsc
Sample ID: ST-1	Test Date: 09/22/22	Test Id: 685414	
Depth: 20-22			
Test Comment: ---			
Visual Description: Moist, yellowish brown silty sand			
Sample Comment: ---			

## Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	0.0	86.8	13.2

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
#4	4.75	100		
#10	2.00	100		
#20	0.85	100		
#40	0.42	100		
#60	0.25	91		
#100	0.15	28		
#140	0.11	16		
#200	0.075	13		

<u>Coefficients</u>	
D <sub>85</sub> = 0.2377 mm	D <sub>30</sub> = 0.1525 mm
D <sub>60</sub> = 0.1943 mm	D <sub>15</sub> = 0.0946 mm
D <sub>50</sub> = 0.1792 mm	D <sub>10</sub> = N/A
C <sub>u</sub> = N/A	C <sub>c</sub> = N/A

<u>Classification</u>	
<u>ASTM</u>	Silty SAND (SM)
<u>AASHTO</u>	Silty Gravel and Sand (A-2-4 (0))

<u>Sample/Test Description</u>
Sand/Gravel Particle Shape : ---
Sand/Gravel Hardness : ---



## **Corrosion Test Results (pH, Resistivity, Chloride, Sulfate)**

## Laboratory Testing - pH of Soil

Project Name:	<u>AF-RO Alexandria 4th Track</u>	Date:	<u>8/30/2022</u>
Project No.:	<u>22-0026.01</u>	Tested By:	<u>SM</u>
Boring No.:	<u>22-King-BR-01</u>	Method:	<u>AASHTO T289</u>
Sample No.:	<u>Composite SS-6 &amp; SS-7</u>		
Depth:	<u>28.0' - 35.0'</u>		

### Calibration Data

	Buffer used for Calibration			Re-check
	pH 4.0	pH 7.00	pH 10.0	pH 7.00
Reading	4.01	7.00	10.01	7.00
Temperature C	25.3	25.3	25.3	25.3

### pH reading for Soil

	pH	T(°C)
Trial 1	4.44	25.5
Trial 2	4.44	25.5
Trial 3	4.43	25.5
Average	<b>4.44</b>	

## Laboratory Testing - Resistivity of Soil

Project Name:	<u>AF-RO Alexandria 4th Track</u>	Date:	<u>8/30/2022</u>
Project No.:	<u>22-0026.01</u>	Tested By:	<u>SM</u>
Boring No.:	<u>22-King-BR-01</u>	Method:	<u>AASHTO T288</u>
Sample No.:	<u>Composite SS-6 &amp; SS-7</u>		
Depth:	<u>28.0' - 35.0'</u>		

	In situ condition	Saturated condition
Resistance reading	<u>2.06 kΩ</u>	<u>1.00 kΩ</u>
Sample resistivity	<u>2060 Ω-cm</u>	<u>1000 Ω-cm</u>



**CHLORIDE ION CONTENT IN SOILS**  
AASHTO T 291 - 94 (2018) (Method B)

Client: Soil and Land Use Technology, Inc.  
 Client Reference: AF to RO 4th Track 22-0026.01  
 Project No.: 2022-640-001  
 Lab ID: 2022-640-001-003

Boring No.: 22-KING-BR-01  
 Depth (ft): 28.0-35.0'  
 Sample No.: S-6/S-7  
 Description: Brown Soil  
 (- # 10 Sieve material)

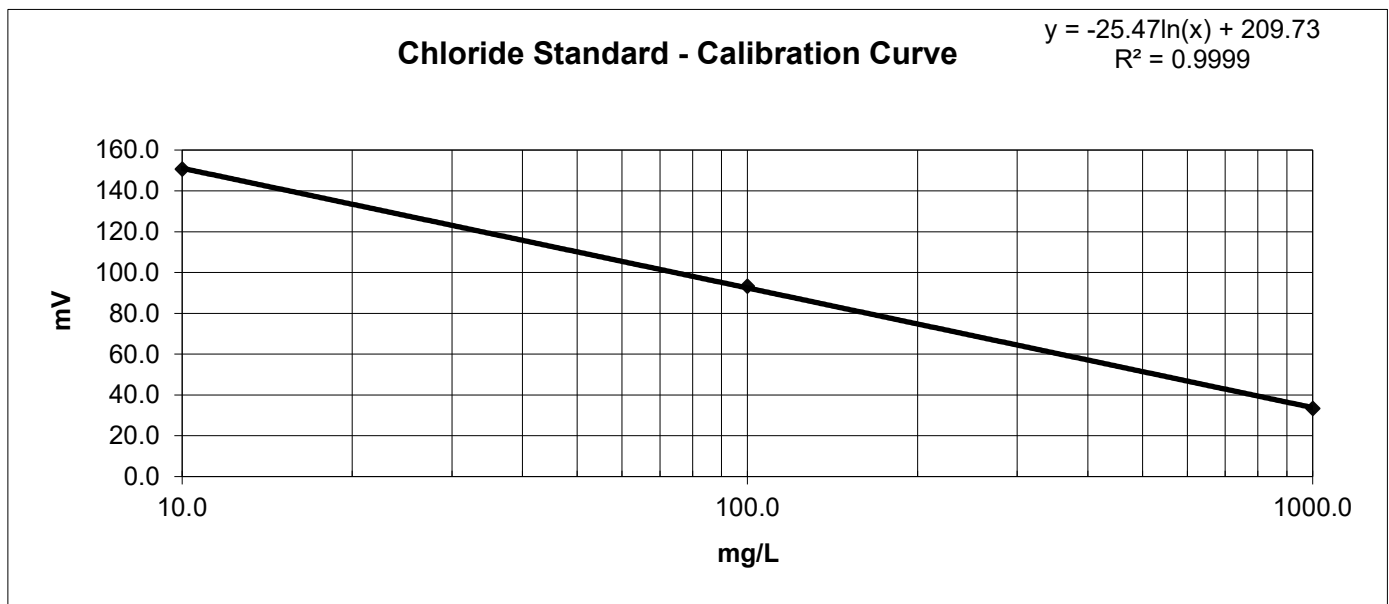
**CHLORIDE STANDARD: CALIBRATION CURVE**

STANDARD	MILLIVOLTS (mV)
10.0 mg/L	150.7
100.0 mg/L	93.2
1000.0 mg/L	33.4

**MEASUREMENT OF CHLORIDES**

Sample Weight (g):	<u>100.0</u>	CONCENTRATION	CONCENTRATION
Water added to Sample (ml):	<u>100.0</u>	(mg/L)	(mg/kg)
Size of Sample Aliquot (ml):	<u>25.0</u>		
Sample Reading (mV):	<u>139.9</u>	15.51	15.51

Notes: 1) Samples and standards were buffered by the addition of an equal volume of the 0.2 M KNO<sub>3</sub> solution (1:1 volume).  
 2) Samples were dried for a minimum of 12 hours at 110 ± 5°C.



Notes:

Tested By JAM Date 9/14/22 Checked By BRB Date 9/20/22

## Water-Soluble Sulfate Ion Content in Soil AASHTO T 290-95 (2020)

Client:	Soil and Land Use Technology, Inc.	Boring No.:	22-KING-BR-01
Client Reference:	AF to RO 4th Track 22-0026.01	Depth (ft):	28.0-35.0'
Project No.:	2022-640-001	Sample No.:	S-6/S-7
Lab ID:	2022-640-001-003	Soil Description:	Brown Soil

### Sulfate Standard - Calibration Curve Spectrophotometer Readings

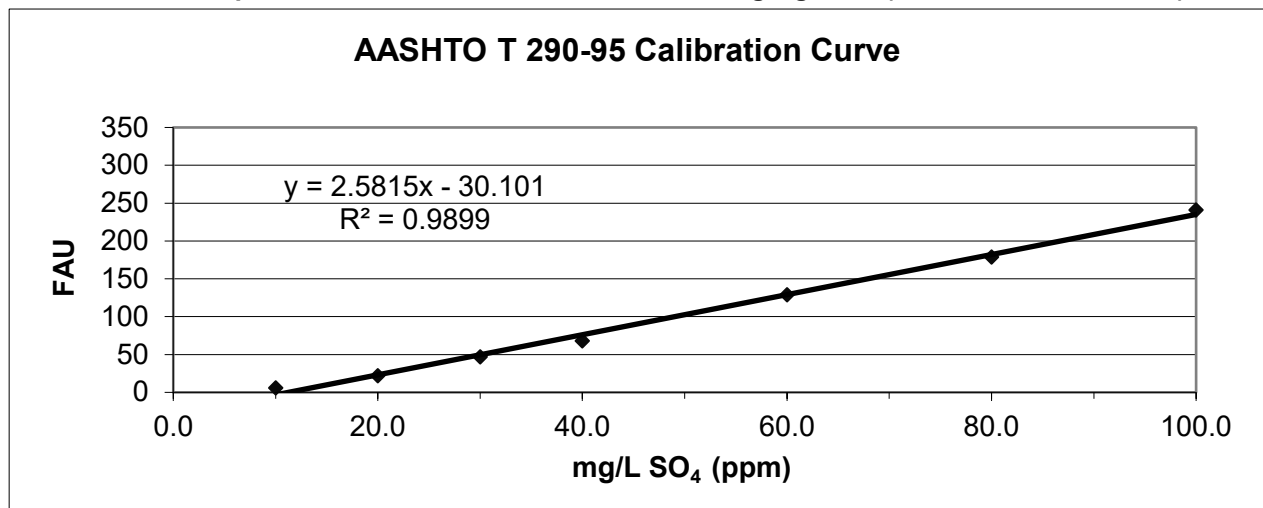
<u>Sulfate Ion Concentrations (mg/L)</u>									
0.0	4.0	10.0	20.0	30.0	40.0	60.0	80.0	100.0	
<u>Spectrophotometer Readings (FAU)</u>									
Underrange	Underrange	6	22	47	68	129	179	241	

### Measurement of Barium Chloride Turbidity

(Sample contains 5.0 mL NaCl solution and 0.3 g BaCl<sub>2</sub>·2H<sub>2</sub>O)

<b>Sample Weight (g):</b> 100.0	<u>Sample Moisture Content</u>
<b>Water added to Sample (mL):</b> 300.0	Tare Number: 893
<b>Size of Sample Aliquot (mL):</b> 50.0	Weight of Tare & Wet Sample (g): 198.39
<b>Sample Reading (FAU):</b> 22	Weight of Tare & Dry Sample (g): 196.77
	Weight of Tare (g): 110.43
<b>Sample Diluted:</b> No	Weight of Water (g): 1.62
	Weight of Dry Sample (g): 86.34
	Moisture Content (%): 1.88
<b>Sulfate Solution Added (ml):</b> 0	

<b>Sample Sulfate Ion Concentration:</b> 20.18	<b>mg/L SO<sub>4</sub> (ppm)</b>	
<b>Sample Sulfate Ion Content:</b> 60.5	<b>mg/Kg SO<sub>4</sub> (not corrected for moisture)</b>	
<b>Sample Sulfate Ion Content:</b> 61.7	<b>mg/Kg SO<sub>4</sub> (corrected for moisture)</b>	



Tested by: JAM      Date: 9/19/22      Checked by: BRB      Date: 9/20/2022



## Shelby Tube Extraction Log



Client:	HDR Engineering, Inc.		
Project Name:	AF-RO Alexandria 4th Track		
Project Location:	Alexandria, VA		
GTX #:	315798	Tested By:	md
Test Date:	09/21/22	Checked By:	jsc

**Tube Handling with  
 Moisture Content (ASTM D2216), Density of Soil (ASTM D7263),  
 Hand-Held Torvane, and Visual Description**

Boring ID	Sample ID	Depth, ft	Section	Visual Description	Bulk Density, lb/ft <sup>3</sup>	Moisture Content, %	Dry Density, lb/ft <sup>3</sup>	Hand Held Torvane Readings, tsf			
								1	2	3	Average
22-King-BR-01	ST-1	20-22	Top	Moist, yellowish brown silty sand	128.1	16.3	110.1	0.40	0.45	0.40	0.42
			Middle	Moist, yellowish brown silty sand	121.6	18.4	102.6	0.25	0.24	0.24	0.24
			Bottom	Moist, yellowish brown silty sand	112.4	18.3	95.1	0.20	0.15	0.20	0.18

Notes: Density determined on undisturbed tube samples provided to GeoTesting Express in Shelby tubes  
 Moisture content determined by ASTM D2216 at 110° C



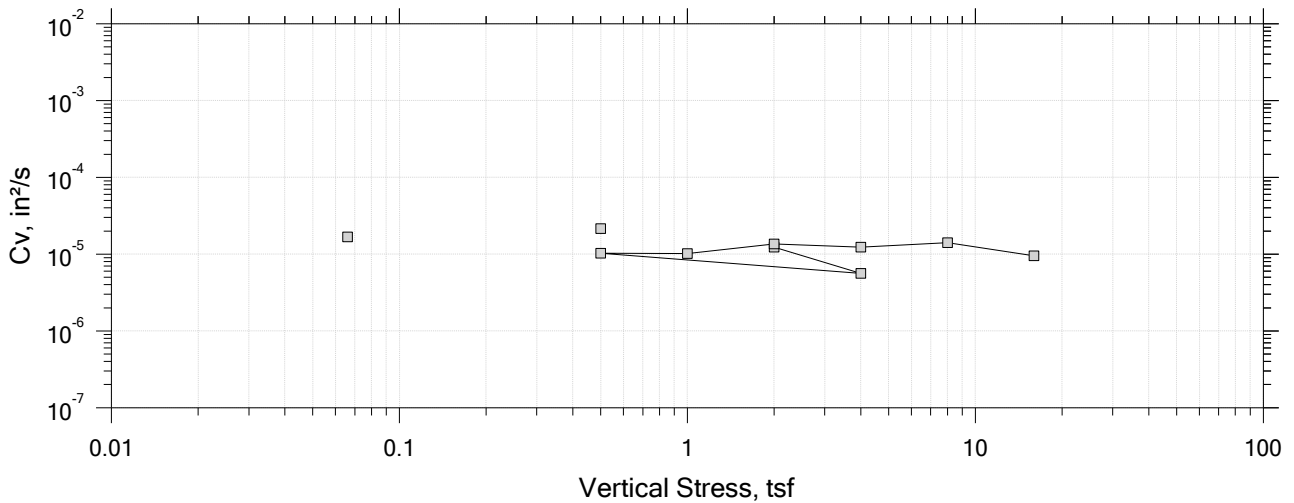
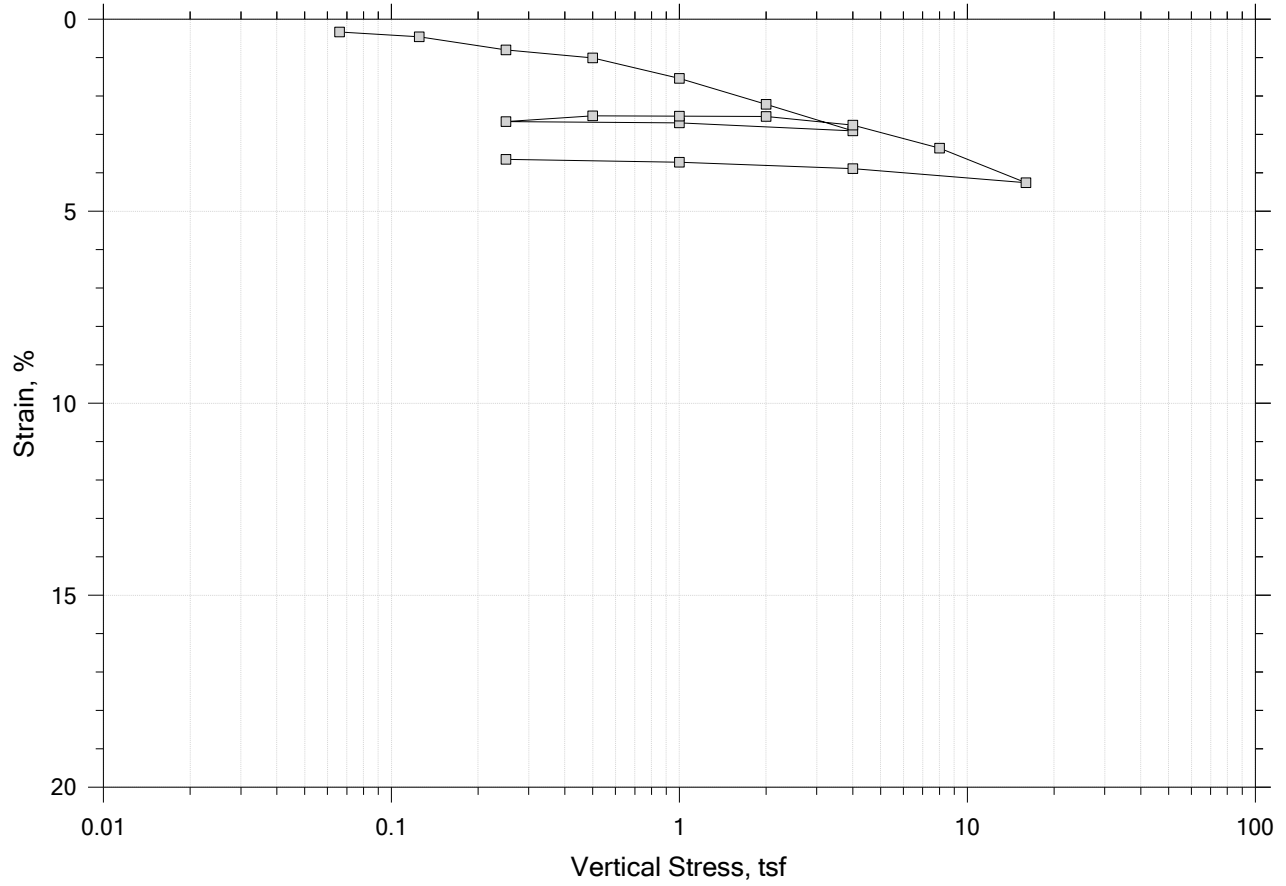
## 1-D Consolidation Results


Note, this test was assigned to understand soil compressibility along the AF to RO project corridor before King Street and Commonwealth Bridge project was identified as a separate task.

The consolidation test results included here do not show significant increase in strain for the increase in stress anticipated at depths where micropiles will be embedded. Moreover, this layer with  $N=2$  does not represent stiff overconsolidated Potomac clays (with  $N > 15$ ) where micropiles will be embedded. Also, excavation will have to be performed to at least EL5, which is much below this layer, for the installation of micropiles.

# One-Dimensional Consolidation by ASTM D2435 - Method B

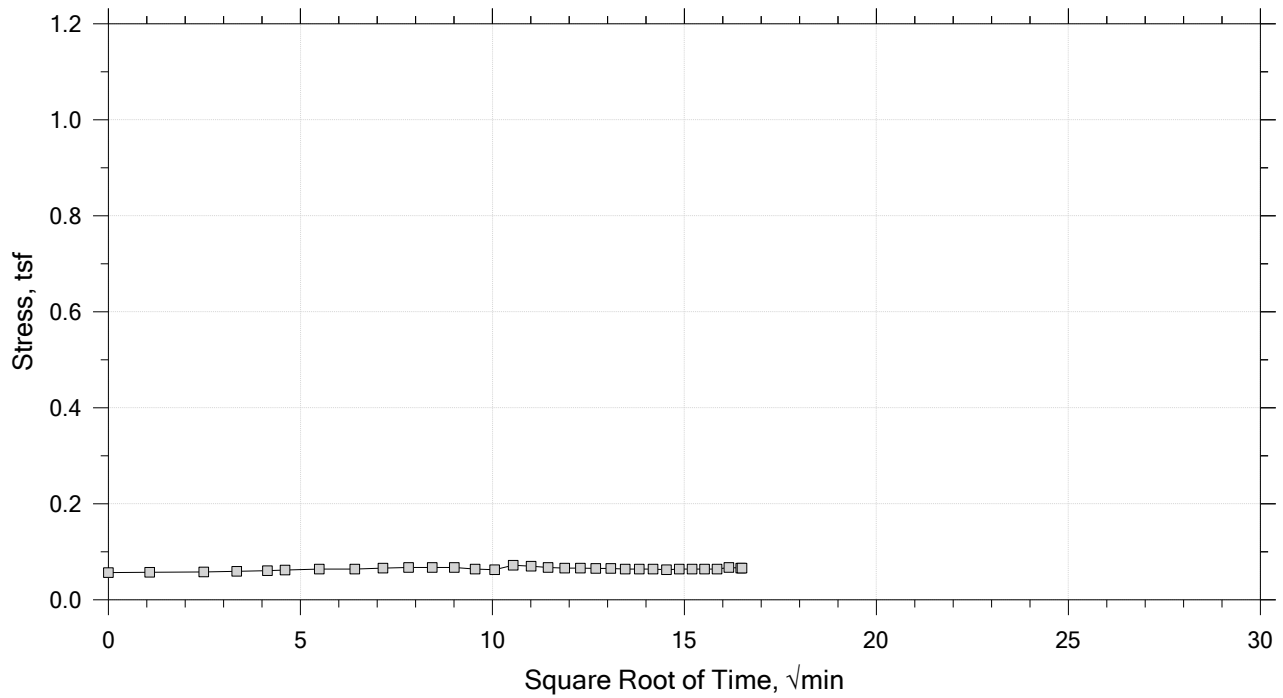
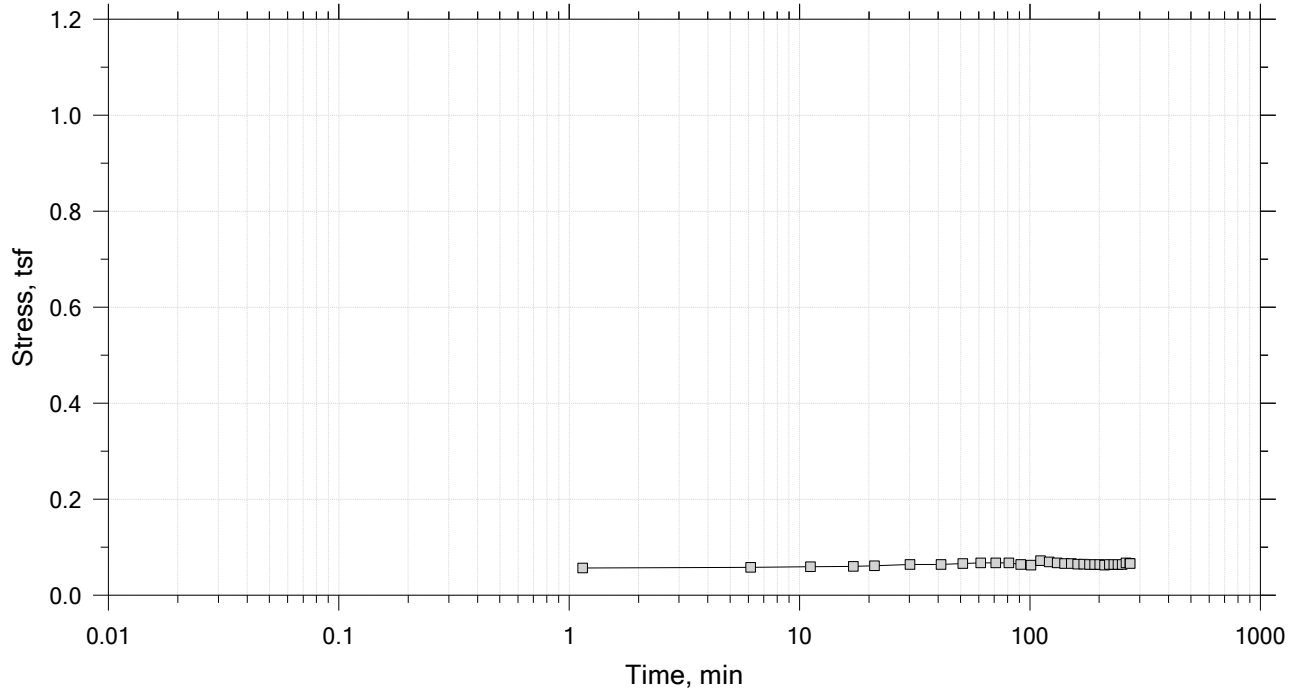
## Summary Report




	Project: AF-RO Alexandria 4th Track	Location: Alexandria, VA	Project No.: GTX-315798
	Boring No.: 22-King-BR-01	Tested By: trm	Checked By: njh
	Sample No.: ST-1	Test Date: 9/21/22	Depth: 20-22
	Test No.: IP-3	Sample Type: intact	Elevation: ---
	Description: Moist, yellowish brown silty sand		
	Remarks: System LTIII-E, Swell Pressure = 0.0661 tsf		
	Displacement at End of Increment		

# One-Dimensional Consolidation by ASTM D2435 - Method B

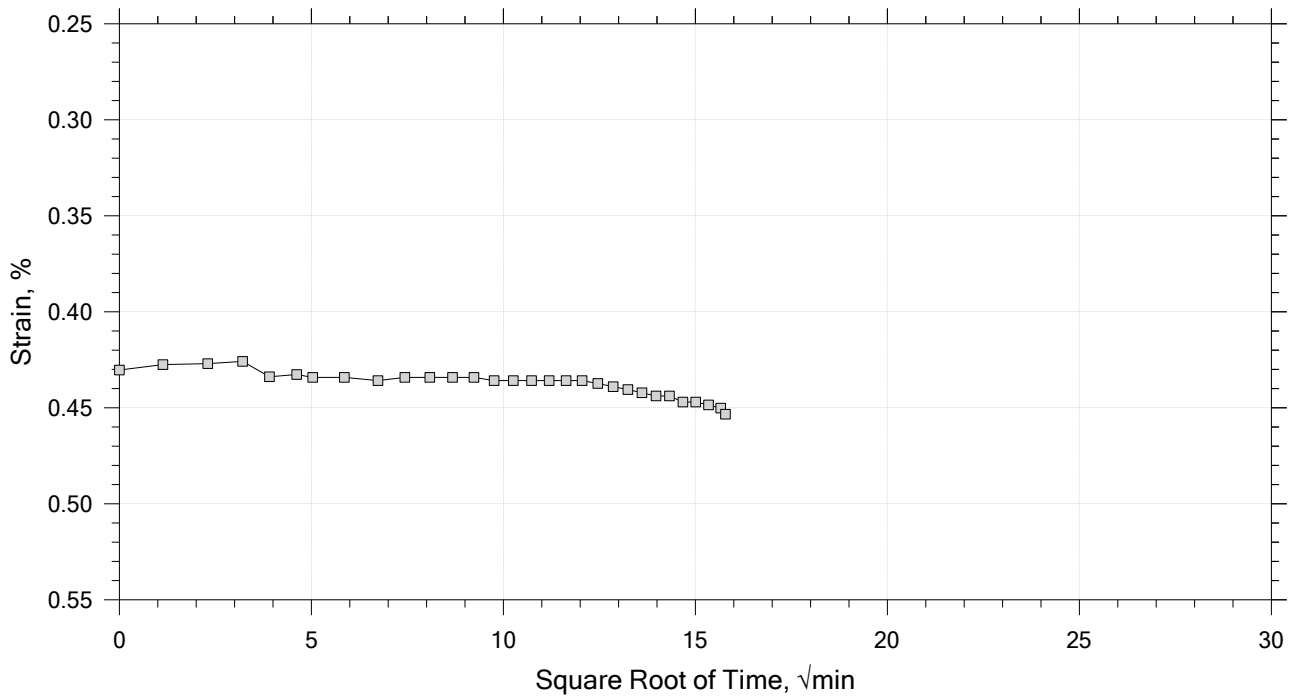
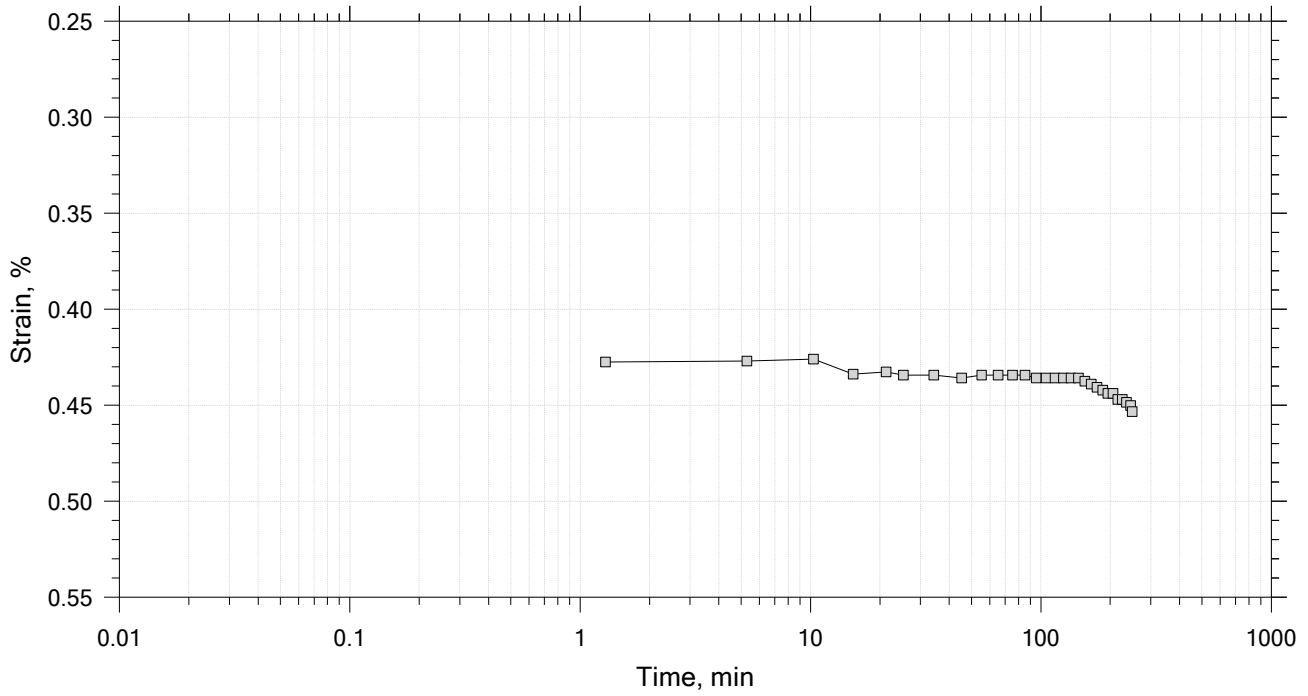
Time Curve 1 of 18  
 Constant Volume Step  
 Stress: 0.0661 tsf




	Project: AF-RO Alexandria 4th Track	Location: Alexandria, VA	Project No.: GTX-315798
	Boring No.: 22-King-BR-01	Tested By: trm	Checked By: njh
	Sample No.: ST-1	Test Date: 9/21/22	Depth: 20-22
	Test No.: IP-3	Sample Type: intact	Elevation: ---
	Description: Moist, yellowish brown silty sand		
	Remarks: System LTIII-E, Swell Pressure = 0.0661 tsf		

# One-Dimensional Consolidation by ASTM D2435 - Method B

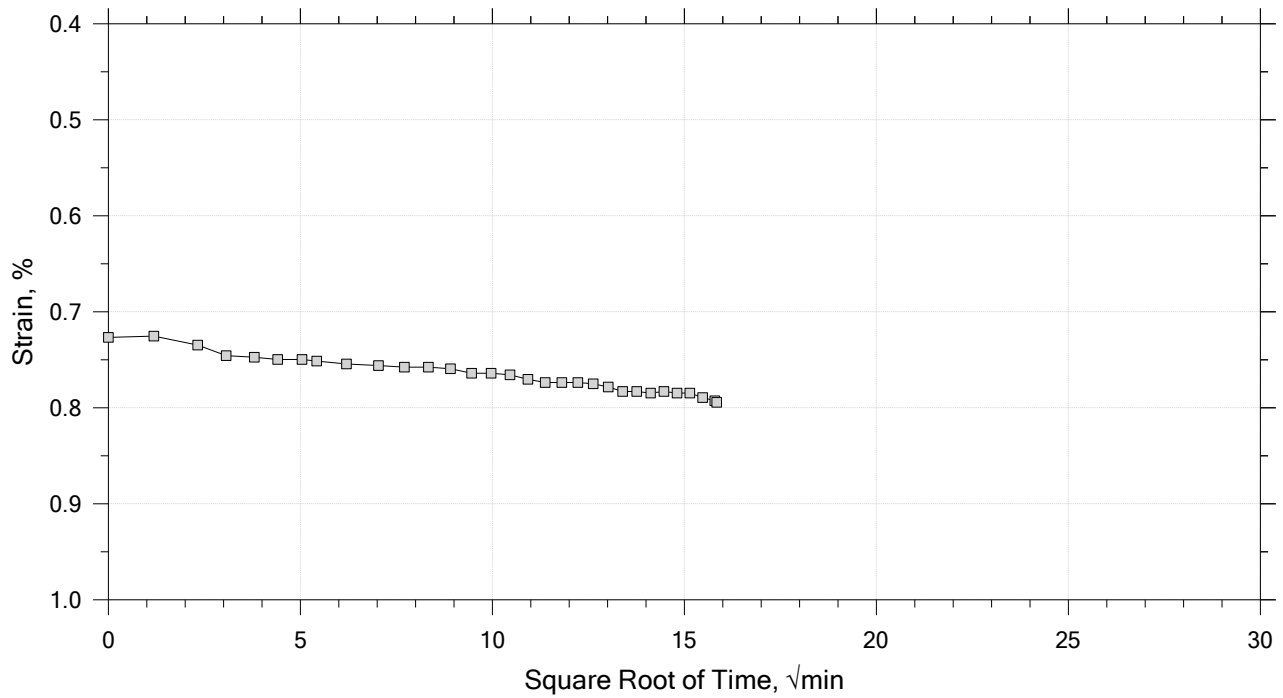
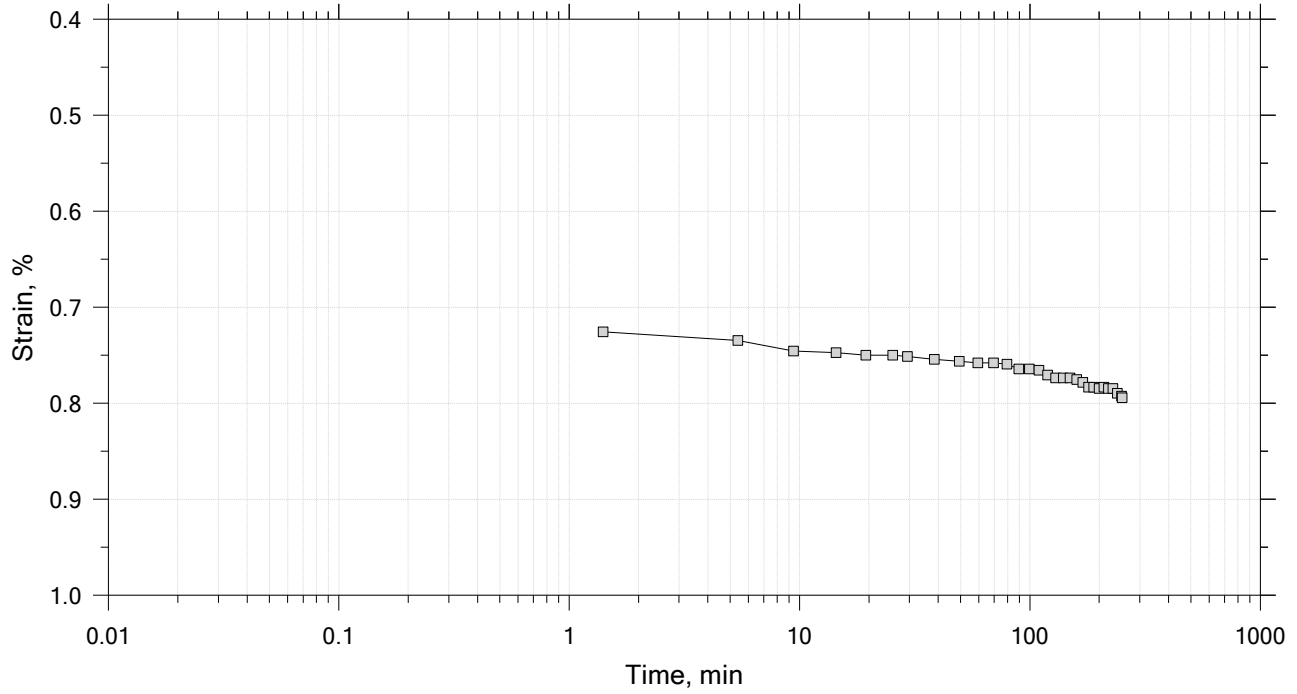
Time Curve 2 of 18  
 Constant Load Step  
 Stress: 0.125 tsf



	Project: AF-RO Alexandria 4th Track	Location: Alexandria, VA	Project No.: GTX-315798
	Boring No.: 22-King-BR-01	Tested By: trm	Checked By: njh
	Sample No.: ST-1	Test Date: 9/21/22	Depth: 20-22
	Test No.: IP-3	Sample Type: intact	Elevation: ---
	Description: Moist, yellowish brown silty sand		
	Remarks: System LTIII-E, Swell Pressure = 0.0661 tsf		

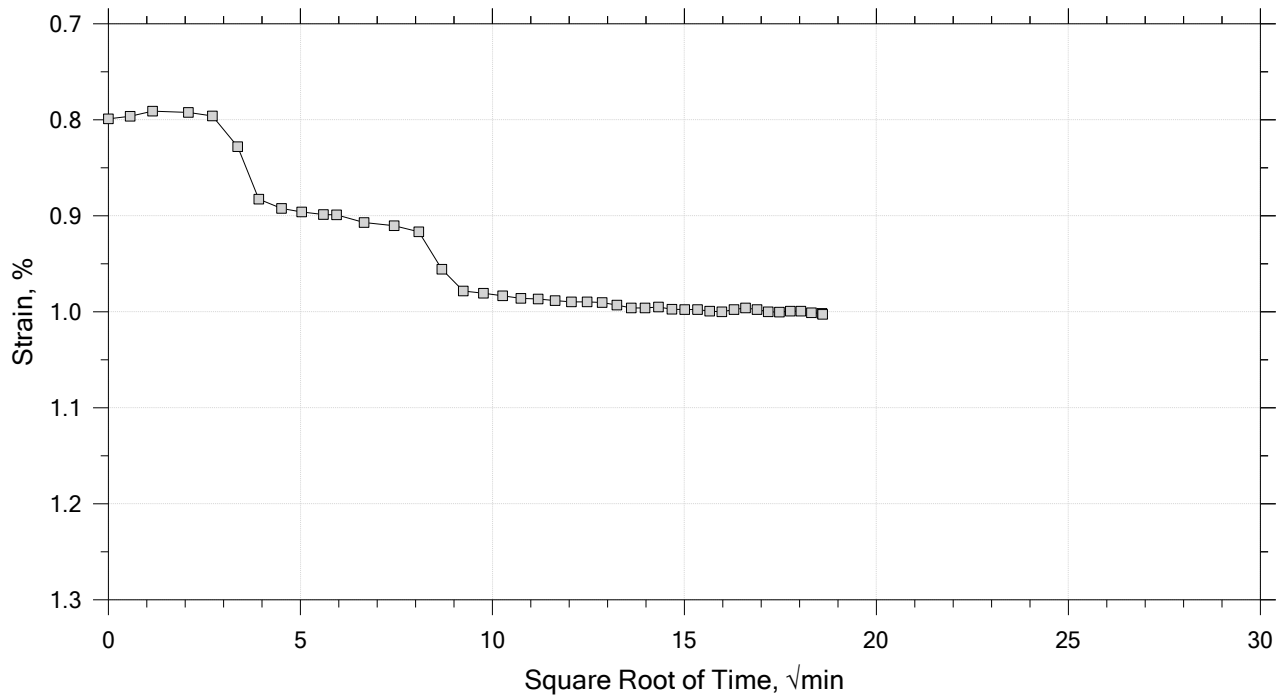
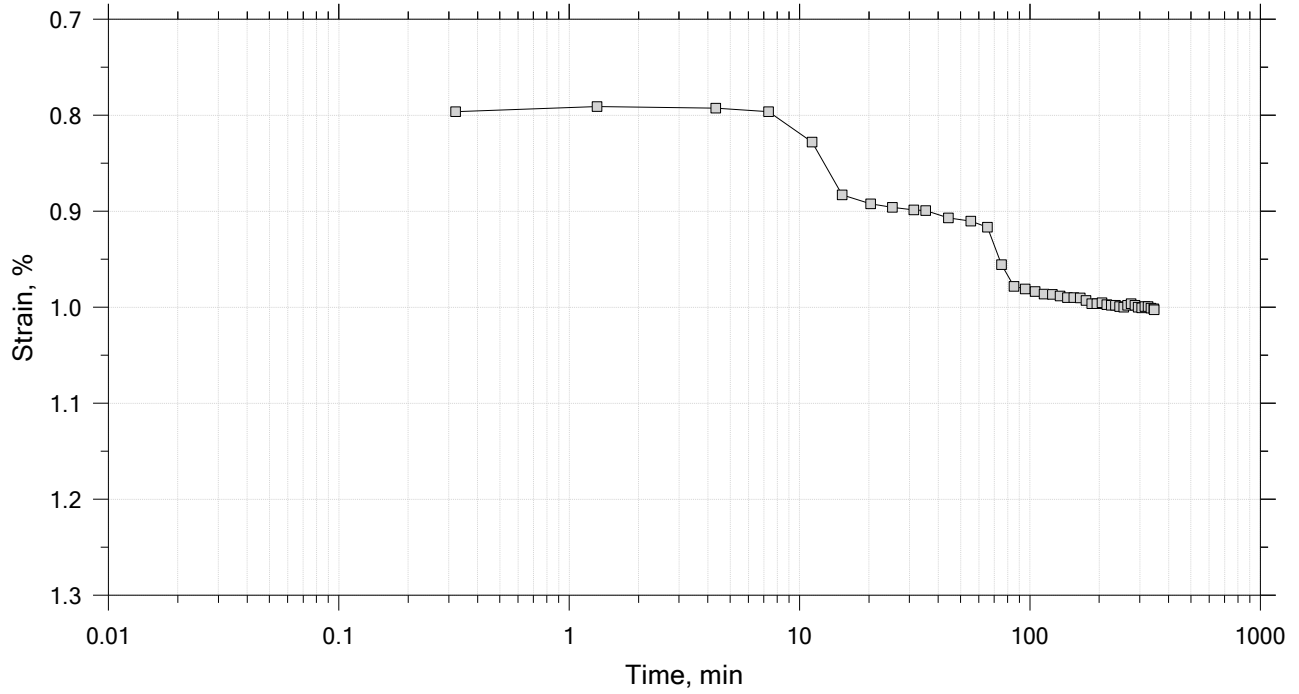
# One-Dimensional Consolidation by ASTM D2435 - Method B


Time Curve 3 of 18  
 Constant Load Step  
 Stress: 0.25 tsf



# One-Dimensional Consolidation by ASTM D2435 - Method B

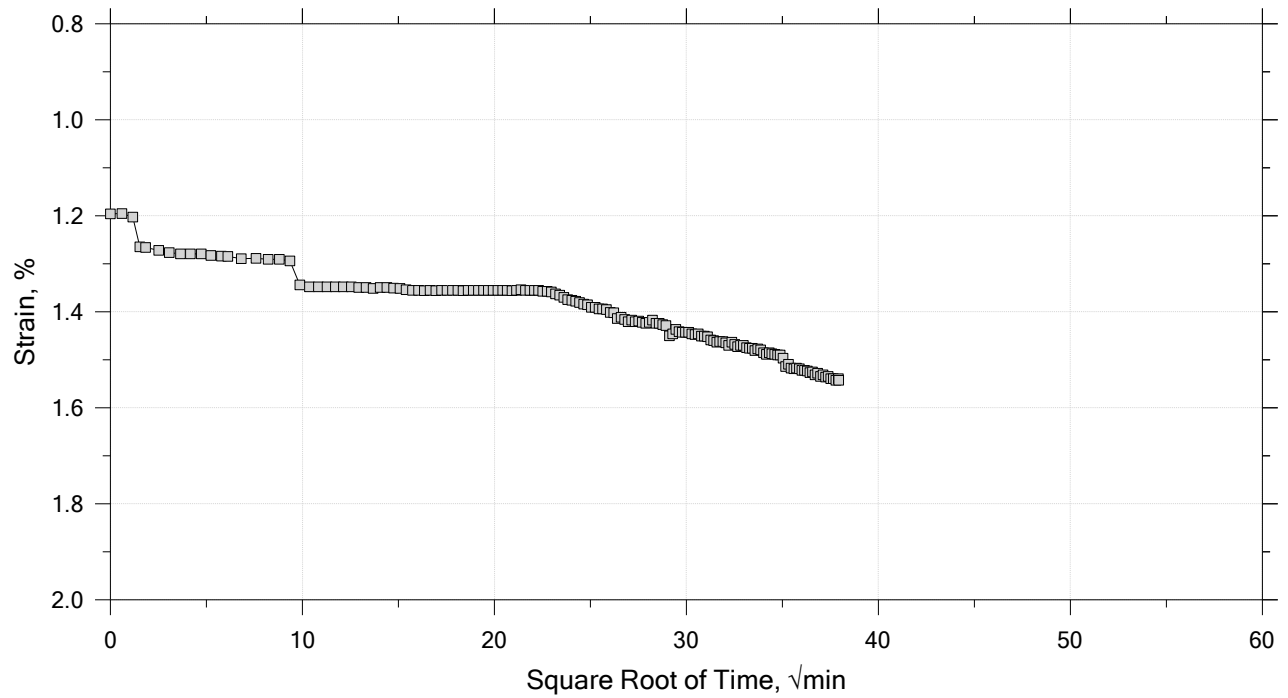
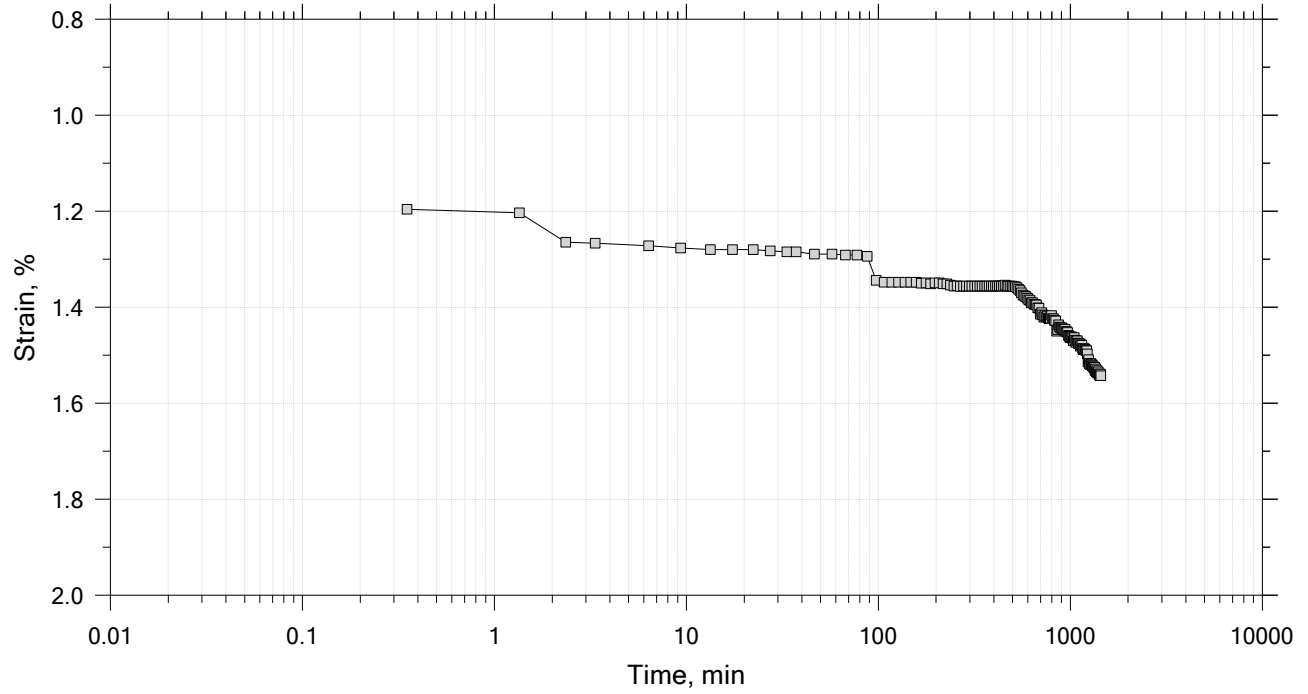
Time Curve 4 of 18  
 Constant Load Step  
 Stress: 0.5 tsf




	Project: AF-RO Alexandria 4th Track	Location: Alexandria, VA	Project No.: GTX-315798
	Boring No.: 22-King-BR-01	Tested By: trm	Checked By: njh
	Sample No.: ST-1	Test Date: 9/21/22	Depth: 20-22
	Test No.: IP-3	Sample Type: intact	Elevation: ---
	Description: Moist, yellowish brown silty sand		
	Remarks: System LTIII-E, Swell Pressure = 0.0661 tsf		

# One-Dimensional Consolidation by ASTM D2435 - Method B

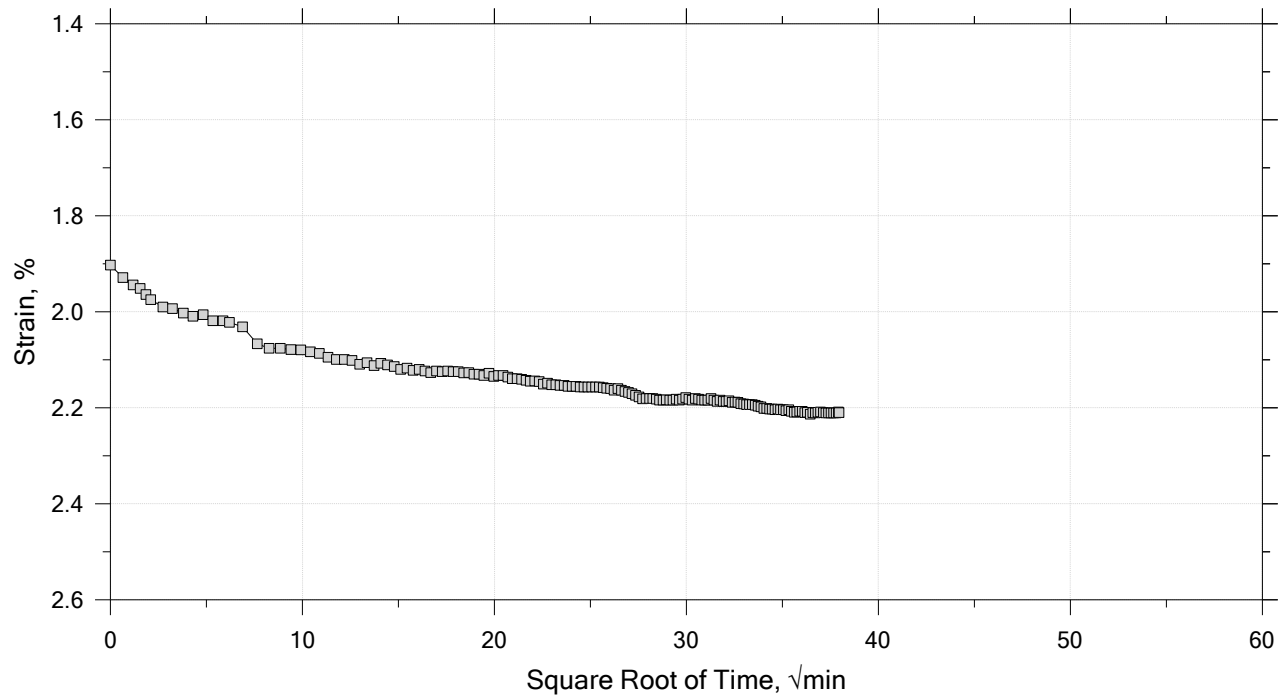
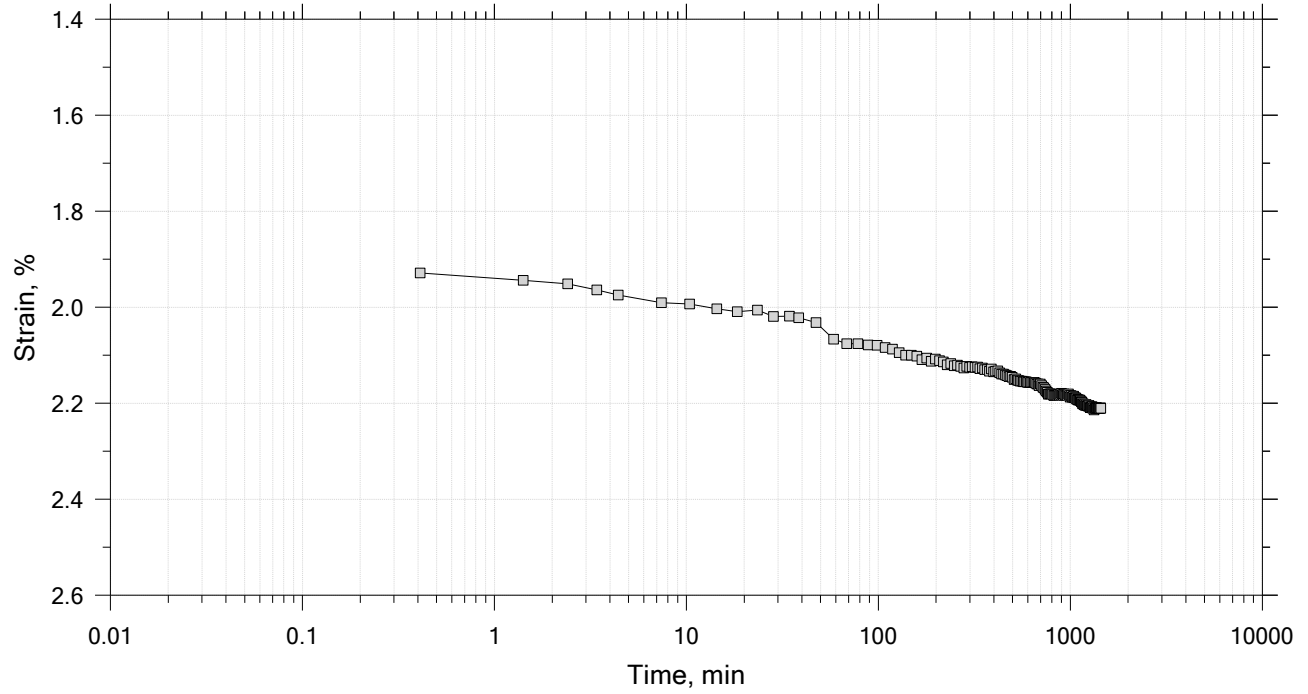
Time Curve 5 of 18  
 Constant Load Step  
 Stress: 1 tsf




	Project: AF-RO Alexandria 4th Track	Location: Alexandria, VA	Project No.: GTX-315798
	Boring No.: 22-King-BR-01	Tested By: trm	Checked By: njh
	Sample No.: ST-1	Test Date: 9/21/22	Depth: 20-22
	Test No.: IP-3	Sample Type: intact	Elevation: ---
	Description: Moist, yellowish brown silty sand		
	Remarks: System LTIII-E, Swell Pressure = 0.0661 tsf		

# One-Dimensional Consolidation by ASTM D2435 - Method B

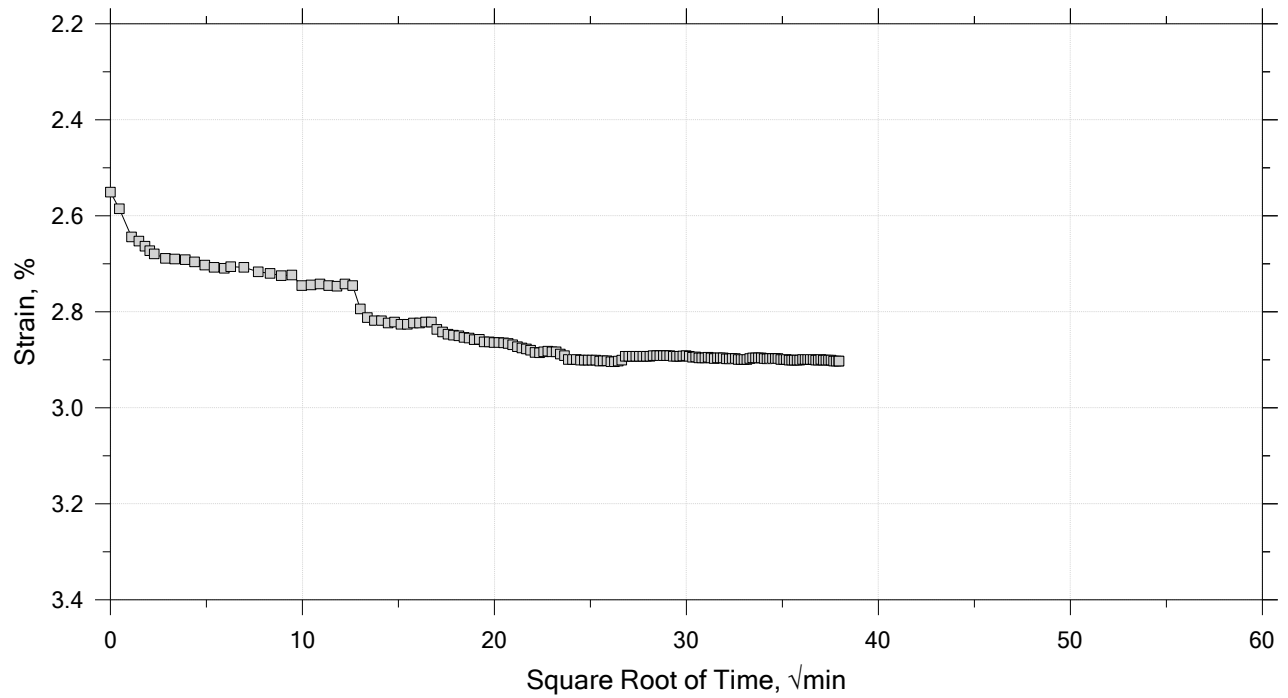
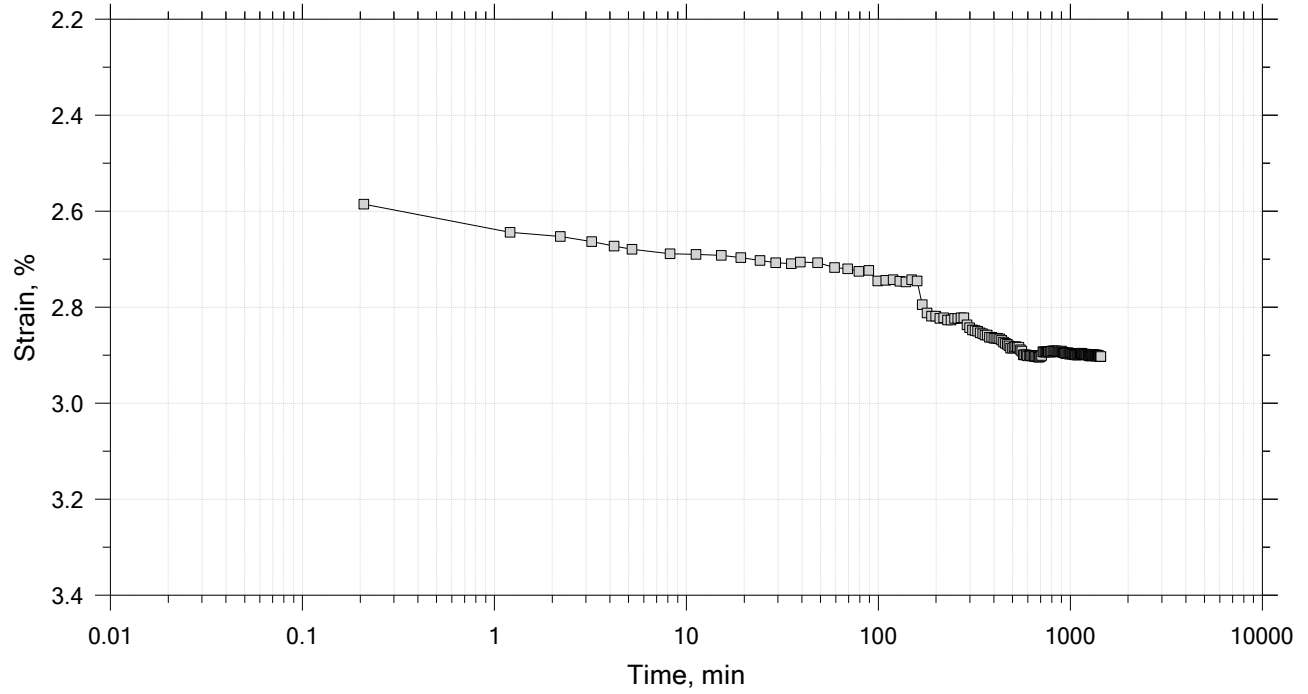
Time Curve 6 of 18  
 Constant Load Step  
 Stress: 2 tsf




	Project: AF-RO Alexandria 4th Track	Location: Alexandria, VA	Project No.: GTX-315798
	Boring No.: 22-King-BR-01	Tested By: trm	Checked By: njh
	Sample No.: ST-1	Test Date: 9/21/22	Depth: 20-22
	Test No.: IP-3	Sample Type: intact	Elevation: ---
	Description: Moist, yellowish brown silty sand		
	Remarks: System LTIII-E, Swell Pressure = 0.0661 tsf		

# One-Dimensional Consolidation by ASTM D2435 - Method B

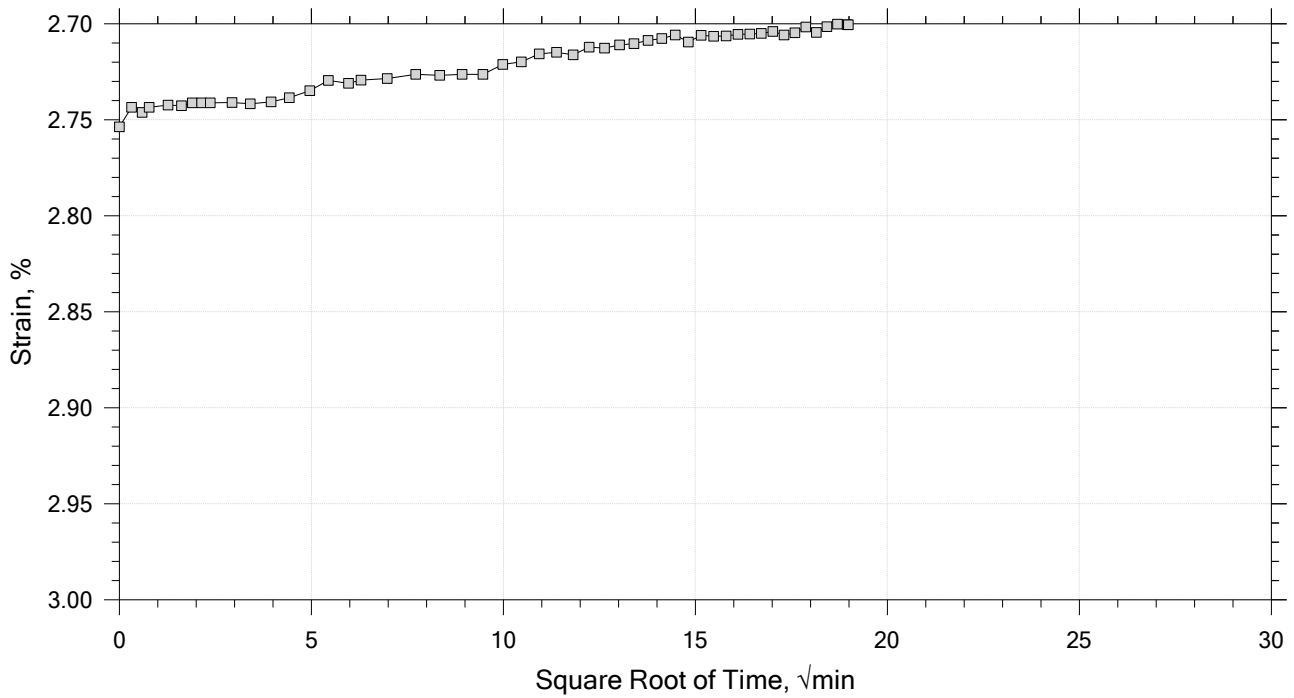
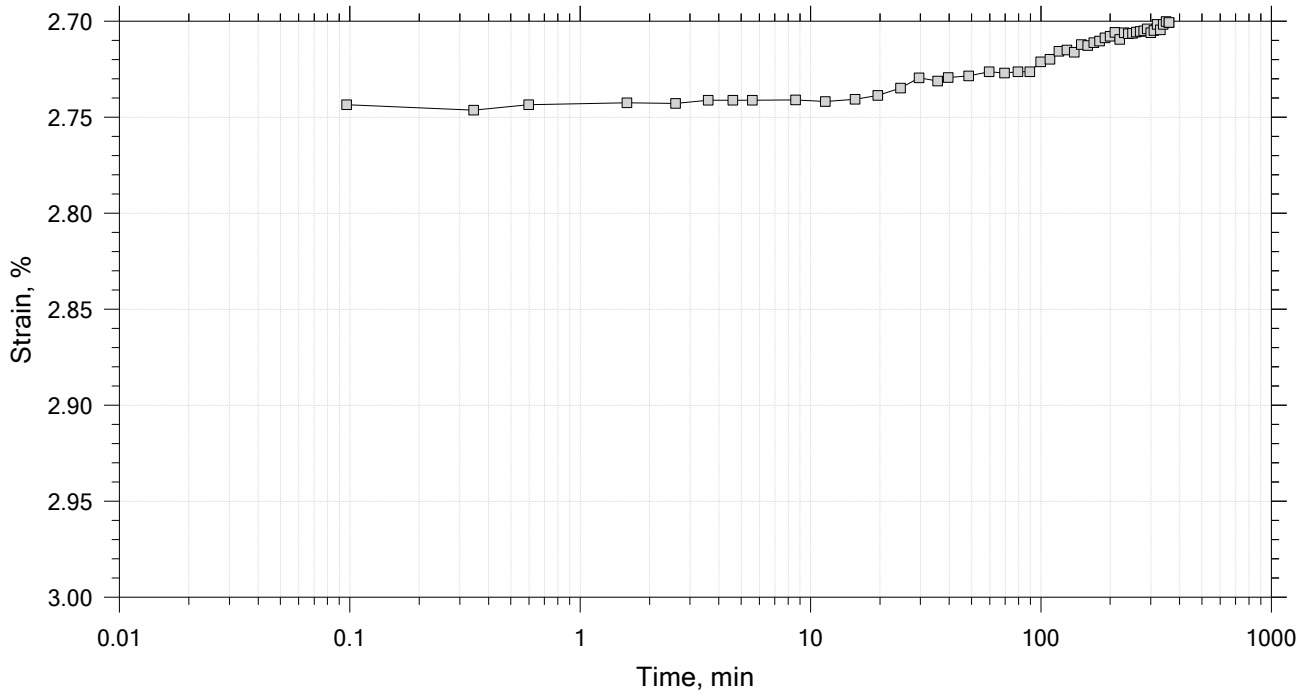
Time Curve 7 of 18  
 Constant Load Step  
 Stress: 4 tsf




	Project: AF-RO Alexandria 4th Track	Location: Alexandria, VA	Project No.: GTX-315798
	Boring No.: 22-King-BR-01	Tested By: trm	Checked By: njh
	Sample No.: ST-1	Test Date: 9/21/22	Depth: 20-22
	Test No.: IP-3	Sample Type: intact	Elevation: ---
	Description: Moist, yellowish brown silty sand		
	Remarks: System LTIII-E, Swell Pressure = 0.0661 tsf		

# One-Dimensional Consolidation by ASTM D2435 - Method B

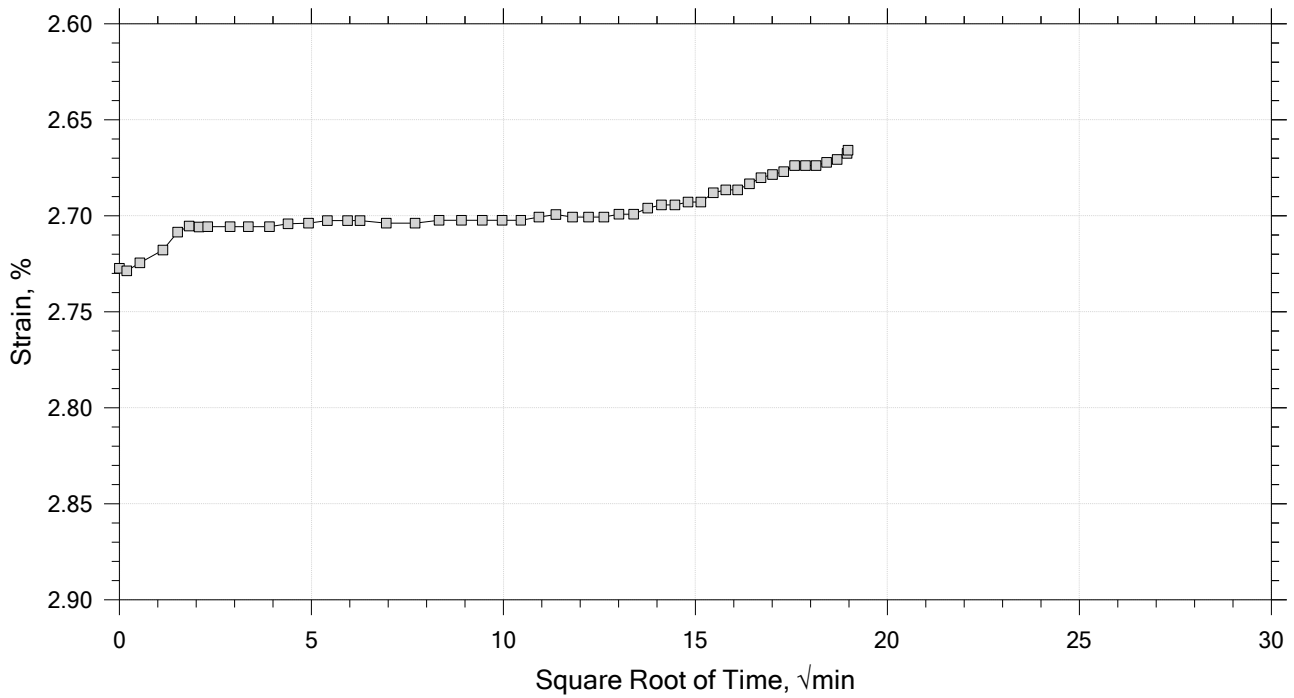
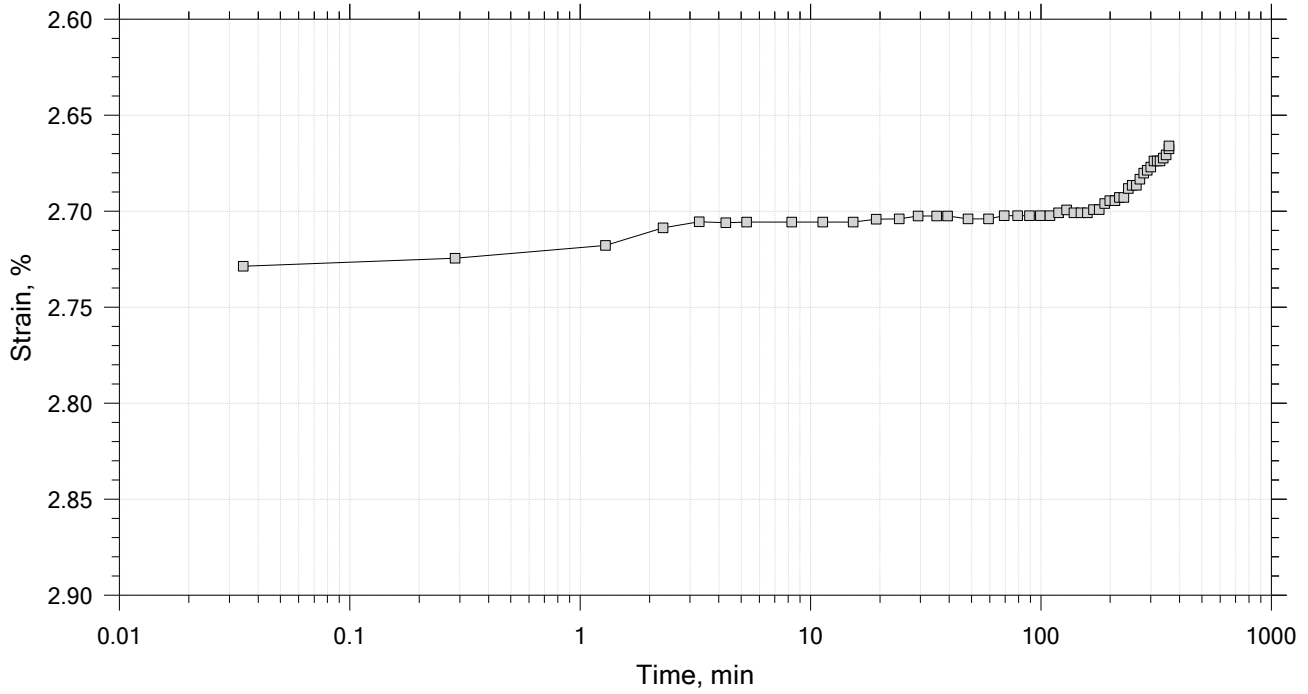
Time Curve 8 of 18  
 Constant Load Step  
 Stress: 1 tsf




	Project: AF-RO Alexandria 4th Track	Location: Alexandria, VA	Project No.: GTX-315798
	Boring No.: 22-King-BR-01	Tested By: trm	Checked By: njh
	Sample No.: ST-1	Test Date: 9/21/22	Depth: 20-22
	Test No.: IP-3	Sample Type: intact	Elevation: ---
	Description: Moist, yellowish brown silty sand		
	Remarks: System LTIII-E, Swell Pressure = 0.0661 tsf		

# One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 9 of 18  
 Constant Load Step  
 Stress: 0.25 tsf



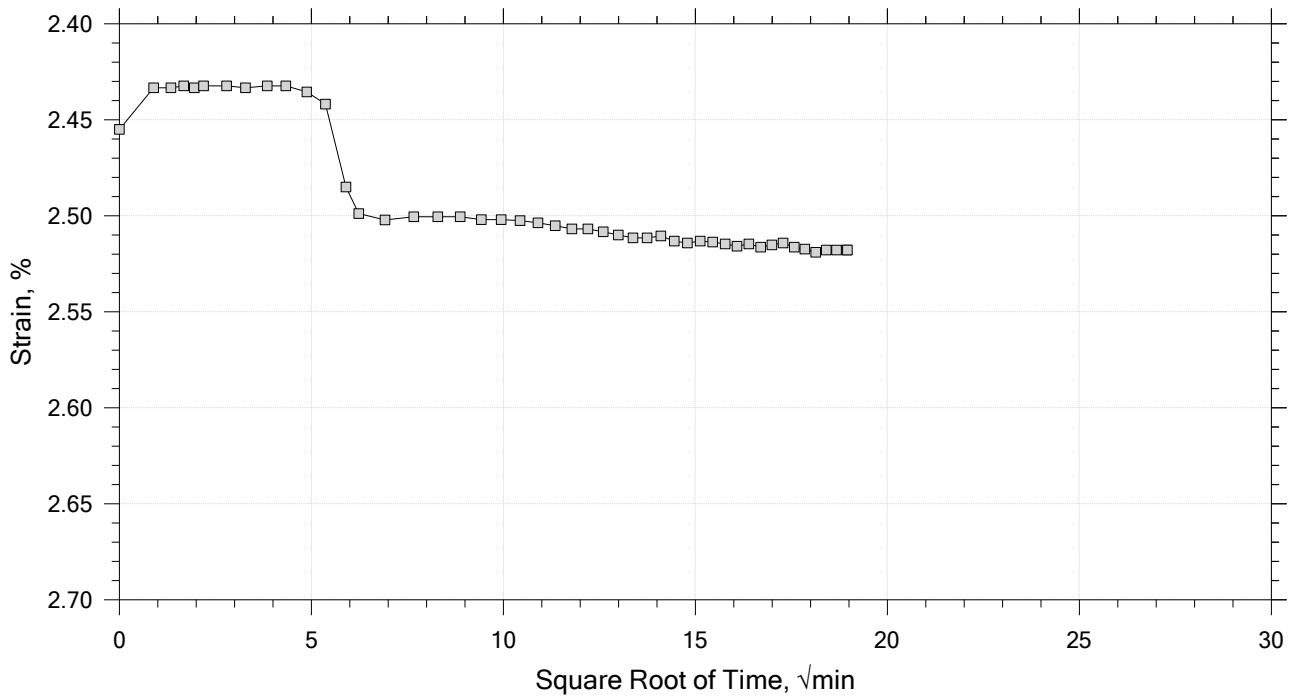
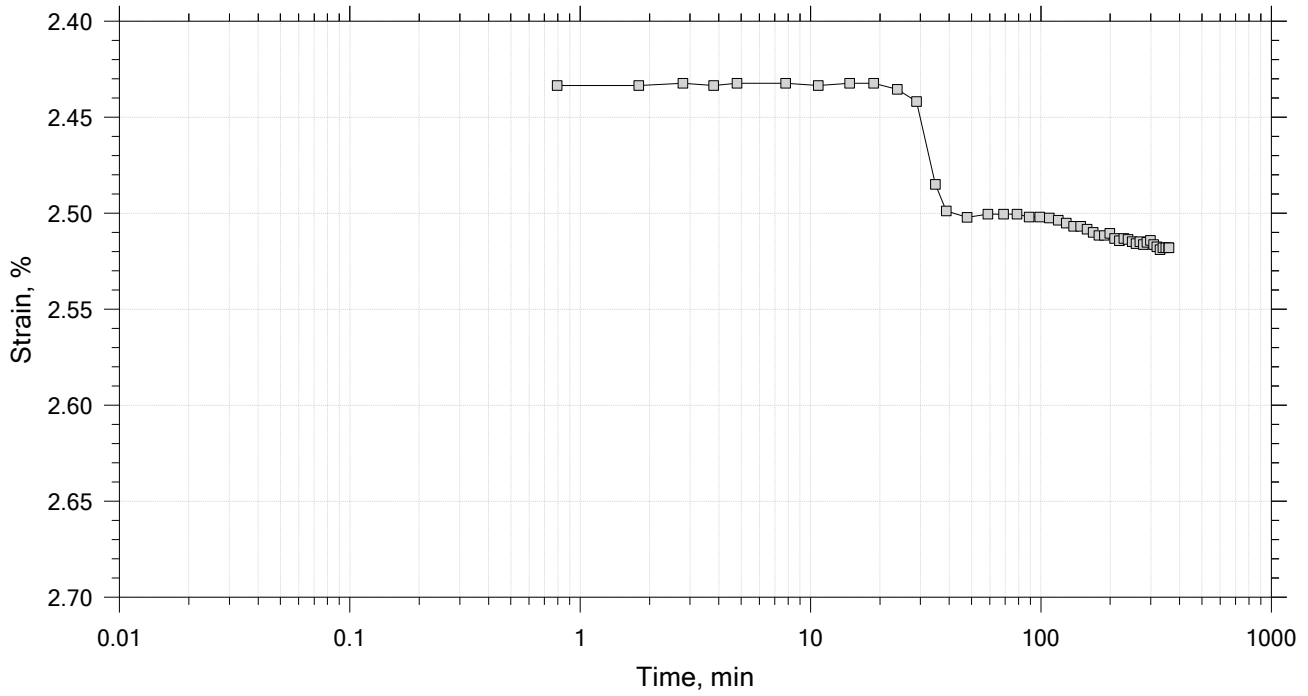
	Project: AF-RO Alexandria 4th Track	Location: Alexandria, VA	Project No.: GTX-315798
	Boring No.: 22-King-BR-01	Tested By: trm	Checked By: njh
	Sample No.: ST-1	Test Date: 9/21/22	Depth: 20-22
	Test No.: IP-3	Sample Type: intact	Elevation: ---
	Description: Moist, yellowish brown silty sand		
	Remarks: System LTIII-E, Swell Pressure = 0.0661 tsf		


# One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 10 of 18

Constant Load Step

Stress: 0.5 tsf



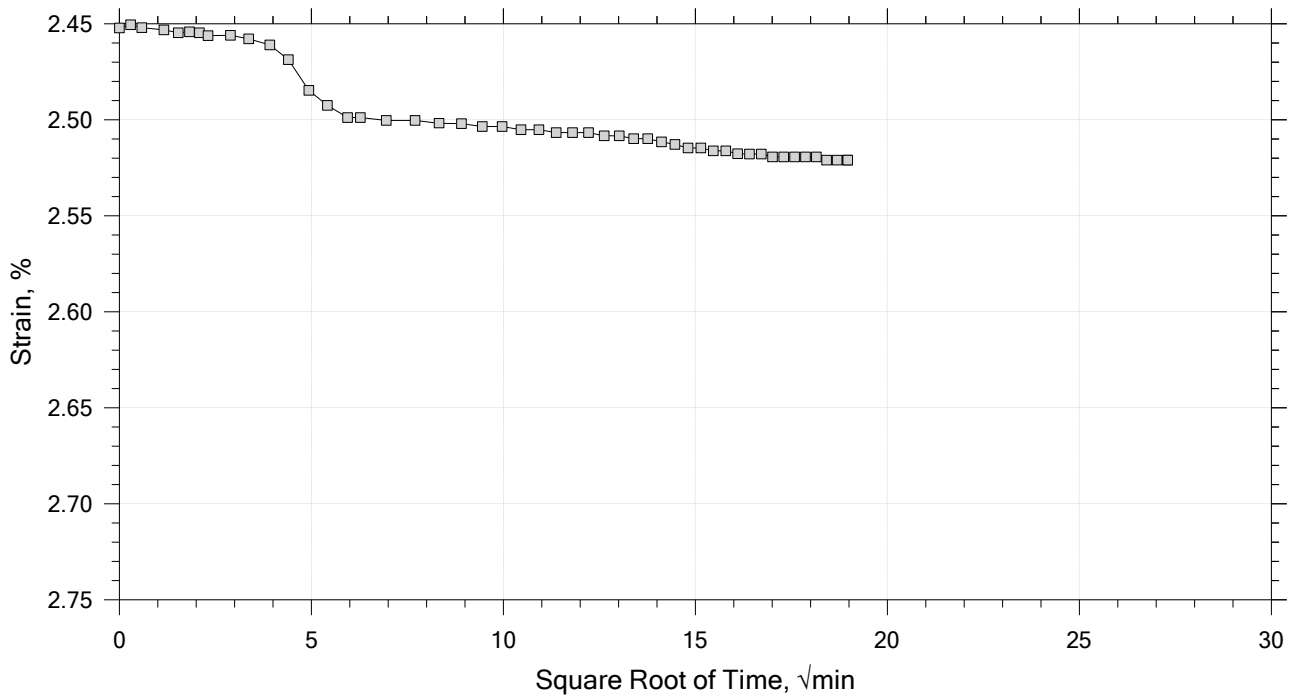
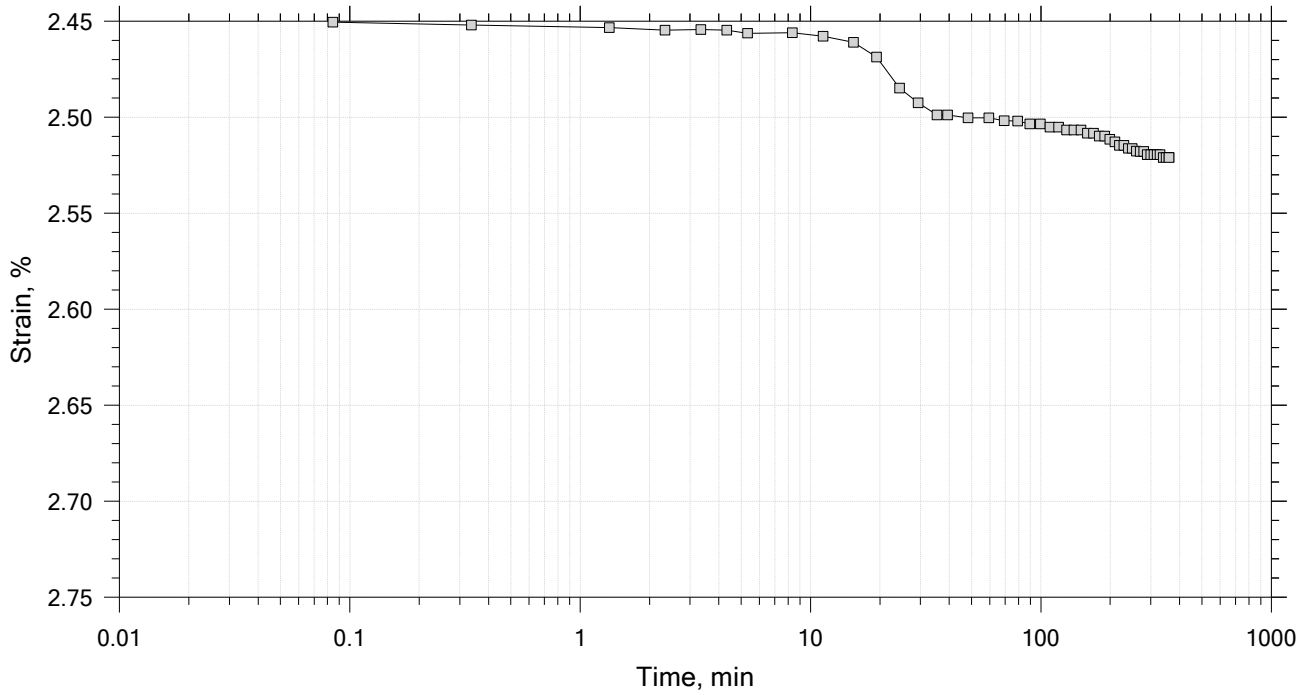
	Project: AF-RO Alexandria 4th Track	Location: Alexandria, VA	Project No.: GTX-315798
	Boring No.: 22-King-BR-01	Tested By: trm	Checked By: njh
	Sample No.: ST-1	Test Date: 9/21/22	Depth: 20-22
	Test No.: IP-3	Sample Type: intact	Elevation: ---
	Description: Moist, yellowish brown silty sand		
	Remarks: System LTIII-E, Swell Pressure = 0.0661 tsf		


# One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 11 of 18

Constant Load Step

Stress: 1 tsf



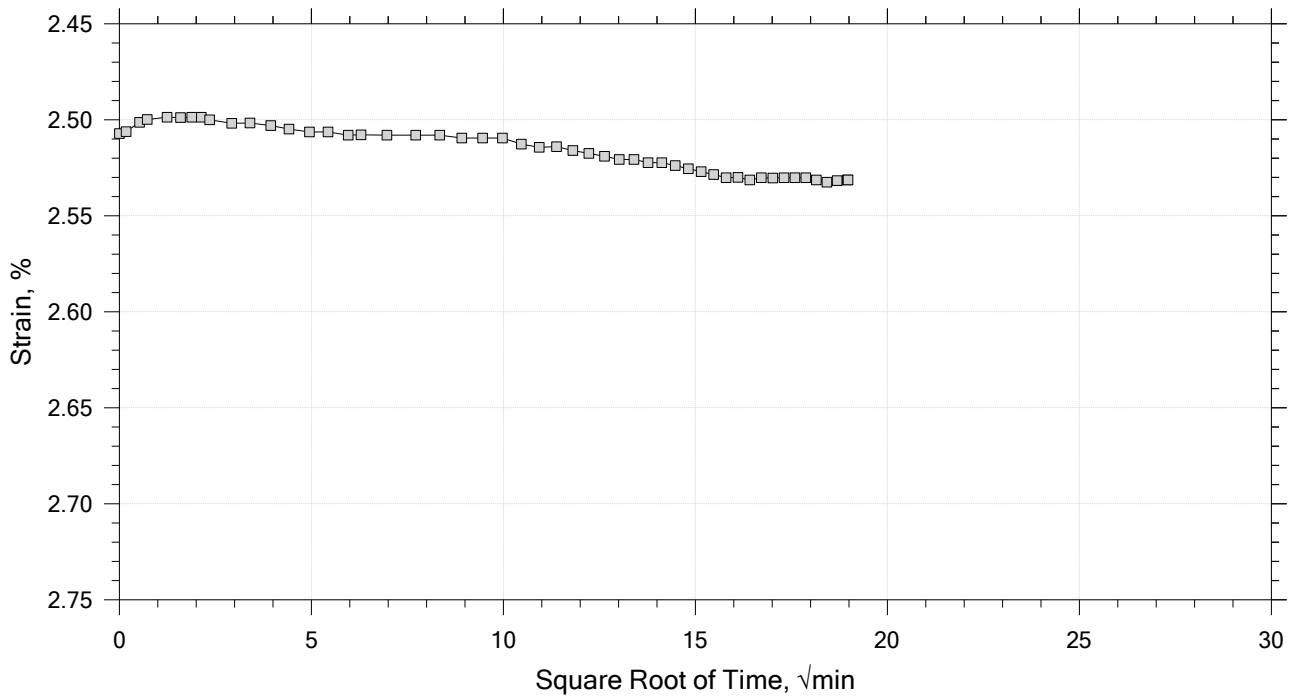
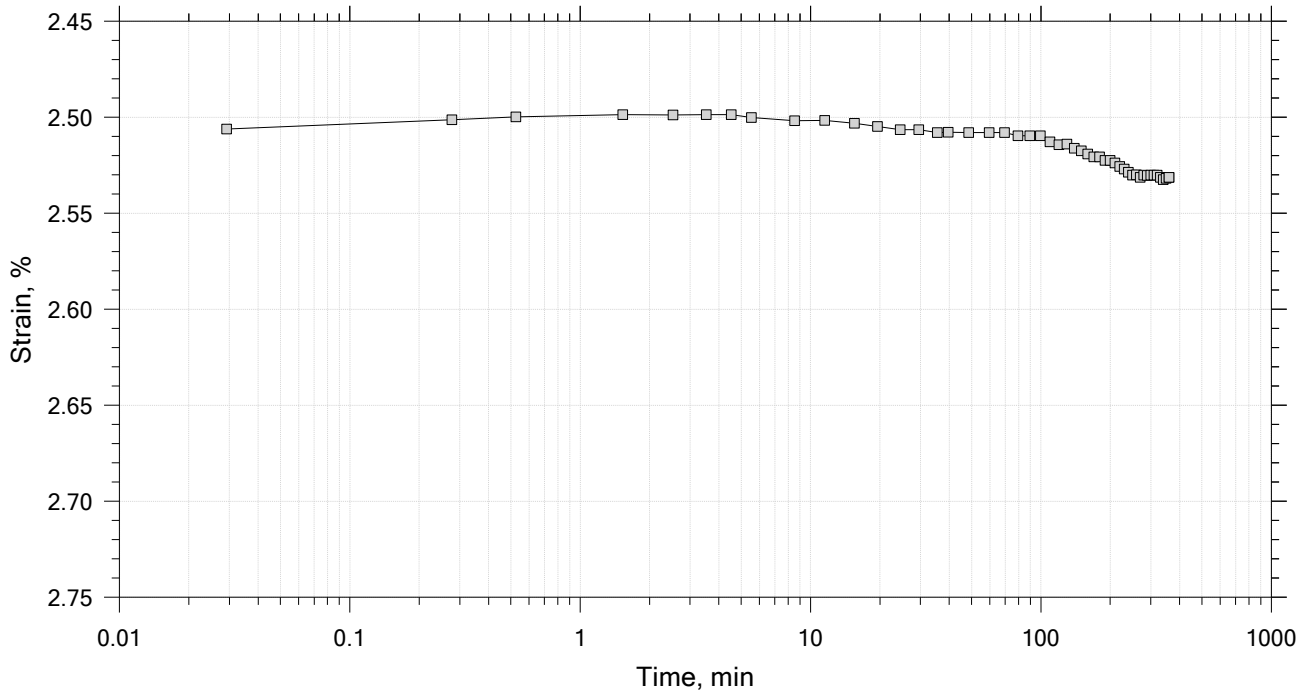
	Project: AF-RO Alexandria 4th Track	Location: Alexandria, VA	Project No.: GTX-315798
	Boring No.: 22-King-BR-01	Tested By: trm	Checked By: njh
	Sample No.: ST-1	Test Date: 9/21/22	Depth: 20-22
	Test No.: IP-3	Sample Type: intact	Elevation: ---
	Description: Moist, yellowish brown silty sand		
	Remarks: System LTIII-E, Swell Pressure = 0.0661 tsf		


# One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 12 of 18

Constant Load Step

Stress: 2 tsf



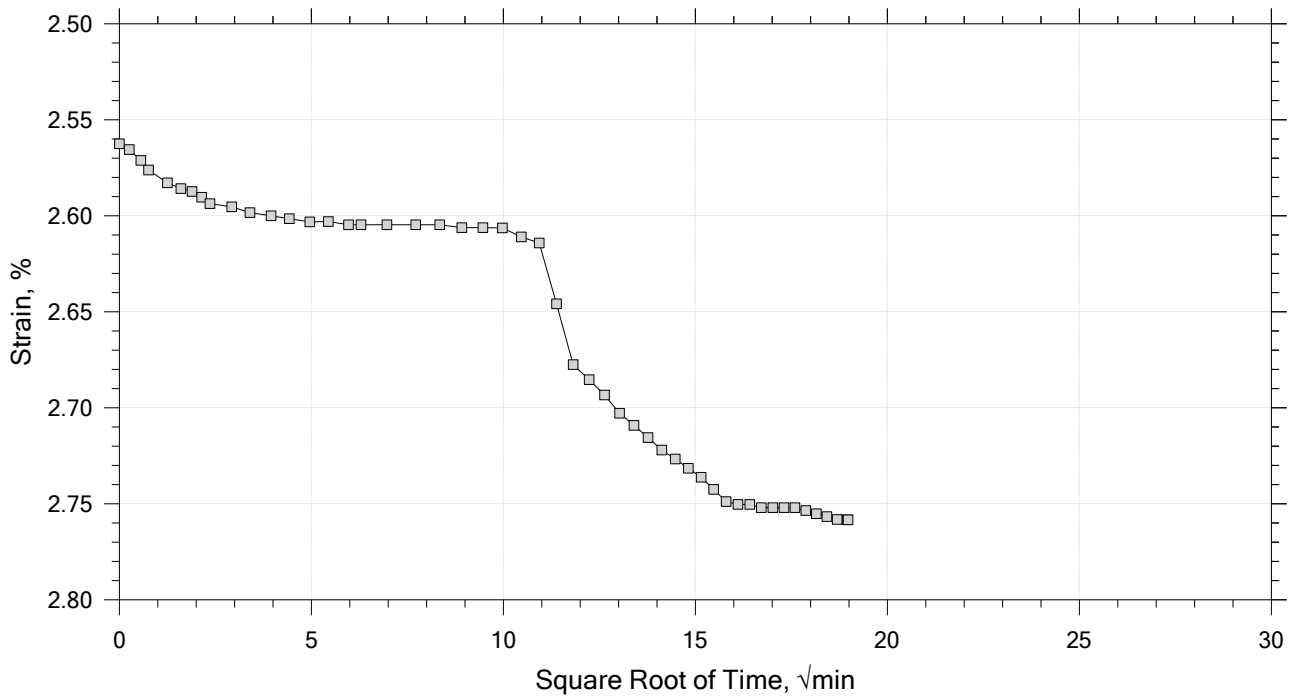
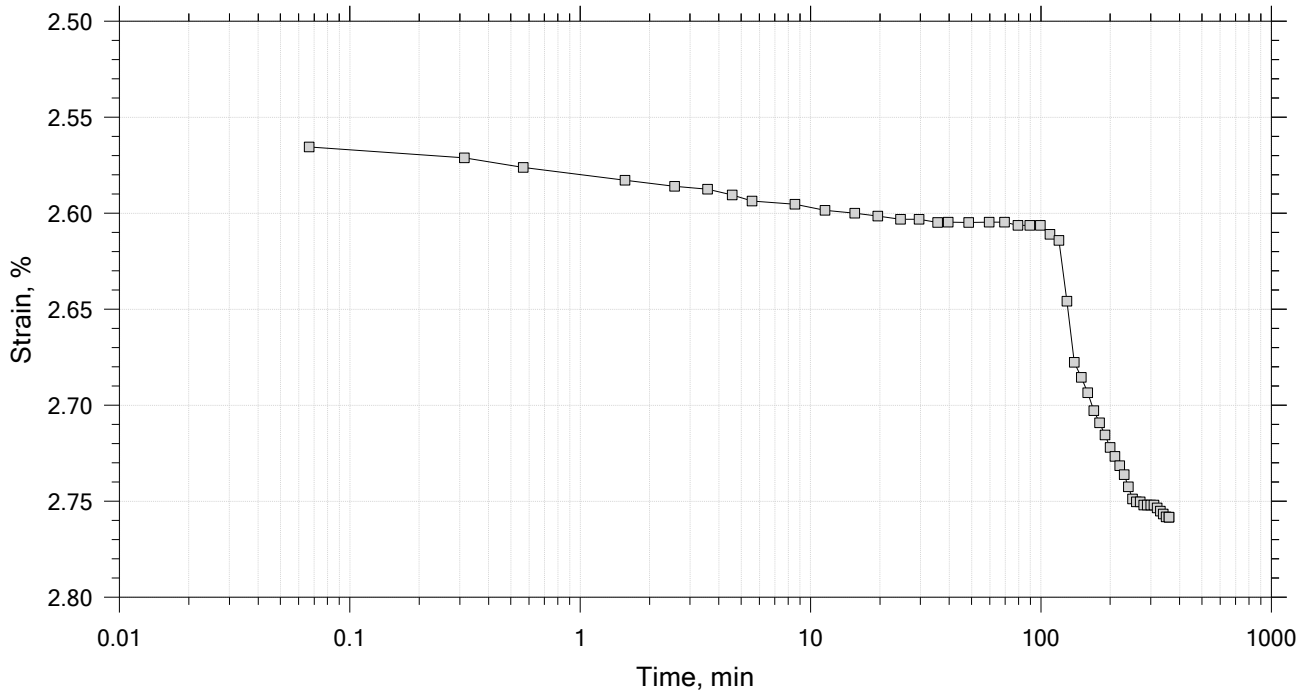
	Project: AF-RO Alexandria 4th Track	Location: Alexandria, VA	Project No.: GTX-315798
	Boring No.: 22-King-BR-01	Tested By: trm	Checked By: njh
	Sample No.: ST-1	Test Date: 9/21/22	Depth: 20-22
	Test No.: IP-3	Sample Type: intact	Elevation: ---
	Description: Moist, yellowish brown silty sand		
	Remarks: System LTIII-E, Swell Pressure = 0.0661 tsf		


# One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 13 of 18

Constant Load Step

Stress: 4 tsf



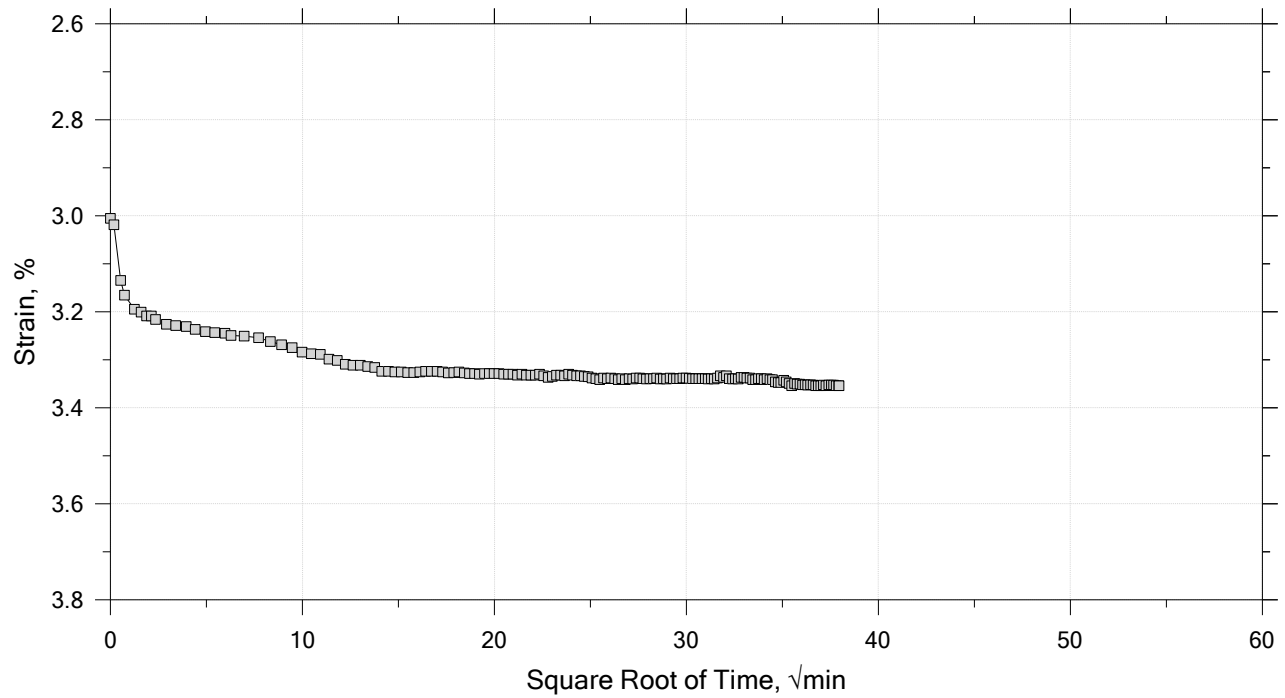
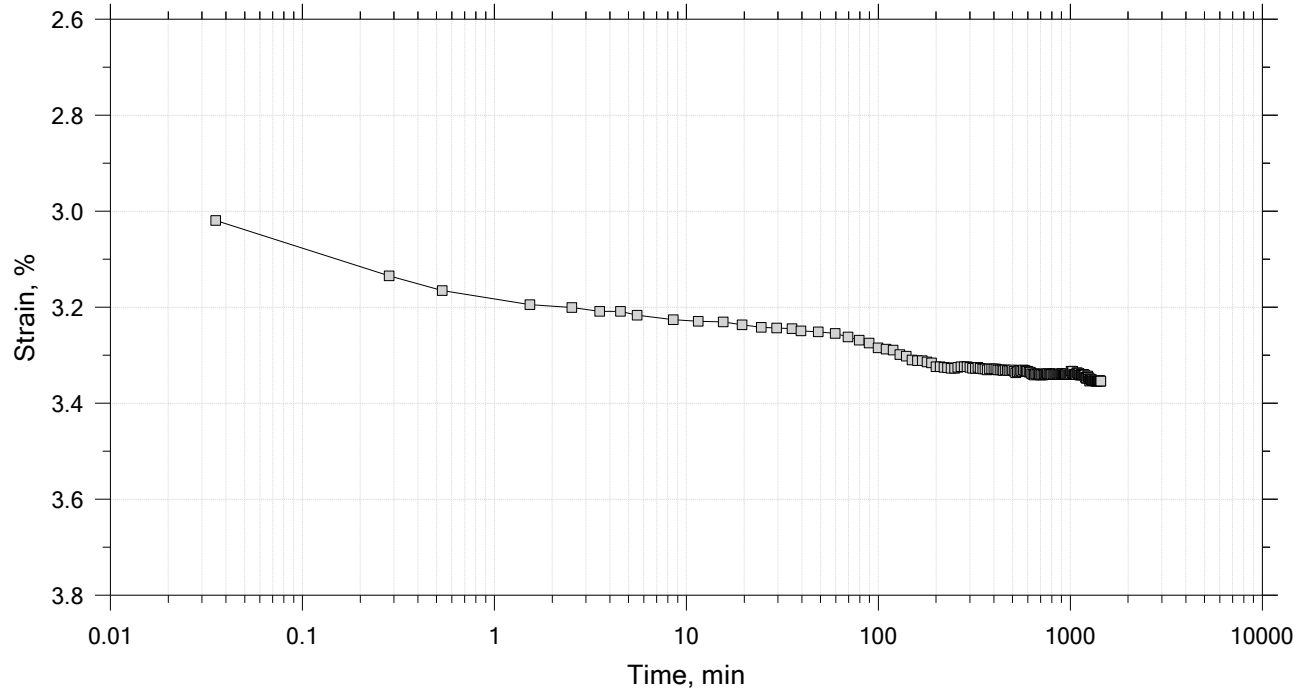
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	Boring No.: 22-King-BR-01	Tested By: trm	Checked By: njh
	Sample No.: ST-1	Test Date: 9/21/22	Depth: 20-22
	Test No.: IP-3	Sample Type: intact	Elevation: ---
	Description: Moist, yellowish brown silty sand		
	Remarks: System LTIII-E, Swell Pressure = 0.0661 tsf		


# One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 14 of 18

Constant Load Step

Stress: 8 tsf



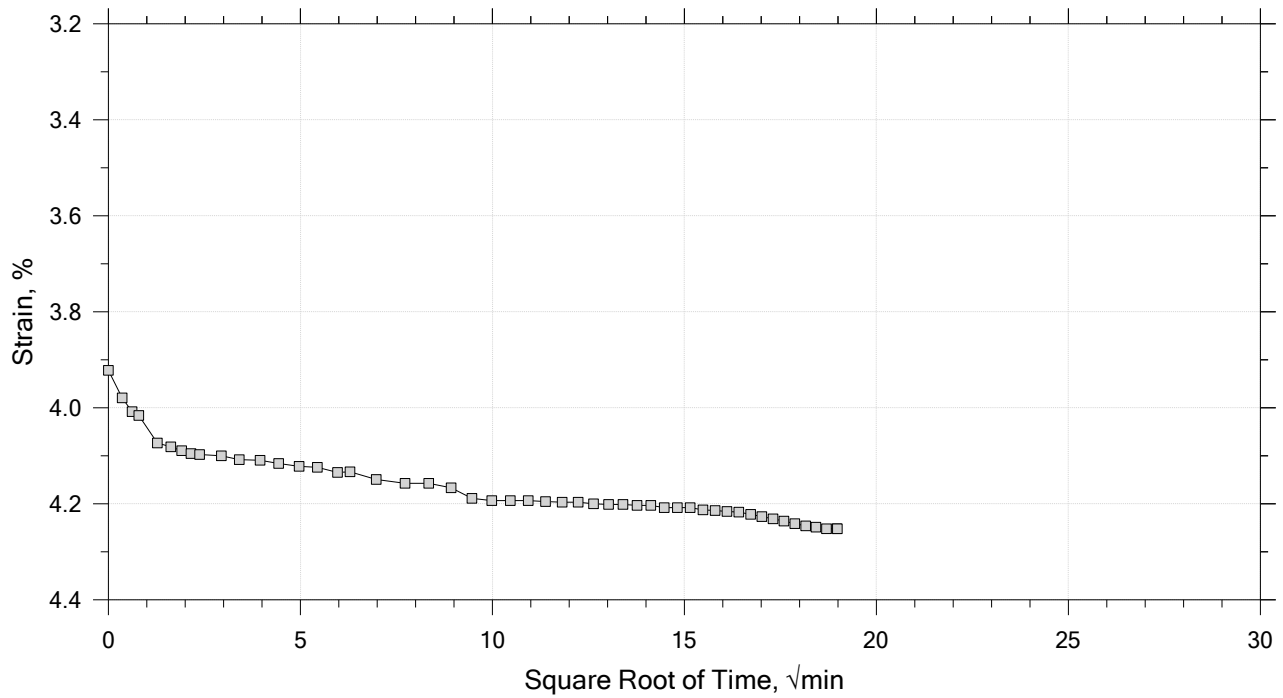
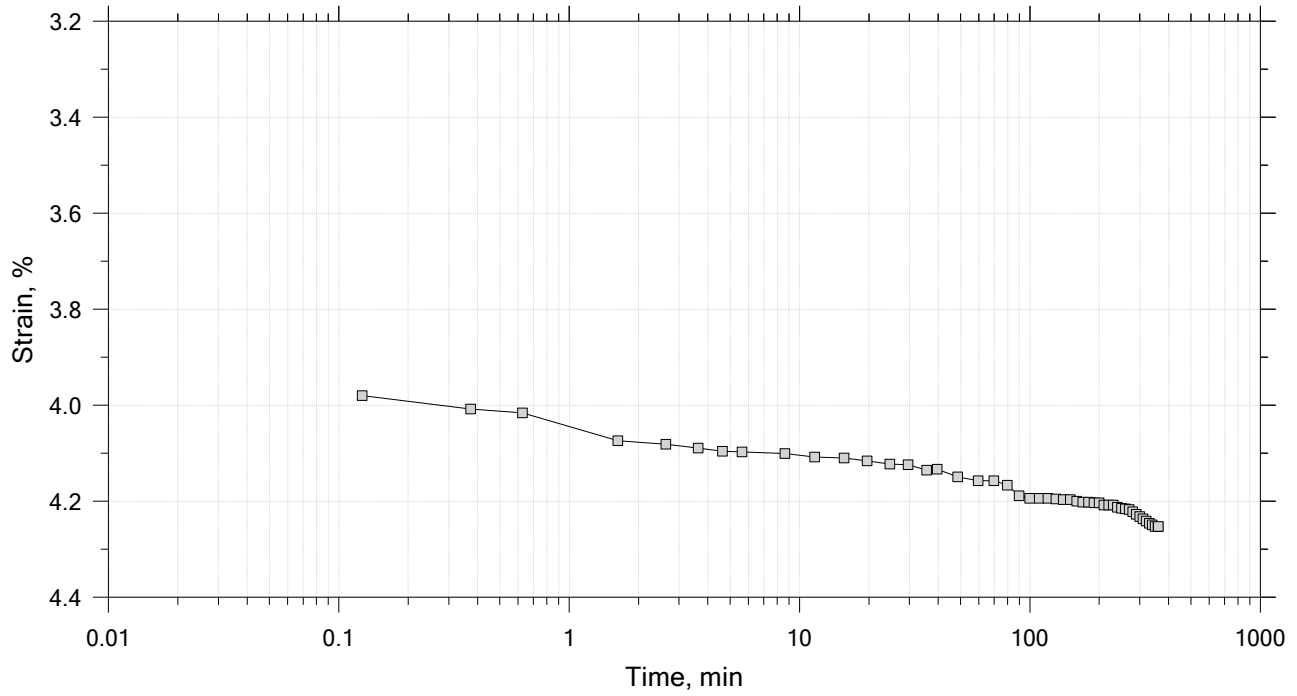
	Project: AF-RO Alexandria 4th Track	Location: Alexandria, VA	Project No.: GTX-315798
	Boring No.: 22-King-BR-01	Tested By: trm	Checked By: njh
	Sample No.: ST-1	Test Date: 9/21/22	Depth: 20-22
	Test No.: IP-3	Sample Type: intact	Elevation: ---
	Description: Moist, yellowish brown silty sand		
	Remarks: System LTIII-E, Swell Pressure = 0.0661 tsf		


# One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 15 of 18

Constant Load Step

Stress: 16 tsf



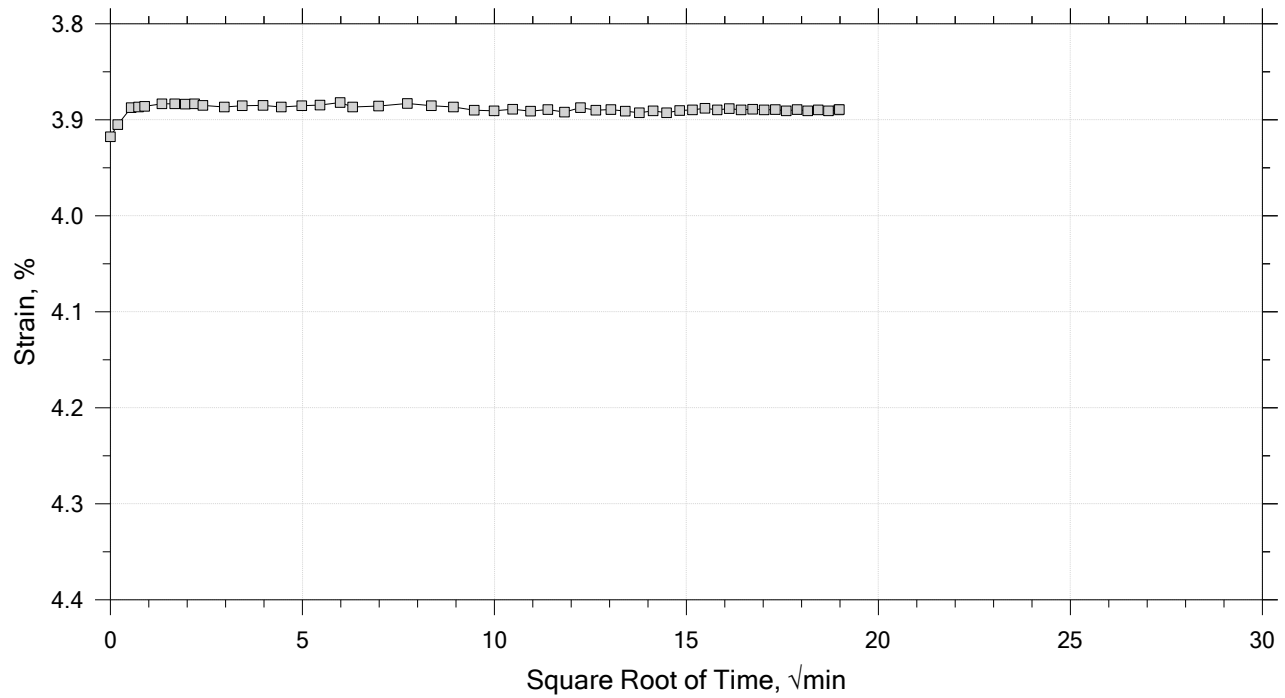
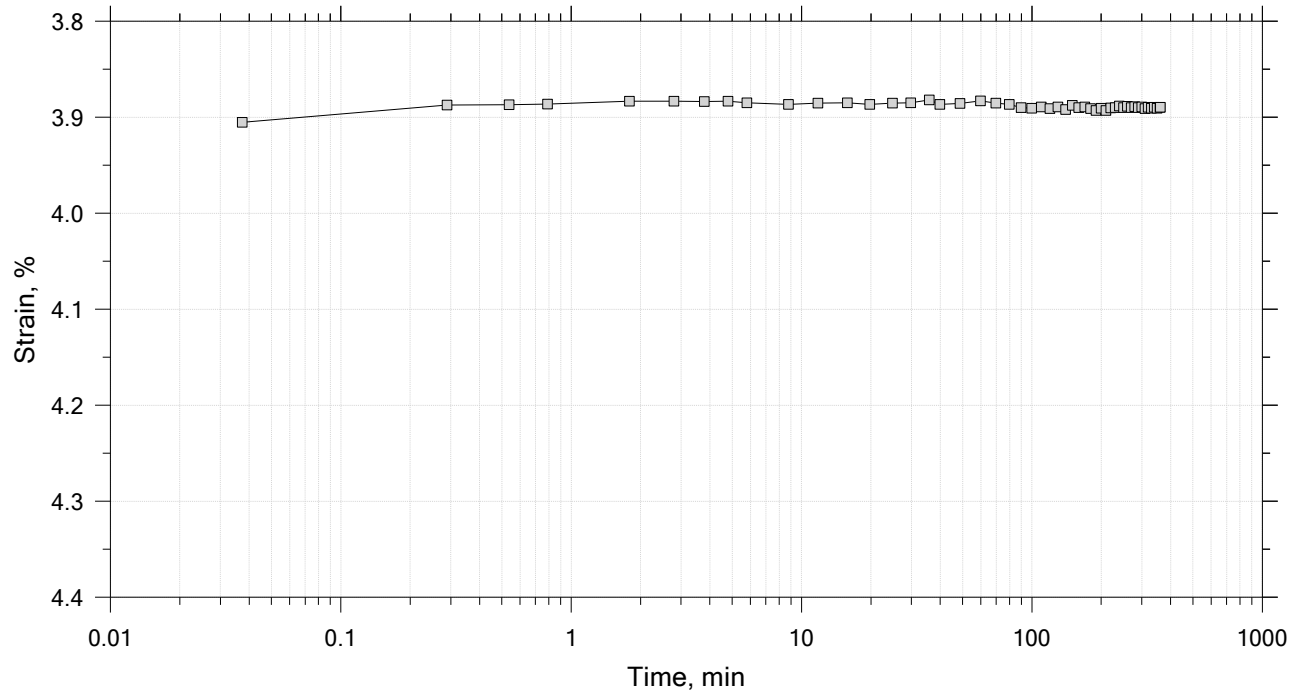
	Project: AF-RO Alexandria 4th Track	Location: Alexandria, VA	Project No.: GTX-315798
	Boring No.: 22-King-BR-01	Tested By: trm	Checked By: njh
	Sample No.: ST-1	Test Date: 9/21/22	Depth: 20-22
	Test No.: IP-3	Sample Type: intact	Elevation: ---
	Description: Moist, yellowish brown silty sand		
	Remarks: System LTIII-E, Swell Pressure = 0.0661 tsf		


# One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 16 of 18

Constant Load Step

Stress: 4 tsf



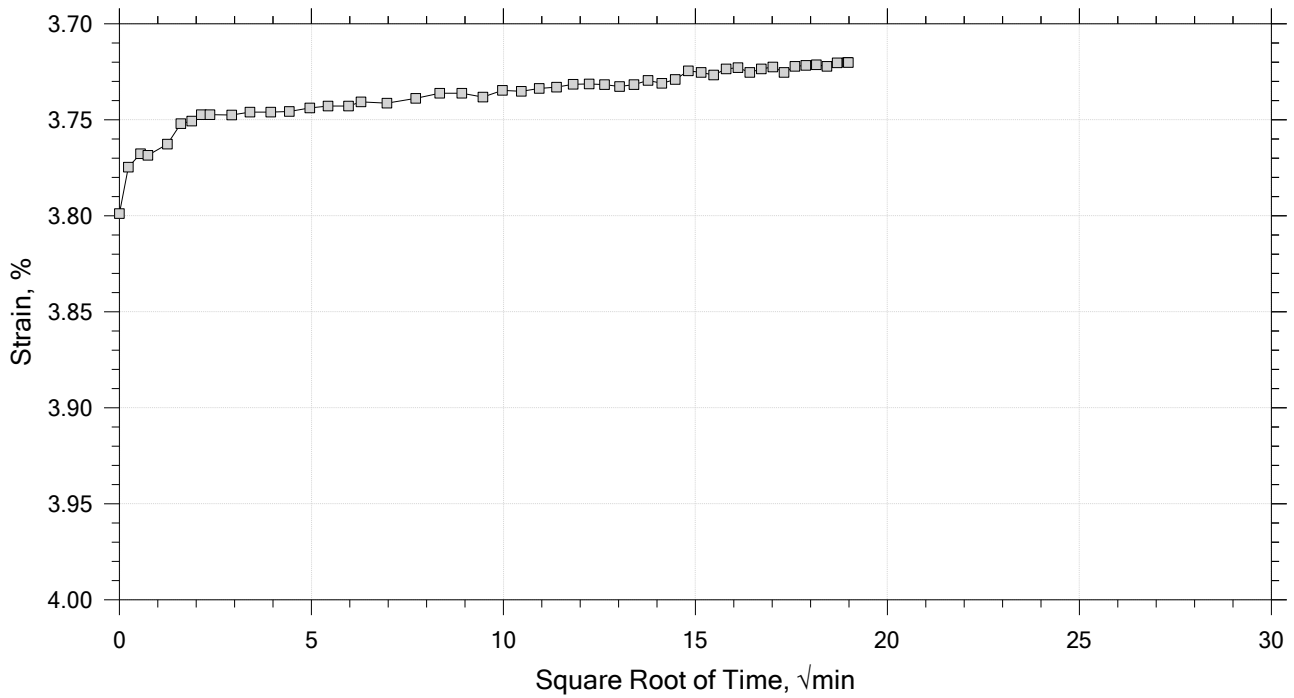
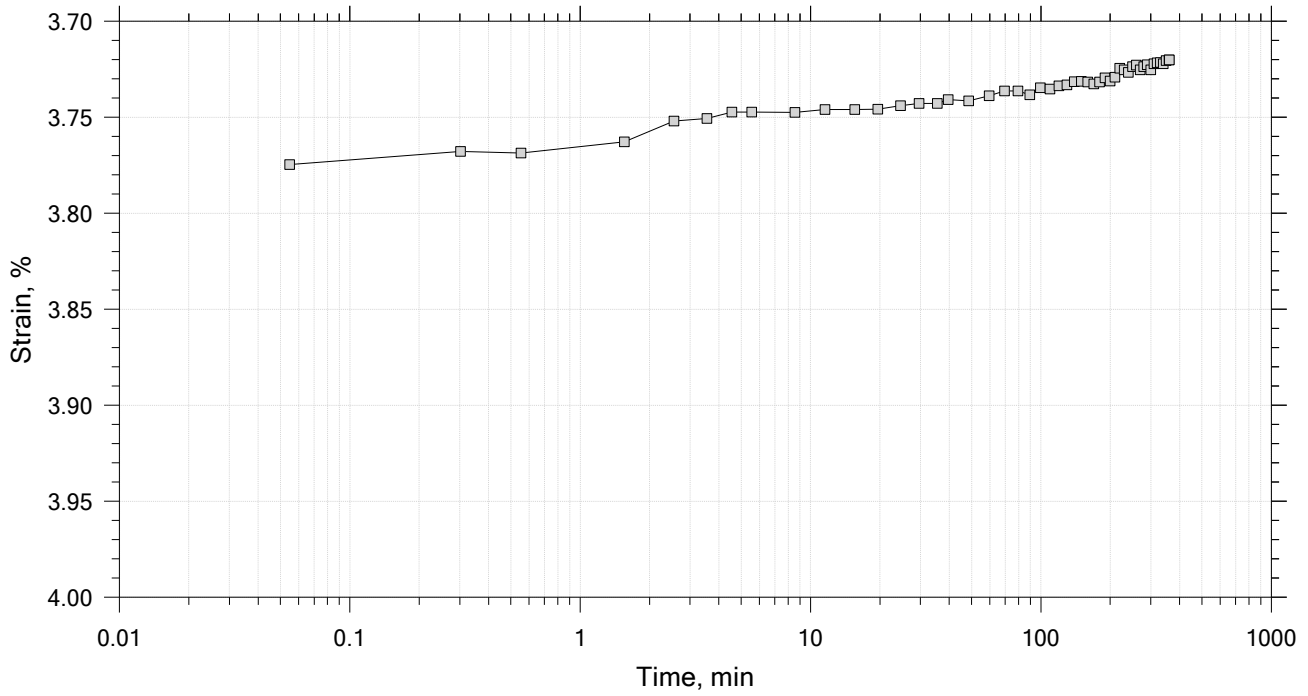
	Project: AF-RO Alexandria 4th Track	Location: Alexandria, VA	Project No.: GTX-315798
	Boring No.: 22-King-BR-01	Tested By: trm	Checked By: njh
	Sample No.: ST-1	Test Date: 9/21/22	Depth: 20-22
	Test No.: IP-3	Sample Type: intact	Elevation: ---
	Description: Moist, yellowish brown silty sand		
	Remarks: System LTIII-E, Swell Pressure = 0.0661 tsf		


# One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 17 of 18

Constant Load Step

Stress: 1 tsf



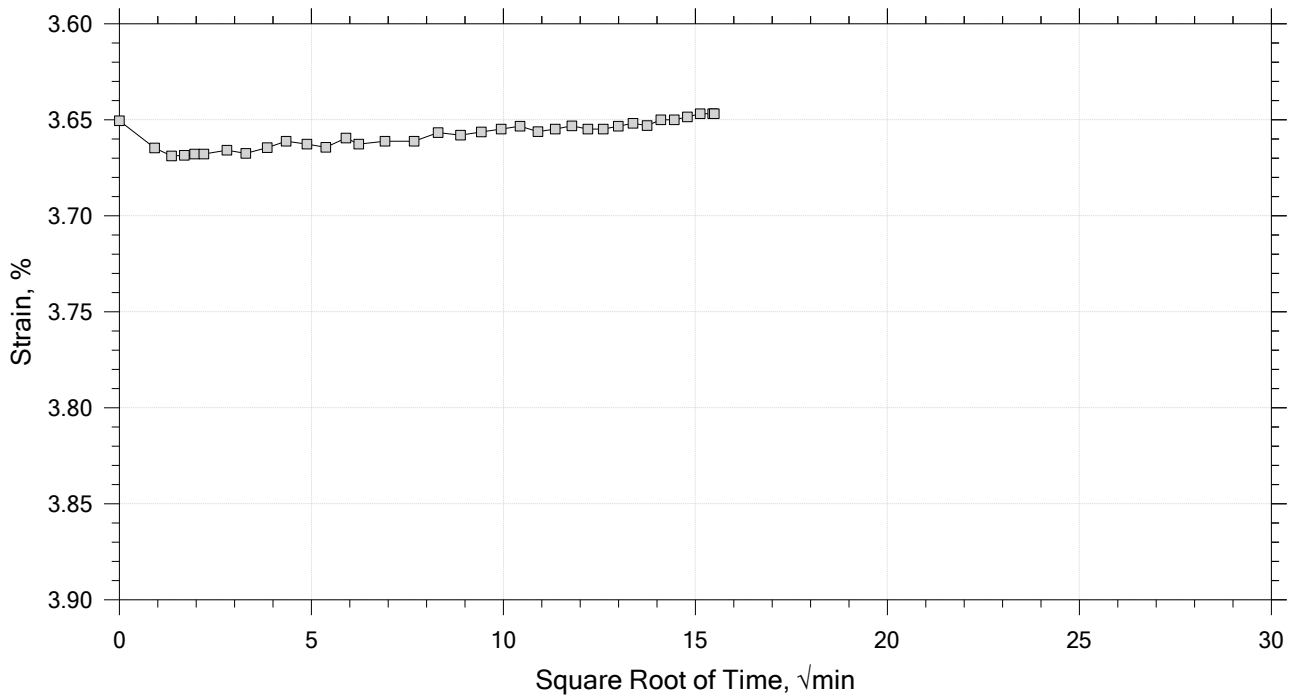
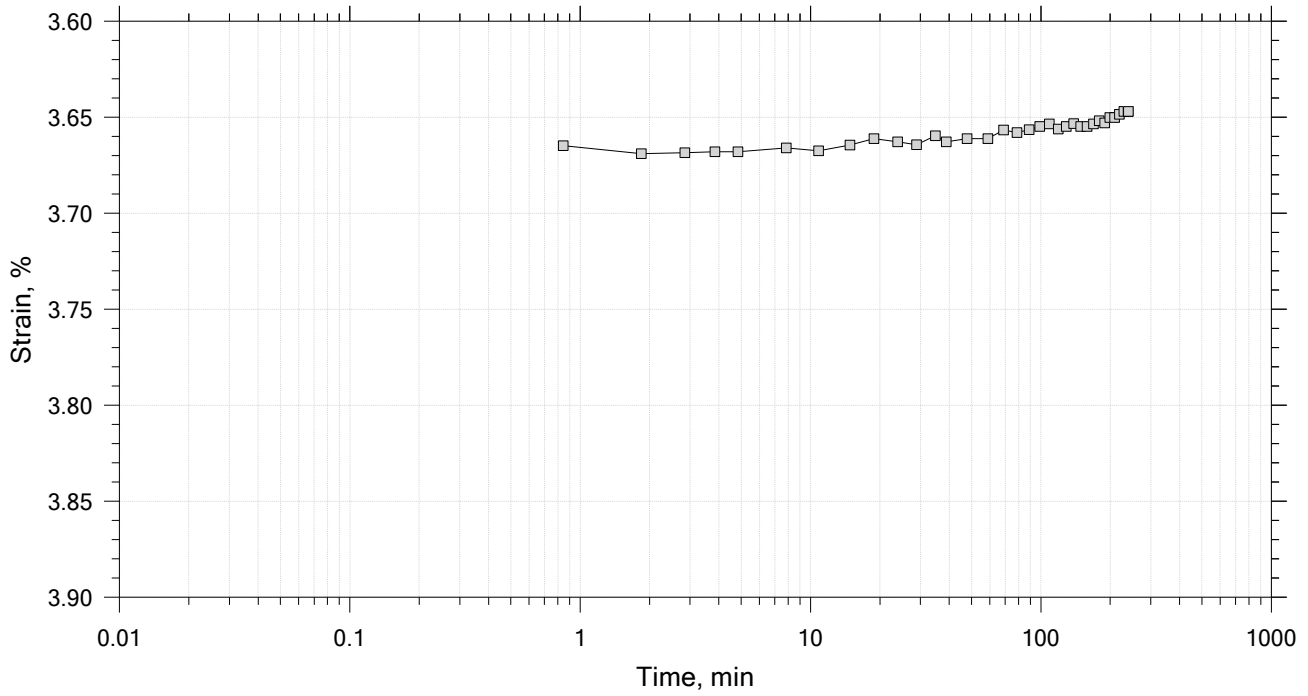
	Project: AF-RO Alexandria 4th Track	Location: Alexandria, VA	Project No.: GTX-315798
	Boring No.: 22-King-BR-01	Tested By: trm	Checked By: njh
	Sample No.: ST-1	Test Date: 9/21/22	Depth: 20-22
	Test No.: IP-3	Sample Type: intact	Elevation: ---
	Description: Moist, yellowish brown silty sand		
	Remarks: System LTIII-E, Swell Pressure = 0.0661 tsf		


# One-Dimensional Consolidation by ASTM D2435 - Method B

Time Curve 18 of 18

Constant Load Step

Stress: 0.25 tsf



	Project: AF-RO Alexandria 4th Track	Location: Alexandria, VA	Project No.: GTX-315798
	Boring No.: 22-King-BR-01	Tested By: trm	Checked By: njh
	Sample No.: ST-1	Test Date: 9/21/22	Depth: 20-22
	Test No.: IP-3	Sample Type: intact	Elevation: ---
	Description: Moist, yellowish brown silty sand		
	Remarks: System LTIII-E, Swell Pressure = 0.0661 tsf		


# One-Dimensional Consolidation by ASTM D2435 - Method B

Specimen Diameter: 2.50 in	Estimated Specific Gravity: 2.60	Liquid Limit: NP
Initial Height: 1.00 in	Initial Void Ratio: 0.584	Plastic Limit: NP
Final Height: 0.96 in	Final Void Ratio: 0.527	Plasticity Index: NP

	Before Test Trimmings	Before Test Specimen	After Test Specimen	After Test Trimmings
Container ID	E1590	RING		E2996
Mass Container, gm	8.18	109.97	109.97	8.16
Mass Container + Wet Soil, gm	144.35	271.24	268.91	169.16
Mass Container + Dry Soil, gm	123.31	242.18	242.18	142.08
Mass Dry Soil, gm	115.13	132.21	132.21	133.92
Water Content, %	18.27	21.98	20.22	20.22
Void Ratio	---	0.58	0.53	---
Degree of Saturation, %	---	97.97	100.00	---
Dry Unit Weight, pcf	---	102.6	106.49	---

Warning: The change in the sample wet weight during the test is not consistent with the change in the moisture content.

Note: Specific Gravity and Void Ratios are calculated assuming the degree of saturation equals 100% at the end of the test. Therefore, values may not represent actual values for the specimen.

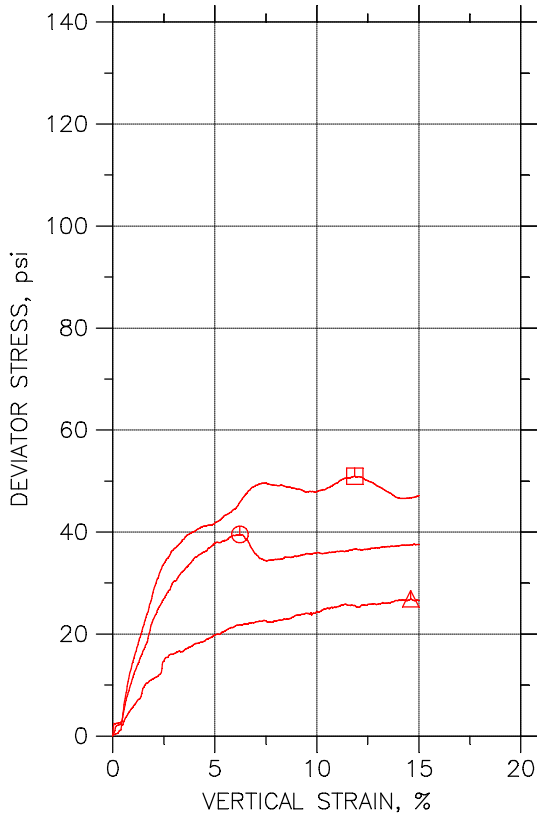
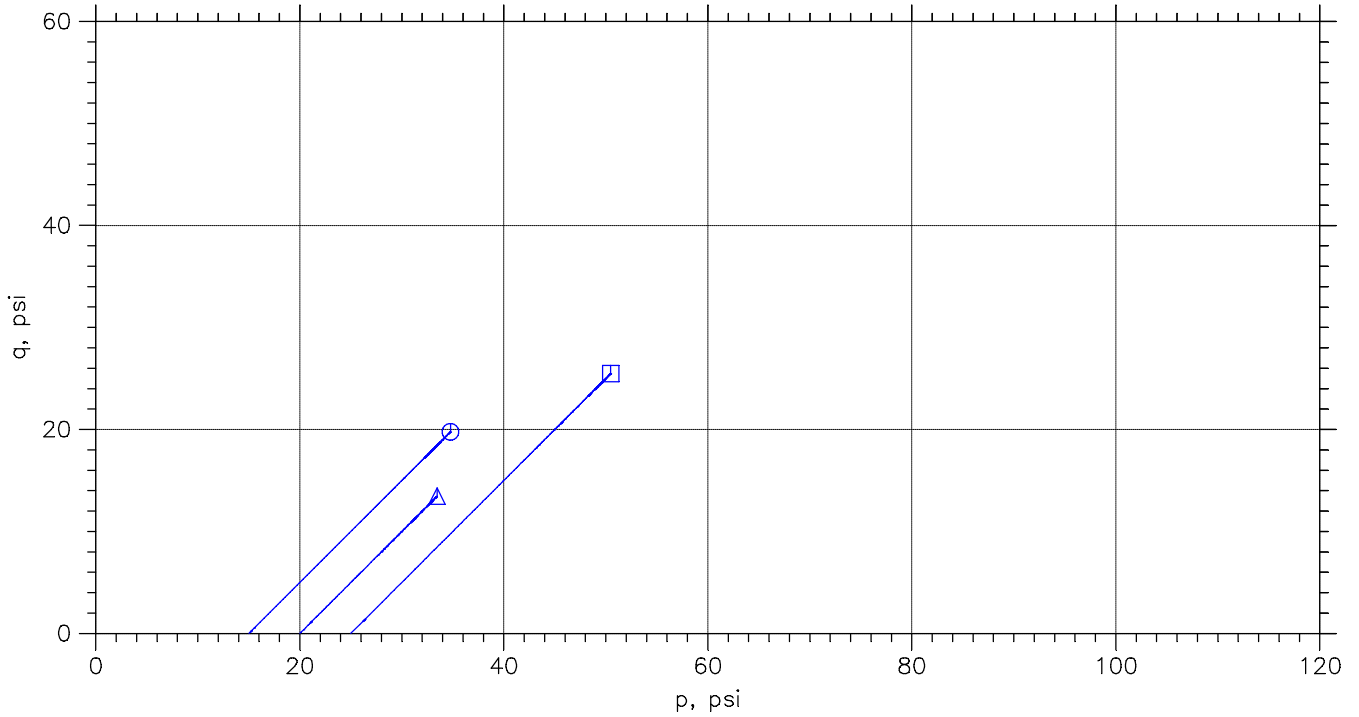
	Project: AF-RO Alexandria 4th Track	Location: Alexandria, VA	Project No.: GTX-315798
	Boring No.: 22-King-BR-01	Tested By: trm	Checked By: njh
	Sample No.: ST-1	Test Date: 9/21/22	Depth: 20-22
	Test No.: IP-3	Sample Type: intact	Elevation: ---
	Description: Moist, yellowish brown silty sand		
	Remarks: System LTIII-E, Swell Pressure = 0.0661 tsf		





## **UU Triaxial Test Results**

# UNCONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D2850



Symbol	⊙	△	□	
Sample No.	ST-1	ST-1	ST-1	
Test No.	UU-2-1	UU-2-2	UU-2-3	
Depth	20-22	20-22	20-22	
Tested by	tm/jlw	tm/jlw	jlw	
Test Date	9/23/22	9/23/22	9/23/22	
Checked by	njh	njh	njh	
Check Date	9/26/22	9/26/22	9/23/22	
Diameter, in	2.01	2.01	2.01	
Height, in	4.5	4.5	4.45	
Water Content, %	18.4	16.4	19.9	
Dry Density, pcf	103.5	113.9	99.71	
Saturation, %	79.3	92.5	77.6	
Void Ratio	0.628	0.48	0.69	
Confining Stress, psi	15	20	25	
Undrained Strength, psi	19.77	13.45	25.47	
Max. Dev. Stress, psi	39.53	26.9	50.94	
Strain at Failure, %	6.23	14.6	11.9	
Strain Rate, %/min	1	1	1	
Estimated Specific Gravity	2.7	2.7	2.7	
Liquid Limit	NP	NP	NP	
Plastic Limit	NP	NP	NP	
Plasticity Index	NP	NP	NP	

	Project: AF-RO Alexandria 4th Trac	
	Location: Alexandria, VA	
	Project No.: GTX-315798	
	Boring No.: 22KingBR01	
	Sample Type: intact	
	Description: UU-2-1 Moist, yellowish brown silty sand, UU-2-2 Moist, grayish brown sand with clay, Remarks: UU-2-3 Moist, gray clay with sand , Specimens are not the same	

Phase calculations based on start and end of test.



# Appendix D

## CALCULATIONS

King Street Bridge Micropile Data Table									
Bridge	Abutment	Maximum Axial Compression or Tension Load per Pile (Kips)	Required Nominal Axial Resistance (Kips)	Footing Bottom Elevation (feet)	Minimum Casing/ Unbonded Length (feet)	Mnimum Bond Length (feet)	Total Length below Footing Bottom (feet)	Minimum Casing Tip Elevation (feet)	Minimum Micropile Tip Elevation (feet)
King Street	Abutment 0 (South)	135	225	5	20	45	65	-15	-60
	Abutment 1 (North)	102	170	5	20	35	55	-15	-50
	Wingwalls (all)	165	275	5	20	55	75	-15	-70

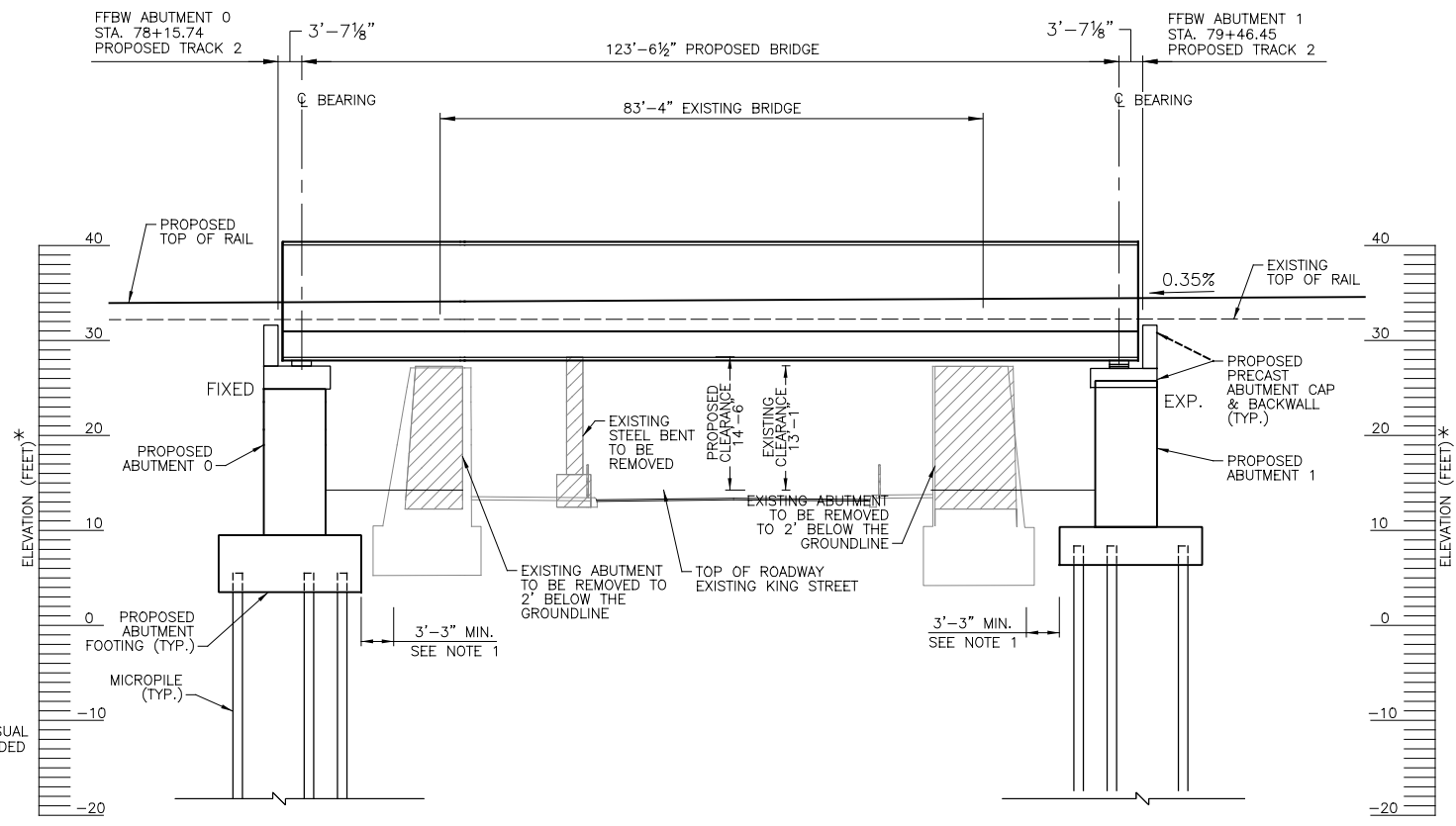
1. Casing Diameter = 12.75 inches; Bond Zone Diameter = 11.75 inches  
2. Micropile lengths are based on a resistance factor of 0.60. A minimum of one verification load testing is required per Section 070440 of CSX Design and Construction Specifications.  
3. Check micropile for adequacy in Structural Resistance .

Commonwealth Avenue Bridge Micropile Data Table									
Bridge	Abutment	Maximum Axial Compression or Tension Load per Pile (Kips)	Required Nominal Axial Resistance (Kips)	Footing Bottom Elevation (feet)	Minimum Casing/ Unbonded Length (feet)	Mnimum Bond Length (feet)	Total Length below Footing Bottom (feet)	Minimum Casing Tip Elevation (feet)	Minimum Micropile Tip Elevation (feet)
Commonwealth Avenue	Abutment 0 (South)	119	198	5	30	40	70	-25	-65
	Wingwalls (all)	158	263	5	30	50	80	-25	-75

1. Casing Diameter = 12.75 inches; Bond Zone Diameter = 11.75 inches  
2. Micropile lengths are based on a resistance factor of 0.60. A minimum of one verification load testing is required per Section 070440 of CSX Design and Construction Specifications.  
3. Check micropile for adequacy in Structural Resistance .

SOUTH TO RICHMOND

NORTH TO WASHINGTON, DC



\* ELEVATION SCALE PROVIDED FOR VISUAL PURPOSES ONLY AND IS NOT INTENDED FOR USE DURING CONSTRUCTION

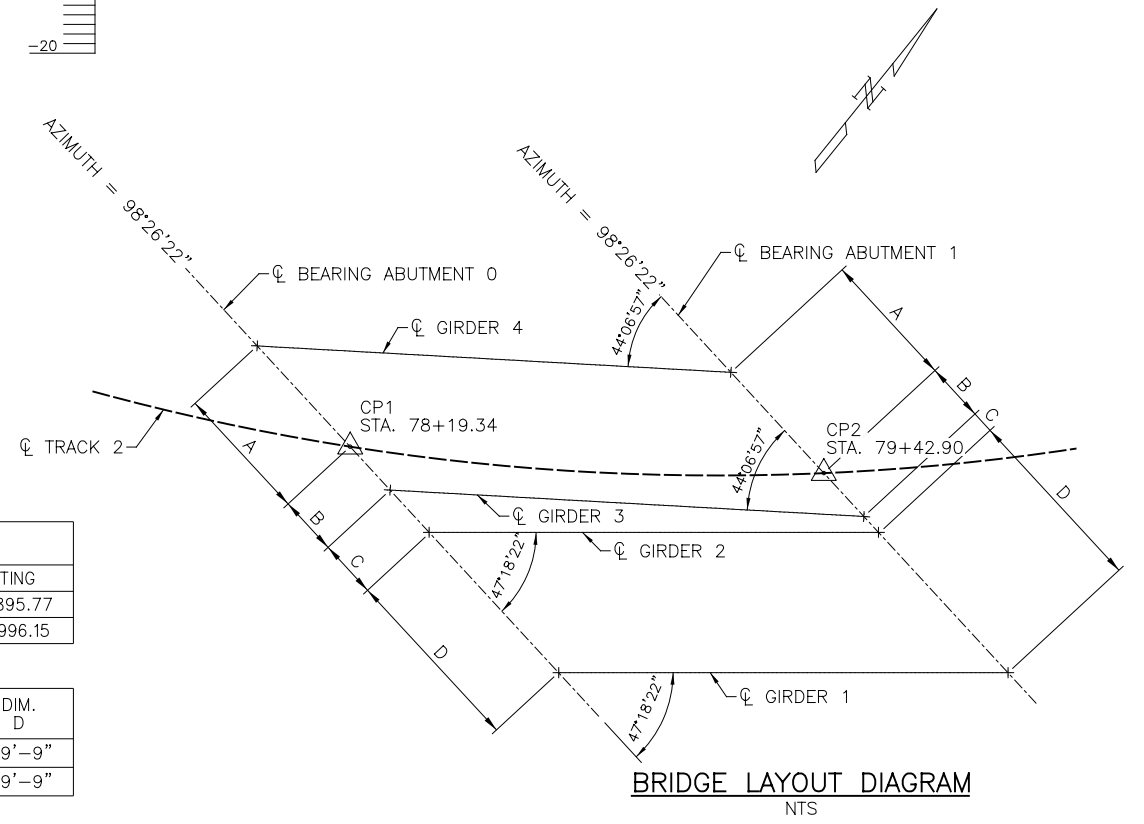
ELEVATION SCALE: 1" = 10'-0"

NOTES

- EXISTING DIMENSIONS ARE BASED ON LIMITED HISTORIC INFORMATION AVAILABLE. ADDITIONAL FIELD EXPLORATION WILL BE REQUIRED TO DETERMINE EXISTING SUBSTRUCTURE EXTENTS AND CONFIRM EXISTING FOUNDATION TYPE.

CONTROL POINTS			
CONTROL POINT	STATION	NORTHING	EASTING
CP1	78+19.34	6980074.19	11892895.77
CP2	79+42.90	6980146.24	11892996.15

	DIM. A	DIM. B	DIM. C	DIM. D
ABUT. 0	35'-8 1/4"	15'-4 3/8"	14'-11 3/8"	49'-9"
ABUT. 1	35'-8 1/2"	15'-4 3/8"	5'-7 1/8"	49'-9"



BRIDGE LAYOUT DIAGRAM NTS

RR\_PDF\_HairPlot.dwg  
RR\_King St\_Bridge\_Pen.tbl  
NENDESHAW  
...:CFP-105.30-GP02.dgn  
9/22/2023

LEVEL 3

DESIGNED BY	RCV
DRAWN BY	NME
CHECKED BY	KKM
APPROVED BY	KKM
DATE	8/07/2023



THESE PLANS ARE UNFINISHED AND UNAPPROVED AND ARE NOT TO BE USED FOR ANY TYPE OF CONSTRUCTION OR THE ACQUISITION OF RIGHT OF WAY



KING STREET BRIDGE ALEXANDRIA, VA.  
SUBDIVISION: RF&P ZONE: CENTRAL  
GENERAL ELEVATION

PROJECT NO.		VA 2541270
DRAWING NO.		CFP-105.30-09
REV.	SHEET NO.	
	9 OF 61	
SCALE		AS SHOWN

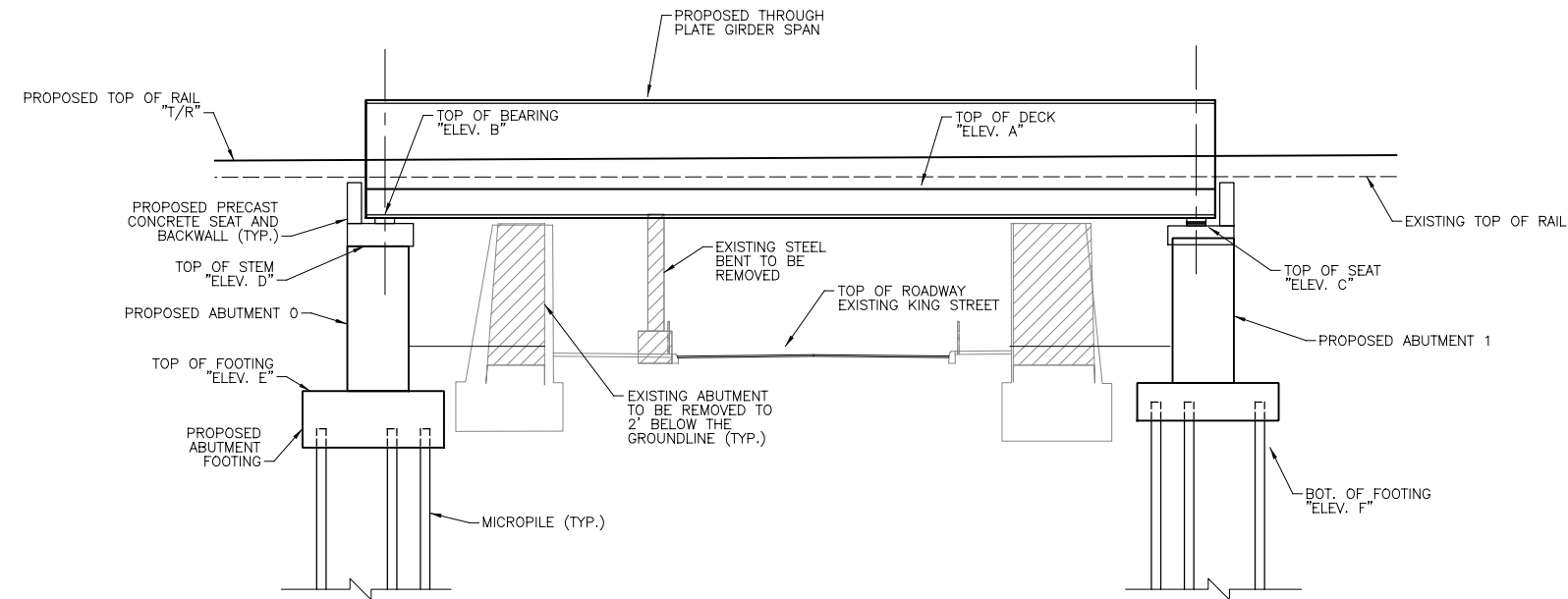
EXISTING COMPONENTS				
NAME	HEIGHT			
	ABUTMENT 0		ABUTMENT 1	
	TRACK 3 / 2	TRACK 1 / 0	TRACK 3 / 2	TRACK 1 / 0
RAIL & TIE PLATE	8"	8"	8"	8"
TIE (BRIDGE)	9 1/2"	9 1/2"	9 1/2"	9 1/2"
STRINGER RISER	-	8 1/2"	-	8 1/2"
STRINGER DEPTH	2'-2 1/4"	2'-2 1/4"	2'-2 1/4"	2'-2 1/4"
GAP TO BOTTOM OF FLOOR BEAM	11/16"	11/16"	11/16"	11/16"
GAP TO BOTTOM OF GIRDER	5/8"	10/16"	1 13/16"	1 3/4"
TOTAL	3'-10 3/4"	4'-7 1/4"	4'-0"	4'-8 1/2"

PROPOSED COMPONENTS TRACK 3 / 2				
NAME	HEIGHT			
	ABUTMENT 0		ABUTMENT 1	
	TRACK 3	TRACK 2	TRACK 3	TRACK 2
RAIL & TIE PLATE	8"	8"	8"	8"
TIE (TRACK)	7"	7"	7"	7"
BALLAST	6"	1'-0 3/16"	11 7/8"	1'-6"
WATERPROOFING	1/2"	1"	1"	1"
DECK PLATE	1"	1"	1"	1"
FLOORBEAM	1'-8 1/2"	1'-8 1/2"	1'-8 1/2"	1'-8 1/2"
GAP TO GIRDER FLANGE	1/2"	1/2"	1/2"	1/2"
GIRDER FLANGE	4"	4"	4"	4"
BEARINGS WITH SHOCK PAD	11 5/8"	11 5/8"	11 5/8"	11 5/8"
TOTAL	4'-11 1/8"	5'-5 13/16"	5'-5 1/2"	5'-11 5/8"

PROPOSED COMPONENTS TRACK 1 / 0				
NAME	HEIGHT			
	ABUTMENT 0		ABUTMENT 1	
	TRACK 1	TRACK 0	TRACK 1	TRACK 0
RAIL & TIE PLATE	8"	8"	8"	8"
TIE (TRACK)	7"	7"	7"	7"
BALLAST	6 1/2"	1'-0"	9 13/16"	1'-2 7/16"
WATERPROOFING	1"	1"	1"	1"
DECK PLATE	1"	1"	1"	1"
FLOORBEAM	1'-8 1/2"	1'-8 1/2"	1'-8 1/2"	1'-8 1/2"
GAP TO GIRDER FLANGE	1/2"	1/2"	1/2"	1/2"
GIRDER FLANGE	4"	4"	4"	4"
BEARINGS WITH SHOCK PAD	11 5/8"	11 5/8"	11 5/8"	11 5/8"
SHIMS	0"	0"	5"	5"
TOTAL	5'-0 1/8"	5'-5 5/8"	5'-8 7/16"	6'-1 1/16"

BRIDGE ELEVATIONS									
PIER/ABUT	TRACK	STATION *	T/R	ELEVATIONS					
				A	B	C	D	E	F
ABUTMENT 0	3	78+01.28	33.47	31.68	29.51	28.54	26.54	11.16	5.16
	2	78+15.74	34.02	31.68	29.51	28.54	26.54	11.16	5.16
	1	78+48.70	33.97	32.09	29.93	28.96	26.54	11.16	5.16
	0	78+62.69	34.39	32.09	29.93	28.96	26.54	11.16	5.16
ABUTMENT 1	3	79+32.17	34.00	31.68	29.51	28.54	26.54	11.16	5.16
	2	79+46.45	34.46	31.68	29.51	28.54	26.54	11.16	5.16
	1	79+71.35	34.24	32.09	29.93	28.54	26.54	11.16	5.16
	0	79+84.19	34.63	32.09	29.93	28.54	26.54	11.16	5.16

\* AT FFBW



ELEVATION DIAGRAM  
SCALE: 1" = 10'-0"

LEVEL 3

DESIGNED BY	RCV
DRAWN BY	NME
CHECKED BY	KKM
APPROVED BY	KKM
DATE	8/07/2023

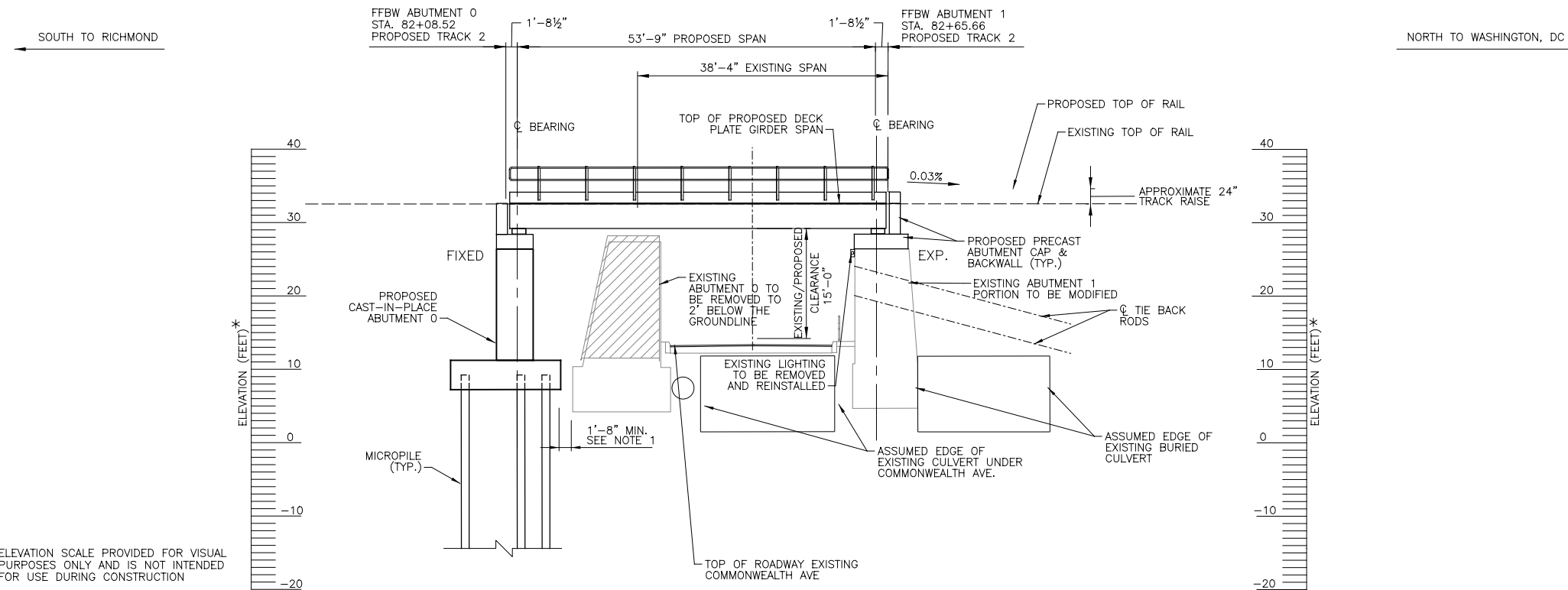


THESE PLANS ARE UNFINISHED AND UNAPPROVED AND ARE NOT TO BE USED FOR ANY TYPE OF CONSTRUCTION OR THE ACQUISITION OF RIGHT OF WAY



KING STREET BRIDGE  
ALEXANDRIA, VA.  
SUBDIVISION: RF&P ZONE: CENTRAL  
BRIDGE ELEVATION

PROJECT NO.	VA 2541270
DRAWING NO.	CFP-105.30-13
REV.	SHEET NO.
	13 OF 61
SCALE	AS SHOWN

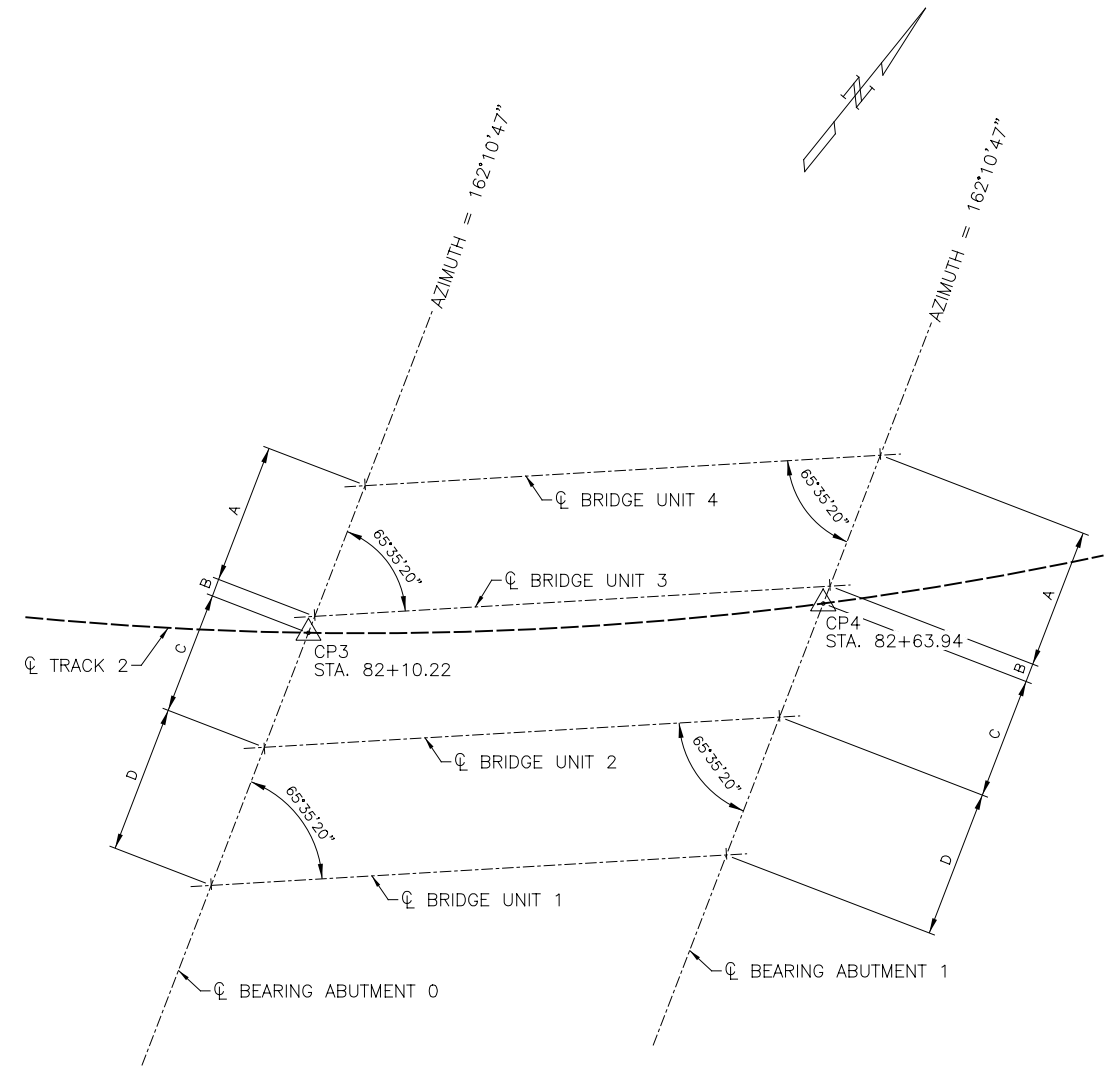


\* ELEVATION SCALE PROVIDED FOR VISUAL PURPOSES ONLY AND IS NOT INTENDED FOR USE DURING CONSTRUCTION

ELEVATION SCALE: 1" = 10'-0"

NOTES

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BRIDGE LAYOUT DIAGRAM NTS

CONTROL POINTS			
CONTROL POINT	STATION	NORTHING	EASTING
CP3	82+10.22	6980314.31	11893203.92
CP4	82+63.94	6980350.35	11893243.74

	DIM A	DIM B	DIM C	DIM D
ABUT. 0	14'-7 1/8"	0'-0 3/8"	14'-7 1/8"	15'-4 3/4"
ABUT. 1	14'-7 1/8"	0'-1 3/8"	14'-6 1/8"	15'-4 3/4"

LEVEL 3

DESIGNED BY	KKM
DRAWN BY	NME
CHECKED BY	KKM
APPROVED BY	KKM
DATE	07/17/2023



THESE PLANS ARE UNFINISHED AND UNAPPROVED AND ARE NOT TO BE USED FOR ANY TYPE OF CONSTRUCTION OR THE ACQUISITION OF RIGHT OF WAY



COMMONWEALTH AVENUE BRIDGE ALEXANDRIA, VA.  
SUBDIVISION: RF&P ZONE: CENTRAL  
GENERAL ELEVATION

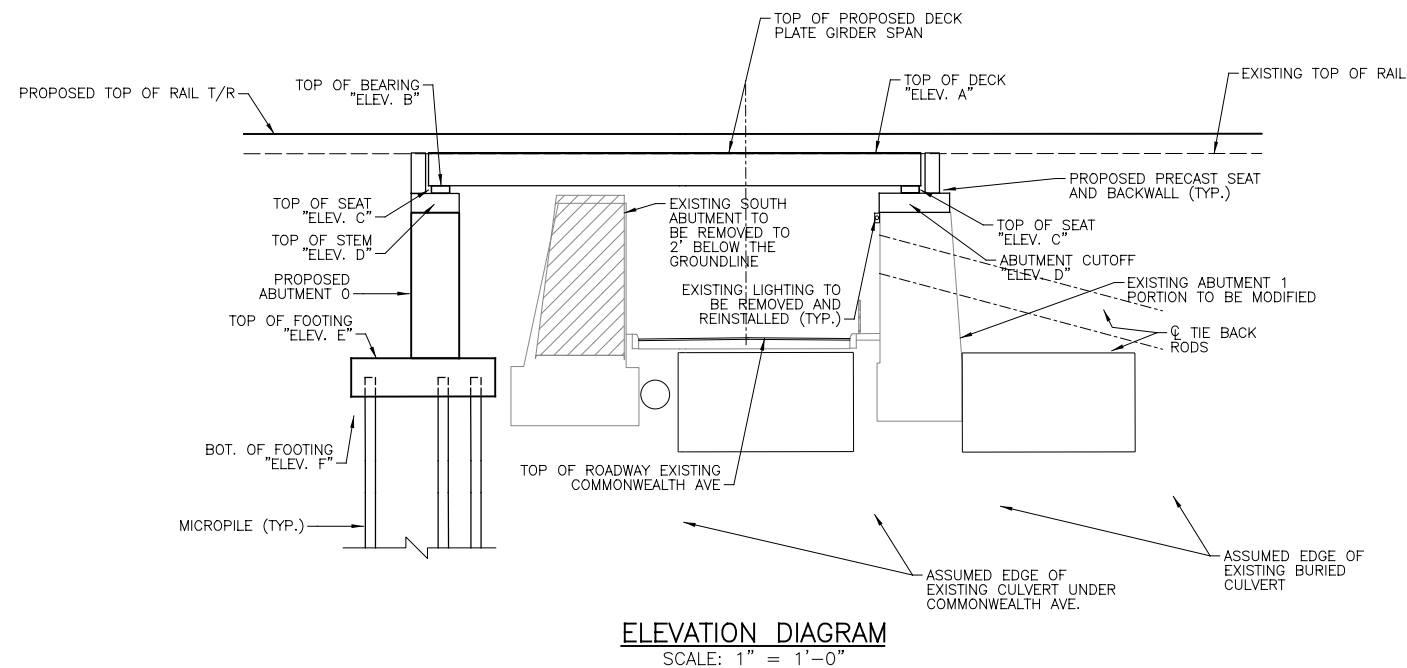
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DRAWING NO.	CFP-105.37-08
REV.	SHEET NO.
	8 OF 50
SCALE	AS SHOWN

EXISTING COMPONENTS								
NAME	HEIGHT							
	TRACK 3		TRACK 2		TRACK 1		TRACK 0	
	ABUT. 0	ABUT. 1	ABUT. 0	ABUT. 1	ABUT. 0	ABUT. 1	ABUT. 0	ABUT. 1
RAIL & TIE PLATE	8"	8"	8"	8"	8"	8"	0"	0"
TIE (BRIDGE)	9 1/2"	9 1/2"	9 1/2"	9 1/2"	9 1/2"	9 1/2"	9 1/2"	9 1/2"
STRINGER DEPTH	1'-3"	1'-3"	1'-3"	1'-3"	1'-3"	1'-3"	1'-3"	1'-3"
GAP TO BOTTOM OF FLOOR BEAM	1/2"	1/2"	1/2"	1/2"	1/2"	1/2"	1/2"	1/2"
GAP TO BOTTOM OF GIRDER	1 1/2"	1 1/2"	1 1/2"	1 1/2"	1 1/2"	1 1/2"	1 1/2"	1 1/2"
BEARING	3 5/16"	9 1/2"	6"	1'-0 7/16"	7 1/2"	1'-2"	7 1/2"	1'-2"
TOTAL	3'-1 13/16"	3'-8"	3'-4 1/2"	3'-10 15/16"	3'-6"	4'-0 1/2"	2'-10"	3'-4 1/2"

PROPOSED COMPONENTS								
NAME	HEIGHT							
	TRACK 3		TRACK 2		TRACK 1		TRACK 0	
	ABUT. 0	ABUT. 1	ABUT. 0	ABUT. 1	ABUT. 0	ABUT. 1	ABUT. 0	ABUT. 1
RAIL & TIE PLATE	8"	8"	8"	8"	8"	8"	8"	8"
TIE (TRACK)	7"	7"	7"	7"	7"	7"	7"	7"
BALLAST	8 3/4"	8 1/2"	8 1/4"	8 1/8"	10 3/4"	10 1/2"	1'-0"	11 3/4"
DECK PLATE	7/8"	7/8"	7/8"	7/8"	7/8"	7/8"	7/8"	7/8"
DECK PLATE GIRDER	3'-4 1/2"	3'-4 1/2"	3'-4 1/2"	3'-4 1/2"	3'-4 1/2"	3'-4 1/2"	3'-4 1/2"	3'-4 1/2"
BEARINGS WITH SHOCK PAD	5"	5"	5"	5"	5"	5"	5"	5"
TOTAL	5'-10 1/8"	5'-9 7/8"	5'-9 5/8"	5'-9 1/2"	6'-0 1/8"	5'-11 15/16"	6'-1 3/8"	6'-1 1/8"

BRIDGE ELEVATIONS									
PIER/ABUT	TRACK	STATION *	T/R	ELEVATIONS					
				A	B	C	D	E	F
ABUTMENT 0	3	82+14.40	34.63	32.65	29.21	28.79	27.29	11.24	5.24
	2	82+08.52	34.60	32.65	29.21	28.79	27.29	11.24	5.24
	1	82+02.59	34.80	32.65	29.21	28.79	27.29	11.24	5.24
	0	81+96.43	34.91	32.65	29.21	28.79	27.29	11.24	5.24
ABUTMENT 1	3	82+71.43	34.61	32.65	29.21	28.79	27.29	-	-
	2	82+65.66	34.58	32.65	29.21	28.79	27.29	-	-
	1	82+59.85	34.78	32.65	29.21	28.79	27.29	-	-
	0	82+53.68	34.89	32.65	29.21	28.79	27.29	-	-

\* AT FFBW



RR\_PDF\_Halfp1c1g  
RR\_Commonwealth\_Bridge\_Pen.tbl  
NENDSHAW 9/22/2023  
...:CFP-105.37-BE01.dgn

DESIGNED BY	RCV
DRAWN BY	NME
CHECKED BY	KKM
APPROVED BY	KKM
DATE	07/17/2023

LEVEL 3

Rev.	Date	Description



THESE PLANS ARE UNFINISHED AND UNAPPROVED AND ARE NOT TO BE USED FOR ANY TYPE OF CONSTRUCTION OR THE ACQUISITION OF RIGHT OF WAY



**COMMONWEALTH AVENUE  
BRIDGE  
ALEXANDRIA, VA.**

SUBDIVISION: RF&P ZONE: CENTRAL

BRIDGE ELEVATION

PROJECT NO.	VA 2541270
DRAWING NO.	CFP-105.37-13
REV.	SHEET NO.
	13 OF 50
SCALE	AS SHOWN

		Service Load Combinations							
		Maximum Load case							
Bridge	Structure		Axial (kip)	V <sub>long</sub> (kip)	V <sub>trans</sub> (kip)	Moment (k-ft)	Vertical Load per Pile (kip)	Lateral Load per Pile (kip)	Total Number of Vertical Piles
KING ST.	Substructure Loads	Abut 0 (SE Abut): All vert. Piles	4126	840	315	5703	135	21.0	40
		Abut 0 (SW Abut): All vert. Piles	4365	859	315	4779	105	16.5	52
		Abut1 (N Abut): All vert. plies	7634	1269	352	2919	102	15.7	81
KING ST.	Substructure Loads	Wingwall SW (nr Abut 0) All vert. piles	509	162	0	2985	114	10.1	16
		Wingwall SE (nr Abut 0) All vert. piles	491	205	0	3718	165	17.1	12
		Wingwall NW (nr Abut 1) All vert. piles	329	220	0	2252	121	20.0	11
		Wingwall NE (nr Abut 1) All vert. piles	667	448	0	5837	160	21.3	21
COMMONWEALTH AVE.	Substructure Loads	Abut 0 (S Abut): All vert. Piles	4476	1141	233	7813	119	22.0	52
		Abut1 (N. Abut)	On Existing Spread footing						
		Wingwall SW: (nr Abut 0) All vert. piles	399	276	0	3080	121	18.4	15
		Wingwall SE: (nr Abut 0) All vert. piles	637	483	0	6823	158	20.1	24

**Note:**  
Controlling Load

This information was provided by structural designers



# SUBSURFACE DIAGRAM

Client: CSX Transportation

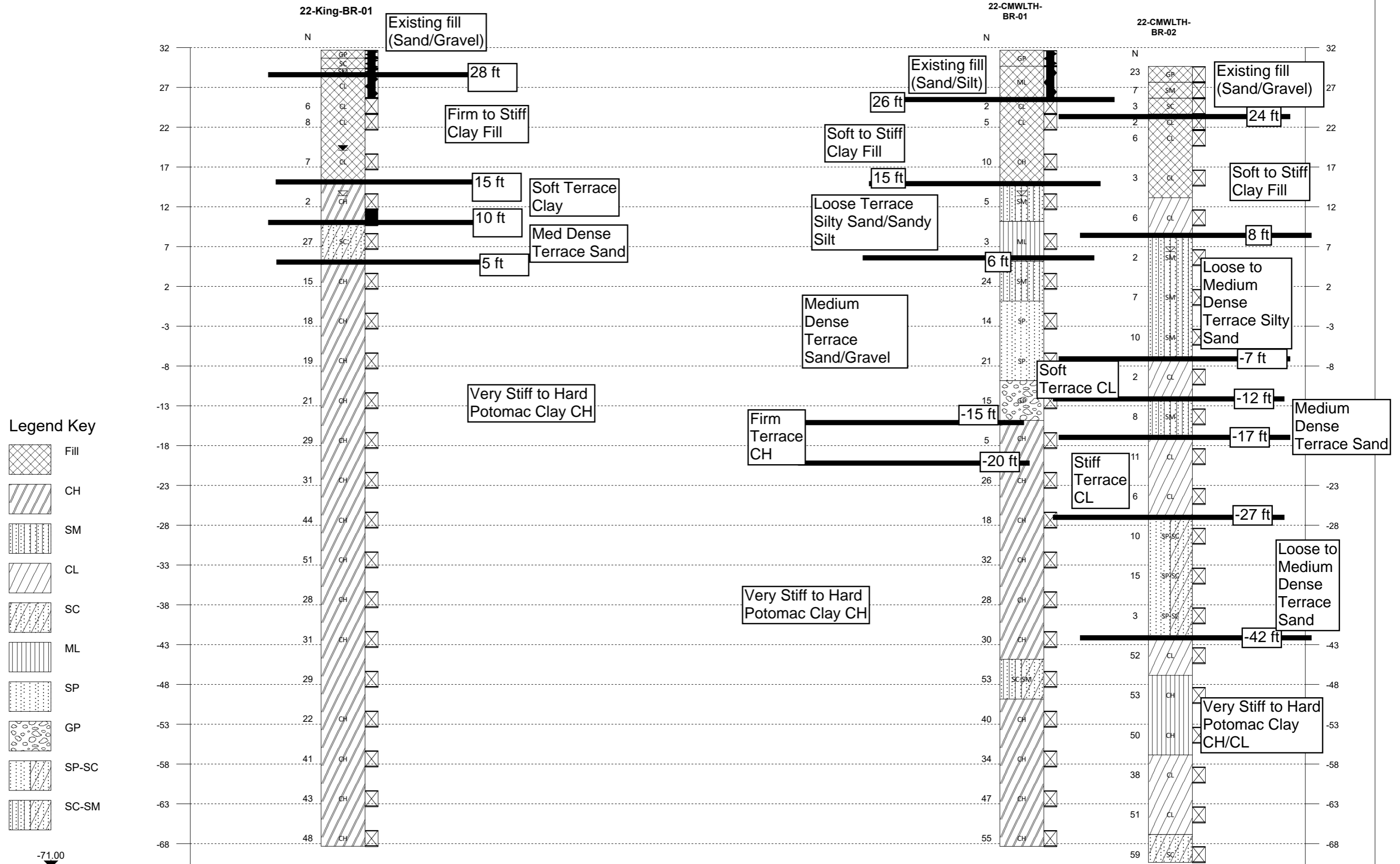
Project Name: DRPT CSX AF to RO Widening

Vertical Scale: 1:140

Project Number: 10331846

Project Location: City of Alexandria and Arlington County

Horizontal Scale: 1:575



-71.00

The soil encountered at depths where micropiles will be mostly embedded are stiff to very stiff over consolidated Potomac clays. We have conservatively selected a Grout-to-Ground bond strength of 12 psi corresponding to Type B pressure grout.

**Table 5-3. Summary of Typical  $\alpha_{\text{bond}}$  (Grout-to-Ground Bond) Values for Micropile Design.**

Soil / Rock Description	Grout-to-Ground Bond Ultimate Strengths, kPa (psi)			
	Type A	Type B	Type C	Type D
<b>Silt &amp; Clay</b> (some sand) (soft, medium plastic)	35-70 (5-10)	35-95 (5-14)	50-120 (5-17.5)	50-145 (5-21)
<b>Silt &amp; Clay</b> (some sand) (stiff, dense to very dense)	50-120 (5-17.5)	70-190 (10-27.5)	95-190 (14-27.5)	95-190 (14-27.5)
<b>Sand</b> (some silt) (fine, loose-medium dense)	70-145 (10-21)	70-190 (10-27.5)	95-190 (14-27.5)	95- 240 (14-35)
<b>Sand</b> (some silt, gravel) (fine-coarse, med.-very dense)	95-215 (14-31)	120-360 (17.5-52)	145-360 (21-52)	145-385 (21-56)
<b>Gravel</b> (some sand) (medium-very dense)	95-265 (14-38.5)	120-360 (17.5-52)	145-360 (21-52)	145-385 (21-56)
<b>Glacial Till</b> (silt, sand, gravel) (medium-very dense, cemented)	95-190 (14-27.5)	95-310 (14-45)	120-310 (17.5-45)	120-335 (17.5-48.5)
<b>Soft Shales</b> (fresh-moderate fracturing, little to no weathering)	205-550 (30-80)	N/A	N/A	N/A
<b>Slates and Hard Shales</b> (fresh- moderate fracturing, little to no weathering)	515-1,380 (75-200)	N/A	N/A	N/A
<b>Limestone</b> (fresh-moderate fracturing, little to no weathering)	1,035-2,070 (150-300)	N/A	N/A	N/A
<b>Sandstone</b> (fresh-moderate fracturing, little to no weathering)	520-1,725 (75.5-250)	N/A	N/A	N/A
<b>Granite and Basalt</b> (fresh- moderate fracturing, little to no weathering)	1,380-4,200 (200-609)	N/A	N/A	N/A

Type A: Gravity grout only

Type B: Pressure grouted through the casing during casing withdrawal

Type C: Primary grout placed under gravity head, then one phase of secondary “global” pressure grouting

Type D: Primary grout placed under gravity head, then one or more phases of secondary “global” pressure grouting

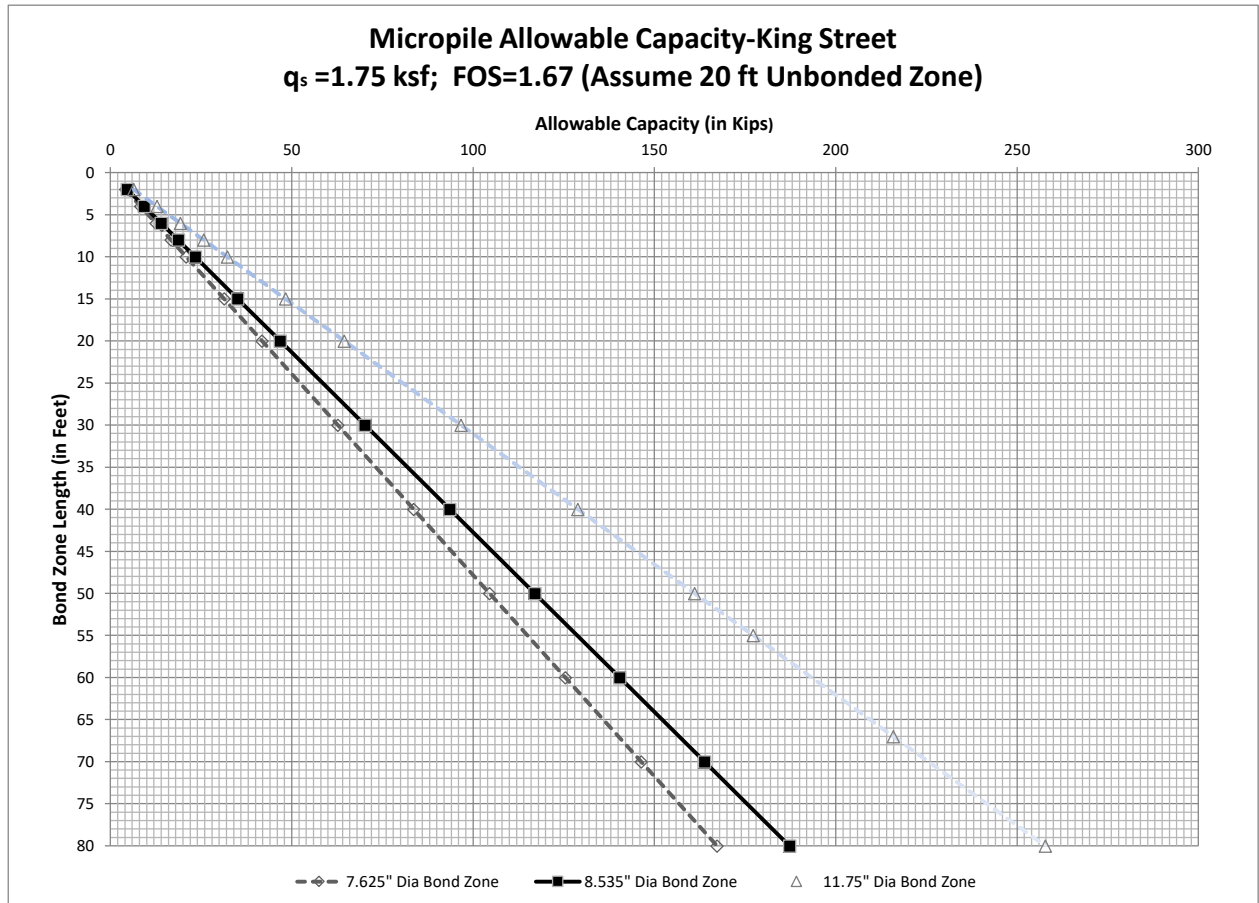
# Micropile Grout-Ground Resistance (Nominal and Factored)-AF to RO King Street Foundation

Prepared by MJS 9/13/2022  
 Checked by

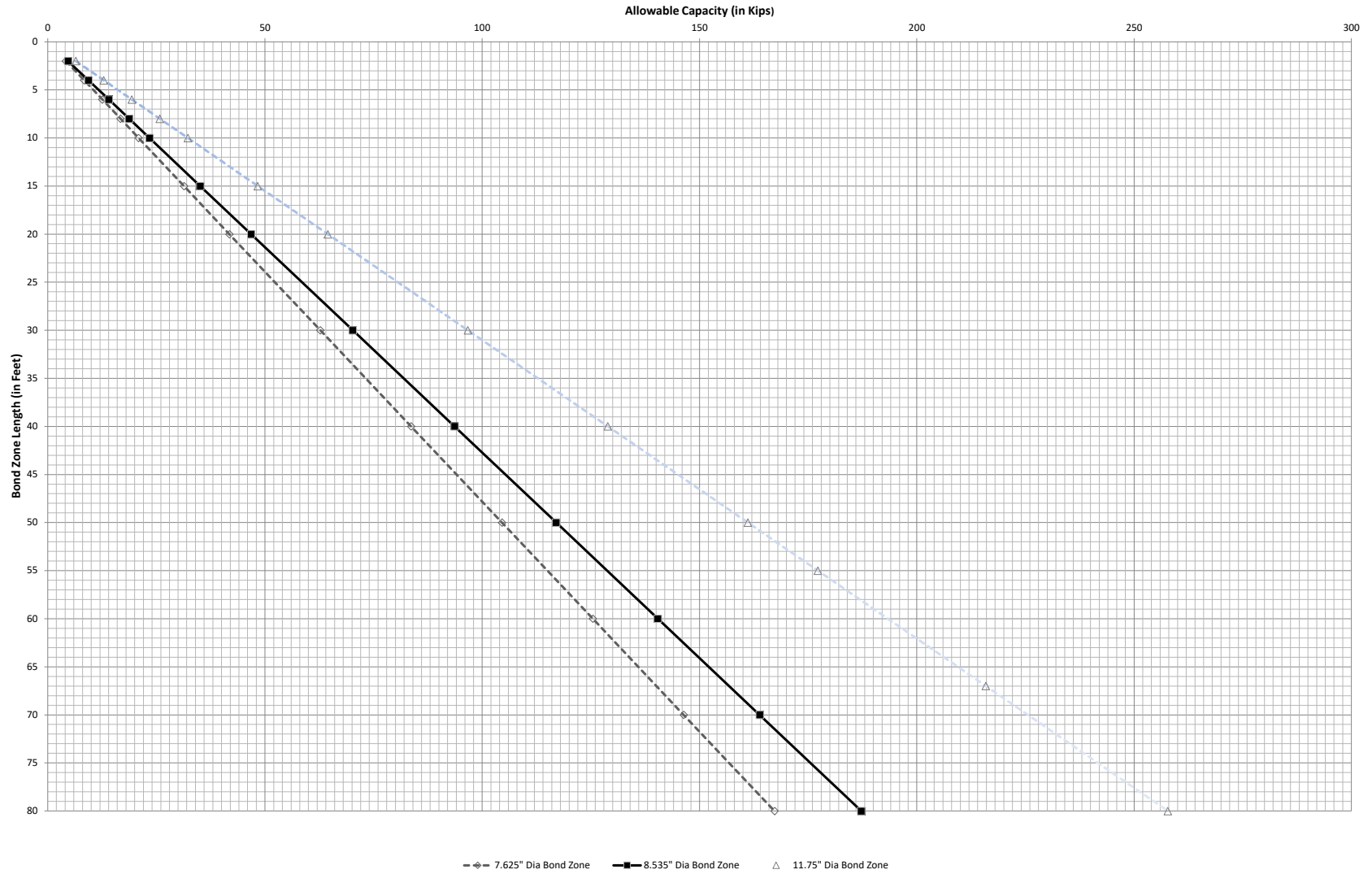
Ultimate Bond Unit Resistance = 1.7 ksf (very stiff clay)-Use Type B: pressure grouting during casing removal  
 = 12 psi  
 Factor of Safety 1.67 (Per CSX Specifications Section 070440)  
 Factored Unit Resistance = 7 psi

Bond Zone Diameter: 7.625 inches Bond Zone Perimeter: 23.9425 inches			Bond Zone Diameter: 8.535 inches Bond Zone Perimeter: 26.80 inches			Bond Zone Diameter: 11.75 inches Bond Zone Perimeter: 36.90 inches		
Bond Zone Length (Feet)	Nominal Resistance (kips)	Factored Resistance (kips)	Bond Zone Length (Feet)	Nominal Resistance (kips)	Factored Resistance (kips)	Bond Zone Length (Feet)	Nominal Resistance (kips)	Factored Resistance (kips)
2	7	4	2	8	5	2	11	6
4	14	8	4	16	9	4	22	13
6	21	13	6	23	14	6	32	19
8	28	17	8	31	19	8	43	26
10	35	21	10	39	23	10	54	32
15	52	31	15	59	35	15	81	48
20	70	42	20	78	47	20	108	64
30	105	63	30	117	70	30	161	97
40	140	84	40	156	94	40	215	129
50	175	105	50	195	117	50	269	161
60	209	125	60	234	140	55	296	177
70	244	146	70	274	164	67	360	216
80	279	167	80	313	187	80	430	258

Note: Must check pile for Structural Resistance vs Geotechnical Resistance in Bond Zone shown here



**Micropile Allowable Capacity-King Street**  
 **$q_s = 1.75$  ksf; FOS=1.67 (Assume 20 ft Unbonded Zone)**



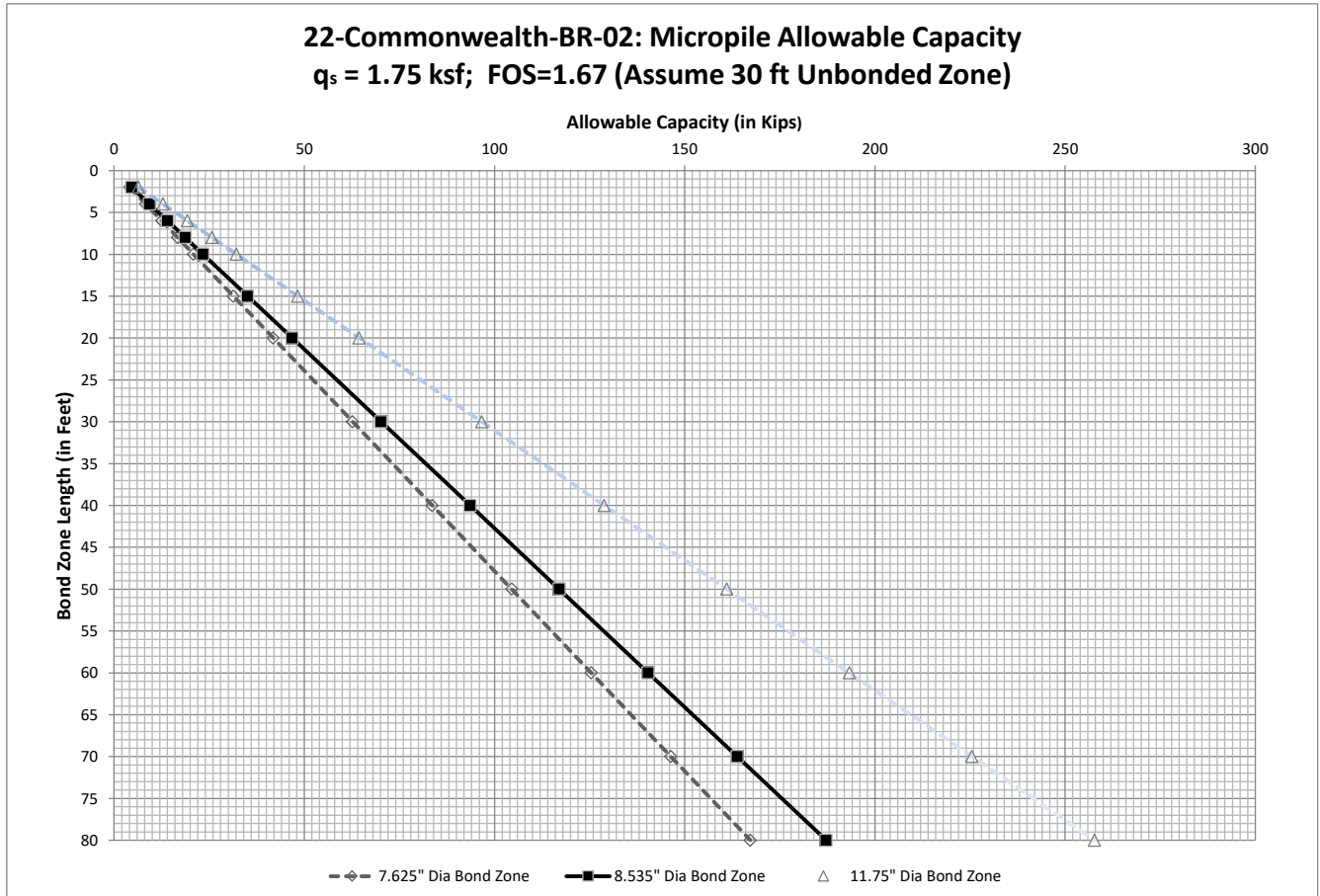
# Micropile Grout-Ground Resistance (Nominal and Factored)-AF to RO Commonwealth (22-Commonwealth-BR-02

Prepared by MJS 9/13/2022  
 Checked by

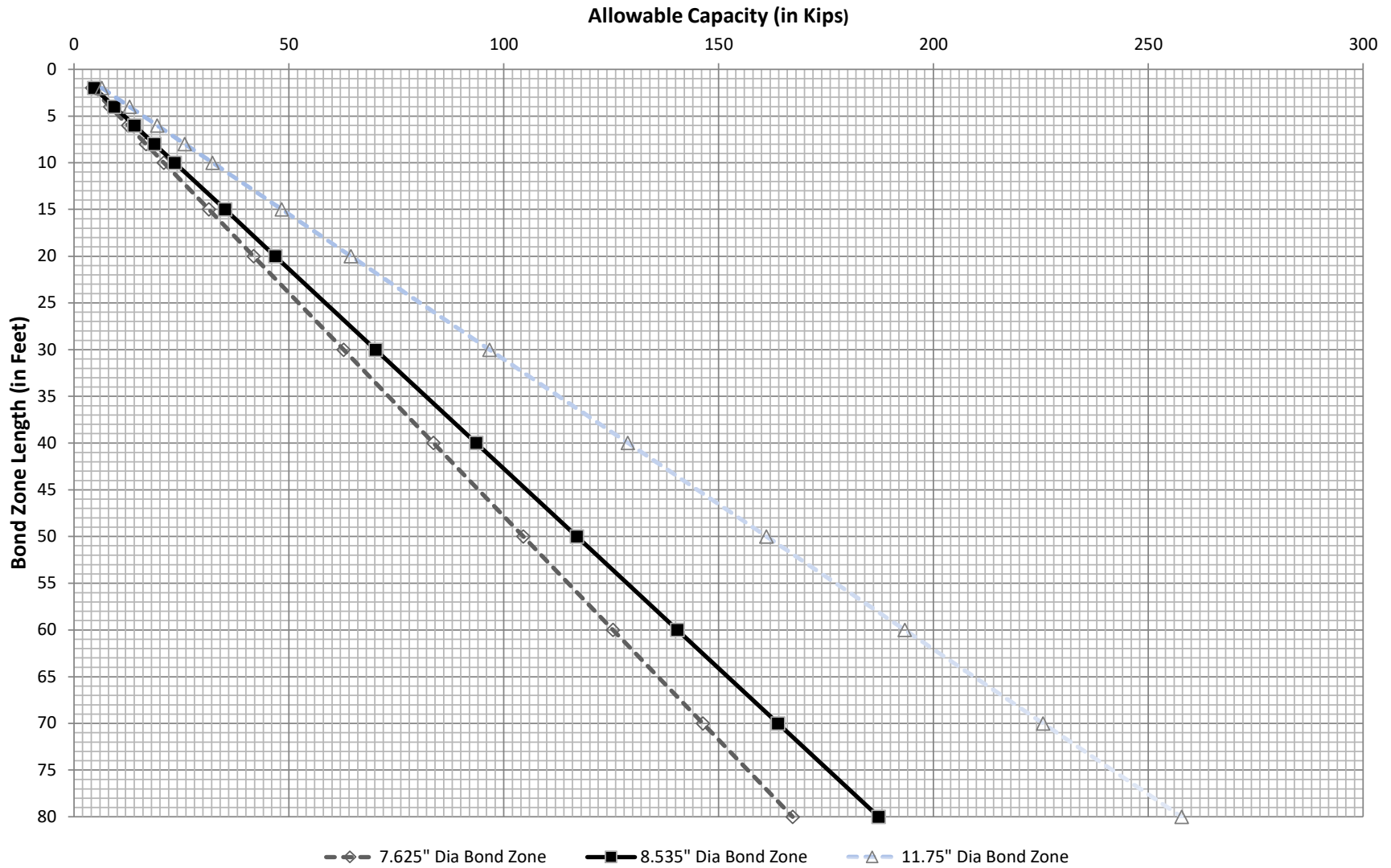
Ultimate Bond Unit Resistance = 1.7 ksf (very stiff clay)-Use Type B: pressure grouting during casing remove  
 = 12 psi  
 Factor of Safety 1.67 (Per CSX Specifications Section 070440)  
 Factored Unit Resistance = 7 psi

Bond Zone Diameter: 7.625 inches Bond Zone Perimeter: 23.9425 inches			Bond Zone Diameter: 8.535 inches Bond Zone Perimeter: 26.80 inches			Bond Zone Diameter: 11.75 inches Bond Zone Perimeter: 36.90 inches		
Bond Zone Length (Feet)	Nominal Resistance (kips)	Factored Resistance (kips)	Bond Zone Length (Feet)	Nominal Resistance (kips)	Factored Resistance (kips)	Bond Zone Length (Feet)	Nominal Resistance (kips)	Factored Resistance (kips)
2	7	4	2	8	5	2	11	6
4	14	8	4	16	9	4	22	13
6	21	13	6	23	14	6	32	19
8	28	17	8	31	19	8	43	26
10	35	21	10	39	23	10	54	32
15	52	31	15	59	35	15	81	48
20	70	42	20	78	47	20	108	64
30	105	63	30	117	70	30	161	97
40	140	84	40	156	94	40	215	129
50	175	105	50	195	117	50	269	161
60	209	125	60	234	140	60	323	193
70	244	146	70	274	164	70	377	226
80	279	167	80	313	187	80	430	258

Note: Must check pile for Structural Resistance vs Geotechnical Resistance in Bond Zone shown here



## 22-Commonwealth-BR-02: Micropile Allowable Capacity $q_s = 1.75$ ksf; FOS=1.67 (Assume 30 ft Unbonded Zone)





**Table 1: Summary of Lateral Pile Analysis for 12.75-inch Diameter Micropiles**

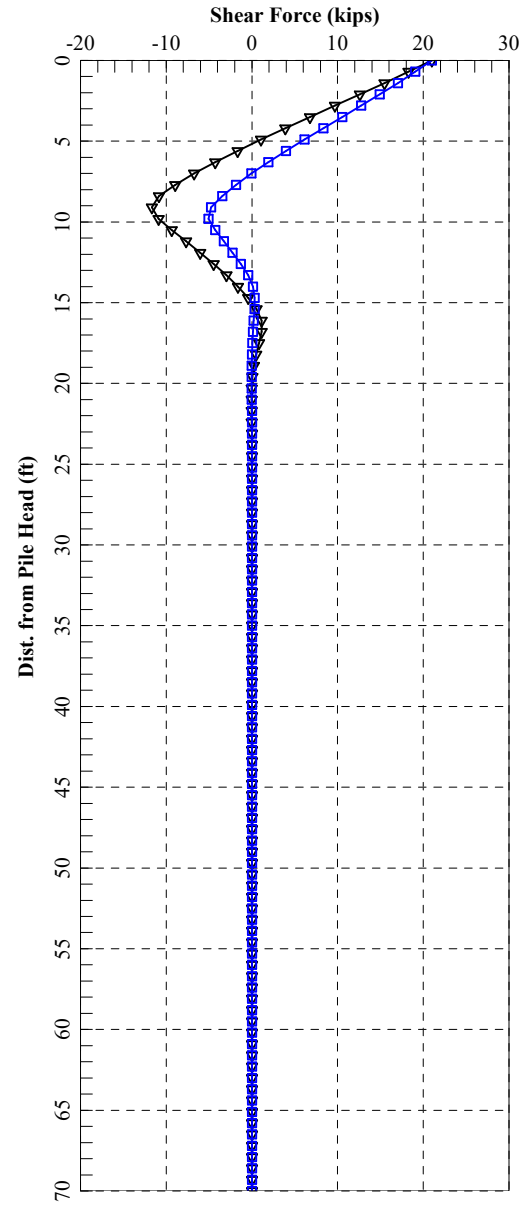
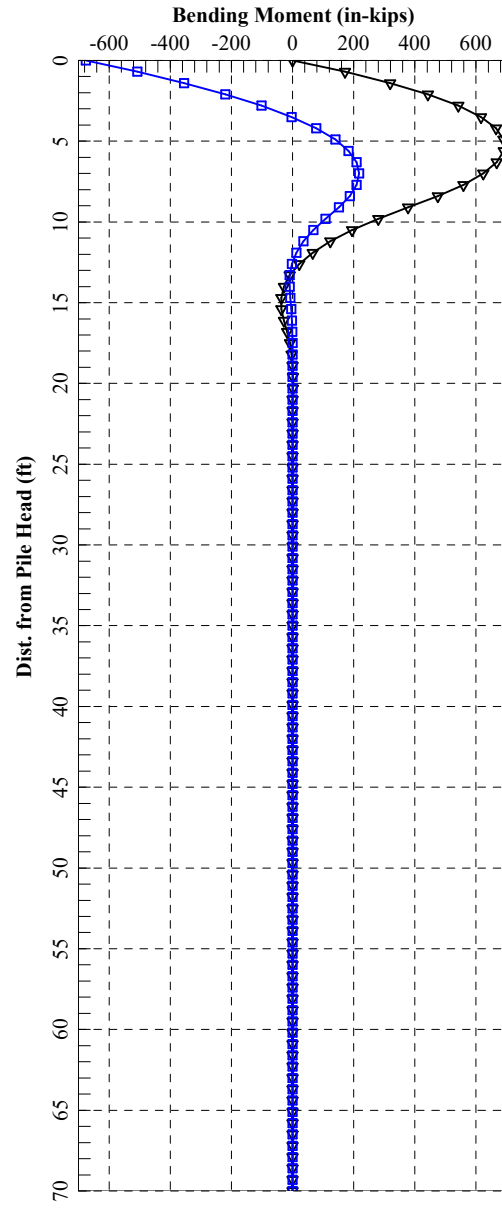
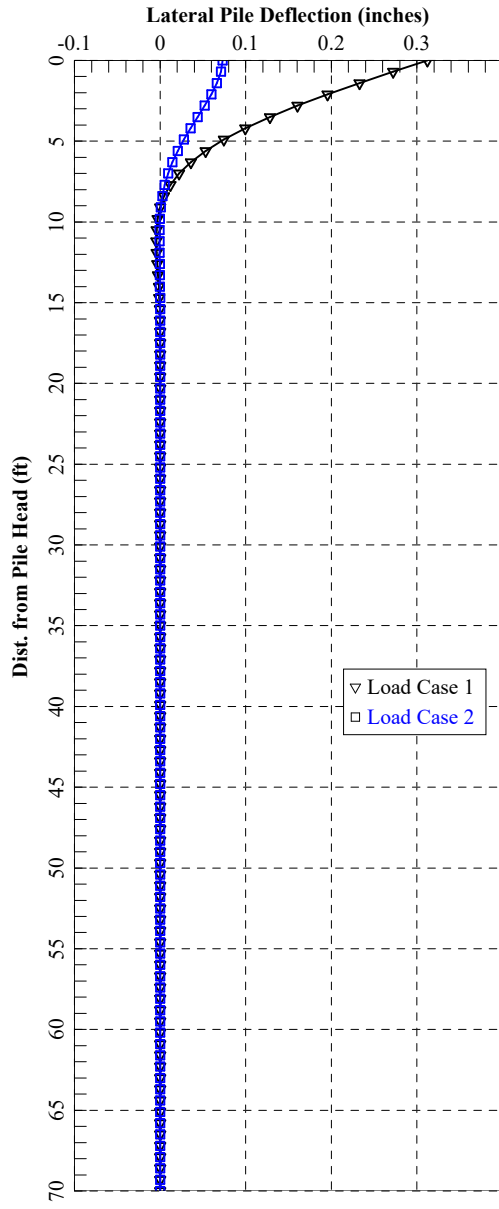
Foundation Location	Head Condition	Lateral Load (kips)	Max Top Deflection (inch)	Max Moment (kip-ft)	Max Shear (kips)	Depth to Point of Fixity (ft)
King	Free	21	0.31	58	12	16
	Fixed		0.07	56	4	15
Commonwealth	Free	22	1.49	112.8	14	25
	Fixed		0.34	96.8	4	25

<sup>1</sup> Assumes reduced area of piles due to corrosion.

<sup>2</sup> Assumes group reduction (p-y) factor of 0.5 within based on average p-y factor for 3D spacing and 3 rows of piles.

<sup>3</sup> Based on second point of zero deflection

King Street\_12.75-inch diameter Micropile



=====  
LPile for Windows, Version 2022-12.007

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

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

Path to file locations:

\GEOTECH\Projects\10331846 - DRPT CSX AF to R0 Widening\5 Design\4  
Analysis\Bridges\King&Commonwealth\Analysis\KingStreet\90%\

Name of input data file:

KingStreetMicropile 092523.lp12d

Name of output report file:

KingStreetMicropile 092523.lp12o

Name of plot output file:

KingStreetMicropile 092523.lp12p

Name of runtime message file:

KingStreetMicropile 092523.lp12r

-----  
Date and Time of Analysis  
-----

Date: September 25, 2023

Time: 22:02:33  
-----

Problem Title

---

Project Name: King Street bridge

Job Number:

Client: CSX

Engineer: SM

12.75-inch OD Micropile\_Embedment4feet

---

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:

- Cyclic loading specified
- Number of cycles of loading = 100 cycles
- Analysis uses p-y modification factors for p-y curves
- Analysis uses layering correction (Method of Georgiadis)
- No distributed lateral loads are entered
- 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 = 2  
Total length of pile = 70.000 ft  
Depth of ground surface below top of pile = -4.0000 ft

Pile diameters used for p-y curve computations are defined using 4 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	12.6800
2	20.000	12.6800
3	20.000	11.7500
4	70.000	11.7500

Input Structural Properties for Pile Sections:  
-----

Pile Section No. 1:

Section 1 is a drilled shaft with permanent casing

Length of section = 20.000000 ft  
Casing outside diameter = 12.680000 in

Pile Section No. 2:

Section 2 is a round drilled shaft, bored pile, or CIDH pile

Length of section = 50.000000 ft  
Shaft Diameter = 11.750000 in

-----  
Soil and Rock Layering Information  
-----

The soil profile is modelled using 2 layers

Layer 1 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer = -4.00000 ft  
Distance from top of pile to bottom of layer = -1.00000 ft  
Effective unit weight at top of layer = 65.000000 pcf  
Effective unit weight at bottom of layer = 65.000000 pcf  
Friction angle at top of layer = 36.000000 deg.  
Friction angle at bottom of layer = 36.000000 deg.  
Subgrade k at top of layer = 90.000000 pci  
Subgrade k at bottom of layer = 90.000000 pci

Layer 2 is stiff clay without free water

Distance from top of pile to top of layer = -1.00000 ft  
 Distance from top of pile to bottom of layer = 83.000000 ft  
 Effective unit weight at top of layer = 65.000000 pcf  
 Effective unit weight at bottom of layer = 65.000000 pcf  
 Undrained cohesion at top of layer = 3000. psf  
 Undrained cohesion at bottom of layer = 3000. psf  
 Epsilon-50 at top of layer = 0.005000  
 Epsilon-50 at bottom of layer = 0.005000

(Depth of the lowest soil layer extends 13.000 ft below the pile tip)

-----  
 Summary of Input Soil Properties  
 -----

Layer Num.	Soil Type Name (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Cohesion psf	Angle of Friction deg.	E50 or krm
1	Sand	-4.000	65.0000	--	36.0000	--
90.0000	(Reese, et al.)	-1.000	65.0000	--	36.0000	--
90.0000	2 Stiff Clay	-1.000	65.0000	3000.	--	0.00500
--	w/o Free Water	83.0000	65.0000	3000.	--	0.00500
--						

-----  
 Modification Factors for p-y Curves  
 -----

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

Point No.	Depth X ft	p-mult	y-mult
1	0.000	0.5000	1.0000
2	100.000	0.5000	1.0000

-----  
 Cyclic Loading Type  
 -----

Cyclic loading criteria were used for computation of p-y curves for all analyses.

Number of cycles of loading = 100

-----  
Pile-head Loading and Pile-head Fixity Conditions  
-----

Number of loads specified = 2

Load Run No.	Load Analysis Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length
1	1 Yes	V = 21000. lbs	M = 0.0000 in-lbs	154000.	No
2	2 Yes	V = 21000. lbs	S = 0.0000 in/in	154000.	No

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 = 2

Pile Section No. 1:  
-----

Dimensions and Properties of Drilled Shaft (Bored Pile) with Permanent Casing:  
-----

Length of Section	=	20.000000 ft
Outer Diameter of Casing	=	12.680000 in
Concrete Cover Thickness Inside Casing	=	3.000000 in
Casing Wall Thickness	=	0.465000 in
Moment of Inertia of Steel Casing	=	333.289908 in^4
Yield Stress of Casing	=	45000. psi
Elastic Modulus of Casing	=	29000000. psi
Number of Reinforcing Bars	=	1 bar
Area of Single Reinforcing Bar	=	4.908739 sq. in.
Edge-to-Edge Bar Spacing	=	-2.50000 in
Maximum Concrete Aggregate Size	=	0.750000 in

Ratio of Bar Spacing to Aggregate Size = -3.33  
 Offset of Center of Rebar Cage from Center of Pile = 0.0000 in  
 Yield Stress of Reinforcing Bars = 75000. psi  
 Modulus of Elasticity of Reinforcing Bars = 29000000. psi  
 Gross Area of Pile = 126.278202 sq. in.  
 Area of Concrete = 103.525295 sq. in.  
 Cross-sectional Area of Steel Casing = 17.844168 sq. in.  
 Area of All Steel (Casing and Bars) = 22.752906 sq. in.  
 Area Ratio of All Steel to Gross Area of Pile = 18.02 percent

Axial Structural Capacities:  
-----

Nom. Axial Structural Capacity =  $0.85 F_c A_c + F_y A_s$  = 1523.129 kips  
 Tensile Load for Cracking of Concrete = -119.182 kips  
 Nominal Axial Tensile Capacity = -1171.143 kips

Reinforcing Bar Dimensions and Positions Used in Computations:

Bar Number	Bar Diam. inches	Bar Area sq. in.	X inches	Y inches
1	2.500000	4.908739	0.000000	0.000000

NOTE: The positions of the above rebars were computed by LPILE

Concrete Properties:  
-----

Compressive Strength of Concrete = 4000. psi  
 Modulus of Elasticity of Concrete = 3604997. psi  
 Modulus of Rupture of Concrete = -474.34165 psi  
 Compression Strain at Peak Stress = 0.001886  
 Tensile Strain at Fracture of Concrete = -0.0001154  
 Maximum Coarse Aggregate Size = 0.750000 in

Number of Axial Thrust Force Values Determined from Pile-head Loadings = 1

Number	Axial Thrust Force kips
1	154.000

Definitions of Run Messages and Notes:  
-----

- C = concrete in section has cracked in tension.
- Y = stress in reinforcing steel has reached yield stress.
- T = ACI 318 criteria for tension-controlled section met, tensile strain in reinforcement exceeds 0.005 while simultaneously compressive strain in concrete more than 0.003. See ACI 318-14, Section 21.2.3.
- Z = depth of tensile zone in concrete section is less than 10 percent of section depth.

Bending Stiffness (EI) = Computed Bending Moment / Curvature.  
 Position of neutral axis is measured from edge of compression side of pile.  
 Compressive stresses and strains are positive in sign.  
 Tensile stresses and strains are negative in sign.

Axial Thrust Force = 154.000 kips

Bending Max Steel Curvature Stress rad/in. ksi	Bending Max Casing Moment Stress in-kip ksi	Run Msg	Bending Stiffness kip-in2	Depth to N Axis in	Max Comp Strain in/in	Max Tens Strain in/in	Max Conc Stress ksi
0.00000125	16.7293229		13383458.	120.1683487	0.0001502	0.0001344	0.6113930
4.1699444	4.3538044						
0.00000250	33.4586217		13383449.	63.2560214	0.0001581	0.0001264	0.6419685
4.2137451	4.5814651						
0.00000375	50.1878719		13383433.	44.2860665	0.0001661	0.0001185	0.6724173
4.2576350	4.8092150						
0.00000500	66.9170494		13383410.	34.8017048	0.0001740	0.0001106	0.7027393
4.3016142	5.0370542						
0.00000625	83.6461299		13383381.	29.1115803	0.0001819	0.0001027	0.7329344
4.3456827	5.2649827						
0.00000750	100.3750893		13383345.	25.3185745	0.0001899	0.00009479	0.7630023
4.3898405	5.4930005						
0.00000875	117.1039032		13383303.	22.6096364	0.0001978	0.00008688	0.7929428
4.4340875	5.7211075						
0.00001000	133.8325474		13383255.	20.5782407	0.0002058	0.00007898	0.8227559
4.4784238	5.9493038						
0.00001125	150.5609977		13383200.	18.9985399	0.0002137	0.00007108	0.8524414
4.5228494	6.1775894						
0.00001250	167.2892298		13383138.	17.7350256	0.0002217	0.00006319	0.8819990
4.5673643	6.4059643						
0.00001375	184.0172195		13383071.	16.7014650	0.0002296	0.00005530	0.9114287
4.6119685	6.6344285						
0.00001500	200.7449425		13382996.	15.8403698	0.0002376	0.00004741	0.9407303
4.6566619	6.8629819						
0.00001625	217.4723746		13382915.	15.1119403	0.0002456	0.00003952	0.9699036
4.7014447	7.0916247						
0.00001750	234.1994916		13382828.	14.4877481	0.0002535	0.00003164	0.9989484
4.7463167	7.3203567						
0.00001875	250.9262692		13382734.	13.9469457	0.0002615	0.00002376	1.0278646
4.7912780	7.5491780						
0.00002000	267.6526832		13382634.	13.4738975	0.0002695	0.00001588	1.0566520
4.8363286	7.7780886						
0.00002125	284.3787092		13382527.	13.0566470	0.0002775	0.00000800	1.0853105
4.8814685	8.0070885						
0.00002250	301.1043231		13382414.	12.6858945	0.0002854	1.32627E-07	1.1138398
4.9266977	8.2361777						
0.00002375	317.8295006		13382295.	12.3542983	0.0002934	-0.00000774	1.1422399
4.9720162	8.4653562						
0.00002500	334.5542005		13382168.	12.0559847	0.0003014	-0.00001560	1.1705106
5.0174240	8.6946240						
0.00002625	351.2779616		13382018.	11.7861964	0.0003094	-0.00002346	1.1986513

5.0629189	8.9239789					
0.00002750	367.9996643	13381806.	11.5410368	0.0003174	-0.00003132	1.2266614
5.1084954	9.1534154					
0.00002875	384.7180550	13381498.	11.3172858	0.0003254	-0.00003918	1.2545399
5.1541474	9.3829274					
0.00003000	401.4319397	13381065.	11.1122601	0.0003334	-0.00004703	1.2822859
5.1998684	9.6125084					
0.00003125	418.1402630	13380488.	10.9237061	0.0003414	-0.00005488	1.3098985
5.2456525	9.8421525					
0.00003250	434.8420707	13379756.	10.7497174	0.0003494	-0.00006273	1.3373770
5.2914942	10.0718542					
0.00003375	451.5365595	13378861.	10.5886707	0.0003574	-0.00007058	1.3647207
5.3373888	10.3016088					
0.00003500	468.2230165	13377800.	10.4391749	0.0003654	-0.00007843	1.3919290
5.3833317	10.5314117					
0.00003625	484.9008269	13376575.	10.3000314	0.0003734	-0.00008627	1.4190014
5.4293189	10.7612589					
0.00003750	501.5694657	13375186.	10.1702017	0.0003814	-0.00009412	1.4459372
5.4753469	10.9911469					
0.00003875	518.2284772	13373638.	10.0487816	0.0003894	-0.000102	1.4727361
5.5214127	11.2210727					
0.00004000	534.8774653	13371937.	9.9349802	0.0003974	-0.000110	1.4993978
5.5675132	11.4510332					
0.00004125	538.0297456	13043145.	9.7635870	0.0004027	-0.000120	1.5170370
5.5364688	11.6038488 C					
0.00004250	552.8756636	13008839.	9.6559313	0.0004104	-0.000129	1.5422008
5.5715549	11.8227949 C					
0.00004375	567.6531942	12974930.	9.5540568	0.0004180	-0.000137	1.5671828
5.6061709	12.0412709 C					
0.00004500	582.3619721	12941377.	9.4574676	0.0004256	-0.000145	1.5919817
5.6402984	12.2592584 C					
0.00004625	596.9990342	12908087.	9.3657000	0.0004332	-0.000153	1.6165931
5.6738900	12.4767100 C					
0.00004750	611.5882549	12875542.	9.2785157	0.0004407	-0.000162	1.6410400
5.7071419	12.6938219 C					
0.00004875	626.1353916	12843803.	9.1955966	0.0004483	-0.000170	1.6653283
5.7401030	12.9106430 C					
0.00005125	655.0595484	12781650.	9.0409904	0.0004634	-0.000186	1.7133796
5.8046838	13.3429438 C					
0.00005375	683.8212911	12722257.	8.8999687	0.0004784	-0.000203	1.7607952
5.8680217	13.7740017 C					
0.00005625	712.4408794	12665616.	8.7708054	0.0004934	-0.000220	1.8075945
5.9302552	14.2039552 C					
0.00005875	740.9356836	12611671.	8.6520611	0.0005083	-0.000237	1.8537948
5.9915115	14.6329315 C					
0.00006125	769.3222456	12560363.	8.5425368	0.0005232	-0.000253	1.8994141
6.0519268	15.0610668 C					
0.00006375	797.6077337	12511494.	8.4411692	0.0005381	-0.000270	1.9444593
6.1115410	15.4884010 C					
0.00006625	825.7928613	12464798.	8.3470114	0.0005530	-0.000287	1.9889285
6.1703085	15.9148885 C					
0.00006875	853.9072388	12420469.	8.2594463	0.0005678	-0.000304	2.0328592
6.2285675	16.3408675 C					
0.00007125	881.9639438	12378441.	8.1778599	0.0005827	-0.000321	2.0762700
6.2864829	16.7665029 C					
0.00007375	909.9273434	12337998.	8.1013957	0.0005975	-0.000338	2.1191086
6.3435236	17.1912636 C					
0.00007625	937.8511892	12299688.	8.0298817	0.0006123	-0.000355	2.1614509

6.4004229	17.6158829 C						
0.00007875	965.7096449	12262980.	7.9626772	0.0006271	-0.000371	2.2032595	
6.4567946	18.0399746 C						
0.00008125	993.5246735	12227996.	7.8995126	0.0006418	-0.000388	2.2445653	
6.5129405	18.4638405 C						
0.00008375	1021.	12194449.	7.8399522	0.0006566	-0.000405	2.2853520	
6.5686813	18.8873013 C						
0.00008625	1049.	12162470.	7.7838166	0.0006714	-0.000422	2.3256527	
6.6243522	19.3106922 C						
0.00008875	1077.	12131629.	7.7306417	0.0006861	-0.000439	2.3654255	
6.6795036	19.7335636 C						
0.00009125	1104.	12102280.	7.6804458	0.0007008	-0.000456	2.4047362	
6.7348277	20.1566077 C						
0.00009375	1132.	12073881.	7.6327241	0.0007156	-0.000473	2.4435182	
6.7896003	20.5791003 C						
0.00009625	1159.	12046674.	7.5874836	0.0007303	-0.000490	2.4818234	
6.8443785	21.0015985 C						
0.00009875	1187.	12020661.	7.5445936	0.0007450	-0.000507	2.5196666	
6.8993284	21.4242684 C						
0.0001013	1215.	11995356.	7.5036086	0.0007597	-0.000524	2.5569773	
6.9536527	21.8463127 C						
0.0001038	1242.	11971095.	7.4646555	0.0007745	-0.000541	2.5938265	
7.0081478	22.2685278 C						
0.0001063	1269.	11947805.	7.4275911	0.0007892	-0.000558	2.6302138	
7.0628140	22.6909140 C						
0.0001088	1297.	11925202.	7.3921232	0.0008039	-0.000575	2.6660955	
7.1171411	23.1129611 C						
0.0001113	1324.	11903371.	7.3582430	0.0008186	-0.000592	2.7014993	
7.1714476	23.5349876 C						
0.0001138	1352.	11882339.	7.3259039	0.0008333	-0.000609	2.7364409	
7.2259251	23.9571851 C						
0.0001163	1379.	11862055.	7.2950065	0.0008480	-0.000626	2.7709198	
7.2805737	24.3795537 C						
0.0001188	1406.	11842279.	7.2653014	0.0008628	-0.000643	2.8048919	
7.3348482	24.8015482 C						
0.0001213	1434.	11823138.	7.2368460	0.0008775	-0.000660	2.8383948	
7.3892099	25.2236299 C						
0.0001238	1461.	11804623.	7.2095881	0.0008922	-0.000677	2.8714346	
7.4437429	25.6458829 C						
0.0001263	1488.	11786696.	7.1834566	0.0009069	-0.000694	2.9040110	
7.4984476	26.0683076 C						
0.0001288	1515.	11769283.	7.1583504	0.0009216	-0.000711	2.9361132	
7.5531914	26.4907714 C						
0.0001313	1542.	11752270.	7.1341326	0.0009364	-0.000728	2.9677188	
7.6076732	26.9129732 C						
0.0001338	1570.	11735756.	7.1108644	0.0009511	-0.000745	2.9988606	
7.6623303	27.3353503 C						
0.0001363	1597.	11719713.	7.0884938	0.0009658	-0.000762	3.0295379	
7.7171598	27.7578998 C						
0.0001388	1624.	11704115.	7.0669722	0.0009805	-0.000779	3.0597501	
7.7721620	28.1806220 C						
0.0001413	1651.	11688939.	7.0462548	0.0009953	-0.000796	3.0894966	
7.8273372	28.6035172 C						
0.0001438	1678.	11674097.	7.0262320	0.0010100	-0.000813	3.1187575	
7.8824046	29.0263046 C						
0.0001463	1705.	11659585.	7.0068828	0.0010248	-0.000830	3.1475374	
7.9374252	29.4490452 C						
0.0001488	1732.	11645437.	6.9882242	0.0010395	-0.000847	3.1758511	

7.9926195	29.8719595 C						
0.0001588	1840.	11592132.	6.9198458	0.0010985	-0.000914	3.2844319	
8.2151417	31.5653617 C						
0.0001688	1948.	11543117.	6.8598382	0.0011576	-0.000982	3.3854209	
8.4389695	33.2600695 C						
0.0001788	2055.	11497866.	6.8070414	0.0012168	-0.001050	3.4788673	
8.6653715	34.9573515 C						
0.0001888	2162.	11455708.	6.7602180	0.0012760	-0.001117	3.5647119	
8.8938477	36.6567077 C						
0.0001988	2269.	11416173.	6.7184799	0.0013353	-0.001185	3.6429300	
9.1244770	38.3582170 C						
0.0002088	2375.	11378959.	6.6812213	0.0013947	-0.001252	3.7135217	
9.3580165	40.0626365 C						
0.0002188	2481.	11343705.	6.6477759	0.0014542	-0.001320	3.7764359	
9.5941353	41.7696353 C						
0.0002288	2587.	11310098.	6.6175672	0.0015138	-0.001387	3.8316220	
9.8323270	43.4787070 C						
0.0002388	2692.	11276980.	6.5905343	0.0015735	-0.001454	3.8791126	
10.0749868	45.0000000 CY						
0.0002488	2793.	11226870.	6.5699944	0.0016343	-0.001520	3.9194012	
10.3488061	45.0000000 CY						
0.0002588	2883.	11141793.	6.5586939	0.0016971	-0.001584	3.9524713	
10.6800417	45.0000000 CY						
0.0002688	2960.	11012480.	6.5503194	0.0017604	-0.001647	3.9770393	
11.0275280	45.0000000 CY						
0.0002788	3023.	10843760.	6.5390847	0.0018228	-0.001712	3.9925923	
11.3470372	45.0000000 CY						
0.0002888	3075.	10648847.	6.5256310	0.0018843	-0.001777	3.9995366	
11.6414473	45.0000000 CY						
0.0002988	3120.	10444691.	6.5118201	0.0019454	-0.001843	3.9992748	
11.9249603	45.0000000 CY						
0.0003088	3160.	10235207.	6.4980751	0.0020063	-0.001909	3.9996746	
12.2010527	45.0000000 CY						
0.0003188	3196.	10025316.	6.4849342	0.0020671	-0.001975	3.9999987	
12.4747571	45.0000000 CY						
0.0003288	3227.	9816165.	6.4720308	0.0021277	-0.002041	3.9990186	
12.7431050	45.0000000 CY						
0.0003388	3255.	9610104.	6.4597486	0.0021882	-0.002107	3.9995421	
13.0100706	45.0000000 CY						
0.0003488	3281.	9408102.	6.4481100	0.0022488	-0.002173	3.9997989	
13.2764218	45.0000000 CY						
0.0003588	3304.	9210758.	6.4370810	0.0023093	-0.002240	3.9999065	
13.5423652	45.0000000 CY						
0.0003688	3326.	9018493.	6.4266272	0.0023698	-0.002306	3.9999383	
13.8080623	45.0000000 CY						
0.0003788	3345.	8831188.	6.4169348	0.0024304	-0.002372	3.9999253	
14.0760593	45.0000000 CY						
0.0003888	3362.	8649415.	6.4077804	0.0024910	-0.002438	3.9998535	
14.3444997	45.0000000 CY						
0.0003988	3379.	8473286.	6.3990757	0.0025516	-0.002505	3.9996666	
14.6128306	45.0000000 CY						
0.0004088	3394.	8302781.	6.3908261	0.0026123	-0.002571	3.9992662	
14.8815081	45.0000000 CY						
0.0004188	3407.	8137289.	6.3832824	0.0026730	-0.002637	3.9985200	
15.1539727	45.0000000 CY						
0.0004288	3420.	7977073.	6.3759162	0.0027337	-0.002703	3.9985145	
15.4242700	45.0000000 CY						
0.0004388	3432.	7822134.	6.3691016	0.0027944	-0.002769	3.9998925	

15.6973115	45.0000000	CY					
0.0004488	3443.		7672266.	6.3629331	0.0028554	-0.002835	3.9991997
15.9748096	45.0000000	CY					
0.0004588	3453.		7527152.	6.3567497	0.0029162	-0.002901	3.9975955
16.2485325	45.0000000	CY					
0.0004688	3462.		7386559.	6.3513025	0.0029772	-0.002967	3.9999151
16.5286764	45.0000000	CY					
0.0004788	3471.		7250909.	6.3460161	0.0030382	-0.003032	3.9988579
16.8078926	45.0000000	CY					
0.0004888	3479.		7119042.	6.3411788	0.0030993	-0.003098	3.9985901
17.0904072	45.0000000	CY					
0.0004988	3487.		6991984.	6.3366539	0.0031604	-0.003164	3.9994401
-17.471437	45.0000000	CY					
0.0005088	3494.		6868301.	6.3323466	0.0032216	-0.003229	3.9970016
-17.885282	45.0000000	CY					
0.0005188	3501.		6749067.	6.3284693	0.0032829	-0.003295	3.9996520
-18.295165	45.0000000	CY					
0.0005288	3507.		6633075.	6.3246115	0.0033441	-0.003360	3.9971152
-18.706998	45.0000000	CY					
0.0005388	3513.		6520971.	6.3213005	0.0034056	-0.003426	3.9996468
-19.112524	45.0000000	CY					
0.0005488	3519.		6412199.	6.3178216	0.0034669	-0.003491	3.9966569
-19.522644	45.0000000	CY					
0.0006088	3545.		5824113.	6.3027708	0.0038368	-0.003882	3.9996441
-21.922941	45.0000000	CY					

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Summary of Results for Nominal Moment Capacity for Section 1  
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Moment values interpolated at maximum compressive strain = 0.003  
or maximum developed moment if pile fails at smaller strains.

Load No.	Axial Thrust kips	Nominal Mom. Cap. in-kip	Max. Comp. Strain	Max. Tens. Strain
1	154.000	3465.790	0.00300000	-0.00299121

Note that the values of moment capacity in the table above are not factored by a strength reduction factor (phi-factor).

In ACI 318, the value of the strength reduction factor depends on whether the transverse reinforcing steel bars are tied hoops (0.65) or spirals (0.75).

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to ACI 318, or the value required by the design standard being followed.

The following table presents factored moment capacities and corresponding bending stiffnesses computed for common resistance factor values used for reinforced concrete sections.

Axial Load No.	Resist. Factor	Nominal Ax. Thrust kips	Nominal Moment Cap in-kips	Ult. (Fac) Ax. Thrust kips	Ult. (Fac) Moment Cap in-kips	Bend. Stiff. at Ult Mom kip-in <sup>2</sup>
1	0.65	154.000000	3466.	100.100000	2253.	11422176.

1	0.75	154.000000	3466.	115.500000	2599.	11306271.
1	0.90	154.000000	3466.	138.600000	3119.	10449810.

Pile Section No. 2:

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Dimensions and Properties of Drilled Shaft (Bored Pile):

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Length of Section	=	50.000000 ft
Shaft Diameter	=	11.750000 in
Concrete Cover Thickness (to edge of long. rebar)	=	2.610000 in
Number of Reinforcing Bars	=	1 bar
Yield Stress of Reinforcing Bars	=	75000. psi
Modulus of Elasticity of Reinforcing Bars	=	29000000. psi
Gross Area of Shaft	=	108.434034 sq. in.
Total Area of Reinforcing Steel	=	4.908739 sq. in.
Area Ratio of Steel Reinforcement	=	4.53 percent
Edge-to-Edge Bar Spacing	=	-2.50000 in
Maximum Concrete Aggregate Size	=	0.750000 in
Ratio of Bar Spacing to Aggregate Size	=	-3.33
Offset of Center of Rebar Cage from Center of Pile	=	0.0000 in

Axial Structural Capacities:

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Nom. Axial Structural Capacity = $0.85 F_c A_c + F_y A_s$	=	720.141 kips
Tensile Load for Cracking of Concrete	=	-59.481 kips
Nominal Axial Tensile Capacity	=	-368.155 kips

Reinforcing Bar Dimensions and Positions Used in Computations:

Bar Number	Bar Diam. inches	Bar Area sq. in.	X inches	Y inches
1	2.500000	4.908739	0.00000	0.00000

NOTE: The positions of the above rebars were computed by LPile

Concrete Properties:

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Compressive Strength of Concrete	=	4000. psi
Modulus of Elasticity of Concrete	=	3604997. psi
Modulus of Rupture of Concrete	=	-474.34165 psi
Compression Strain at Peak Stress	=	0.001886
Tensile Strain at Fracture of Concrete	=	-0.0001154
Maximum Coarse Aggregate Size	=	0.750000 in

Number of Axial Thrust Force Values Determined from Pile-head Loadings = 1

Number	Axial Thrust Force kips
1	154.000

Definitions of Run Messages and Notes:

C = concrete in section has cracked in tension.  
 Y = stress in reinforcing steel has reached yield stress.  
 T = ACI 318 criteria for tension-controlled section met, tensile strain in reinforcement exceeds 0.005 while simultaneously compressive strain in concrete more than 0.003. See ACI 318-14, Section 21.2.3.  
 Z = depth of tensile zone in concrete section is less than 10 percent of section depth.

Bending Stiffness (EI) = Computed Bending Moment / Curvature.  
 Position of neutral axis is measured from edge of compression side of pile.  
 Compressive stresses and strains are positive in sign.  
 Tensile stresses and strains are negative in sign.

Axial Thrust Force = 154.000 kips

Bending Max Steel Run Curvature Stress rad/in. ksi	Bending Moment in-kip	Bending Stiffness kip-in <sup>2</sup>	Depth to N Axis in	Max Comp Strain in/in	Max Tens Strain in/in	Max Conc Stress ksi
0.00000125 8.1831559	4.2839843	3427187.	230.3834826	0.0002880	0.0002733	1.1278721
0.00000250 8.2281559	8.5679185	3427167.	118.1330555	0.0002953	0.0002660	1.1539751
0.00000375 8.2733402	12.8517526	3427134.	80.7179416	0.0003027	0.0002586	1.1799815
0.00000500 8.3187089	17.1354365	3427087.	62.0116562	0.0003101	0.0002513	1.2058912
0.00000625 8.3642619	21.4189202	3427027.	50.7889021	0.0003174	0.0002440	1.2317036
0.00000750 8.4099994	25.7021537	3426954.	43.3079137	0.0003248	0.0002367	1.2574187
0.00000875 8.4559212	29.9850867	3426867.	37.9650772	0.0003322	0.0002294	1.2830359
0.00001000 8.5020273	34.2676694	3426767.	33.9585856	0.0003396	0.0002221	1.3085551
0.00001125 8.5483179	38.5498515	3426653.	30.8429907	0.0003470	0.0002148	1.3339758
0.00001250 8.5947929	42.8315831	3426527.	28.3510236	0.0003544	0.0002075	1.3592979
0.00001375 8.6414524	47.1128140	3426386.	26.3126039	0.0003618	0.0002002	1.3845210
0.00001500 8.6882963	51.3934942	3426233.	24.6143448	0.0003692	0.0001930	1.4096447
0.00001625	55.6735735	3426066.	23.1777478	0.0003766	0.0001857	1.4346687

8.7353246						
0.00001750	59.9530018	3425886.	21.9467424	0.0003841	0.0001784	1.4595929
8.7825374						
0.00001875	64.2317290	3425692.	20.8802104	0.0003915	0.0001712	1.4844167
8.8299348						
0.00002000	68.5097051	3425485.	19.9473131	0.0003989	0.0001639	1.5091400
8.8775167						
0.00002125	72.7868797	3425265.	19.1244679	0.0004064	0.0001567	1.5337623
8.9252831						
0.00002250	77.0632029	3425031.	18.3933328	0.0004138	0.0001495	1.5582835
8.9732341						
0.00002375	81.3386244	3424784.	17.7394273	0.0004213	0.0001422	1.5827031
9.0213697						
0.00002500	85.6130940	3424524.	17.1511671	0.0004288	0.0001350	1.6070209
9.0696900						
0.00002625	89.8865616	3424250.	16.6191742	0.0004363	0.0001278	1.6312365
9.1181949						
0.00002750	94.1589769	3423963.	16.1357759	0.0004437	0.0001206	1.6553497
9.1668845						
0.00002875	98.4302898	3423662.	15.6946339	0.0004512	0.0001134	1.6793601
9.2157589						
0.00003000	102.7004499	3423348.	15.2904660	0.0004587	0.0001062	1.7032673
9.2648180						
0.00003125	106.9694071	3423021.	14.9188355	0.0004662	0.00009903	1.7270712
9.3140619						
0.00003250	111.2371111	3422680.	14.5759881	0.0004737	0.00009184	1.7507714
9.3634907						
0.00003375	115.5035116	3422326.	14.2587257	0.0004812	0.00008467	1.7743675
9.4131044						
0.00003500	119.7685582	3421959.	13.9643071	0.0004888	0.00007750	1.7978592
9.4629030						
0.00003625	124.0322007	3421578.	13.6903691	0.0004963	0.00007034	1.8212463
9.5128866						
0.00003750	128.2943886	3421184.	13.4348639	0.0005038	0.00006318	1.8445284
9.5630552						
0.00003875	132.5550718	3420776.	13.1960075	0.0005113	0.00005603	1.8677052
9.6134089						
0.00004000	136.8141996	3420355.	12.9722393	0.0005189	0.00004889	1.8907763
9.6639476						
0.00004125	141.0717218	3419921.	12.7621875	0.0005264	0.00004175	1.9137416
9.7146716						
0.00004250	145.3275879	3419473.	12.5646420	0.0005340	0.00003462	1.9366005
9.7655808						
0.00004375	149.5817474	3419011.	12.3785309	0.0005416	0.00002750	1.9593529
9.8166752						
0.00004500	153.8341499	3418537.	12.2029012	0.0005491	0.00002038	1.9819985
9.8679550						
0.00004625	158.0847448	3418049.	12.0369033	0.0005567	0.00001327	2.0045368
9.9194201						
0.00004750	162.3334817	3417547.	11.8797767	0.0005643	0.00000616	2.0269676
9.9710707						
0.00004875	166.5803098	3417032.	11.7308392	0.0005719	-9.34091E-07	2.0492905
10.0229068						
0.00005125	175.0675467	3415952.	11.4551310	0.0005871	-0.00001511	2.0936112
10.1271308						
0.00005375	183.5430840	3414755.	11.2055237	0.0006023	-0.00002927	2.1374930
10.2320618						
0.00005625	192.0022830	3413374.	10.9785093	0.0006175	-0.00004340	2.1809292

10.3376544							
0.00005875	200.4405823	3411755.	10.7711760	0.0006328	-0.00005751	2.2239128	
10.4438616							
0.00006125	208.8538620	3409859.	10.5810888	0.0006481	-0.00007160	2.2664374	
10.5506388							
0.00006375	217.2384377	3407662.	10.4061963	0.0006634	-0.00008567	2.3084969	
10.6579446							
0.00006625	225.5911634	3405150.	10.2447592	0.0006787	-0.00009972	2.3500862	
10.7657423							
0.00006875	233.9092584	3402316.	10.0952929	0.0006941	-0.000114	2.3912003	
10.8739983							
0.00007125	233.9092584	3282937.	9.8887362	0.0007046	-0.000133	2.4189829	
10.8426185 C							
0.00007375	235.8931414	3198551.	9.7461498	0.0007188	-0.000148	2.4562481	
10.9181046 C							
0.00007625	241.2740340	3164250.	9.6116960	0.0007329	-0.000163	2.4928273	
10.9908989 C							
0.00007875	246.4429460	3129434.	9.4846305	0.0007469	-0.000178	2.5287352	
11.0610704 C							
0.00008125	251.4127476	3094311.	9.3643089	0.0007609	-0.000194	2.5639881	
11.1287077 C							
0.00008375	256.1967197	3059065.	9.2501720	0.0007747	-0.000209	2.5986035	
11.1939183 C							
0.00008625	260.8084450	3023866.	9.1417333	0.0007885	-0.000225	2.6326003	
11.2568324 C							
0.00008875	265.2616532	2988864.	9.0385688	0.0008022	-0.000241	2.6659980	
11.3175975 C							
0.00009125	269.5701284	2954193.	8.9403083	0.0008158	-0.000256	2.6988177	
11.3763814 C							
0.00009375	273.7476025	2919974.	8.8466289	0.0008294	-0.000272	2.7310808	
11.4333724 C							
0.00009625	277.8019075	2886254.	8.7572060	0.0008429	-0.000288	2.7628005	
11.4886610 C							
0.00009875	281.7042774	2852702.	8.6714776	0.0008563	-0.000304	2.7939271	
11.5415634 C							
0.0001013	285.5080786	2819833.	8.5895194	0.0008697	-0.000320	2.8245493	
11.5931055 C							
0.0001038	289.2264306	2787725.	8.5111440	0.0008830	-0.000336	2.8546913	
11.6435433 C							
0.0001063	292.8114044	2755872.	8.4357328	0.0008963	-0.000352	2.8842695	
11.6917502 C							
0.0001088	296.3162134	2724747.	8.3634355	0.0009095	-0.000368	2.9133758	
11.7388428 C							
0.0001113	299.7475037	2694360.	8.2940874	0.0009227	-0.000384	2.9420246	
11.7849664 C							
0.0001138	303.0625852	2664286.	8.2271604	0.0009358	-0.000401	2.9701372	
11.8290221 C							
0.0001163	306.3402768	2635185.	8.1630611	0.0009490	-0.000417	2.9978586	
11.8729059 C							
0.0001188	309.4948171	2606272.	8.1009722	0.0009620	-0.000433	3.0250306	
11.9144183 C							
0.0001213	312.6229450	2578334.	8.0414607	0.0009750	-0.000450	3.0518335	
11.9559913 C							
0.0001238	315.6416608	2550640.	7.9837550	0.0009880	-0.000466	3.0781119	
11.9954150 C							
0.0001263	318.6422160	2523899.	7.9284062	0.0010010	-0.000482	3.1040392	
12.0351009 C							
0.0001288	321.5311484	2497329.	7.8745788	0.0010139	-0.000499	3.1294367	

12.0724418 C							
0.0001313	324.4073900	2471675.	7.8229083	0.0010268	-0.000515	3.1544962	
12.1101873 C							
0.0001338	327.1904505	2446284.	7.7726660	0.0010396	-0.000532	3.1790605	
12.1459802 C							
0.0001363	329.9430545	2421600.	7.7242358	0.0010524	-0.000549	3.2032544	
12.1816481 C							
0.0001388	332.6456864	2397446.	7.6773638	0.0010652	-0.000565	3.2270381	
12.2165635 C							
0.0001413	335.2807023	2373669.	7.6318322	0.0010780	-0.000582	3.2503787	
12.2501729 C							
0.0001438	337.9031492	2350631.	7.5879783	0.0010908	-0.000598	3.2733860	
12.2841741 C							
0.0001463	340.4451978	2327830.	7.5451949	0.0011035	-0.000615	3.2959230	
12.3163566 C							
0.0001488	342.9561830	2305588.	7.5037984	0.0011162	-0.000632	3.3180917	
12.3483185 C							
0.0001588	352.6391895	2221349.	7.3503157	0.0011669	-0.000698	3.4029772	
12.4718618 C							
0.0001688	361.7258899	2143561.	7.2133110	0.0012172	-0.000766	3.4817814	
12.5870240 C							
0.0001788	370.3159599	2071698.	7.0905270	0.0012674	-0.000833	3.5547299	
12.6964402 C							
0.0001888	378.4813952	2005199.	6.9800932	0.0013175	-0.000900	3.6219849	
12.8022435 C							
0.0001988	386.2655379	1943474.	6.8803693	0.0013675	-0.000968	3.6836411	
12.9057244 C							
0.0002088	393.6869436	1885925.	6.7898606	0.0014174	-0.001035	3.7397351	
13.0071522 C							
0.0002188	400.8054569	1832254.	6.7077129	0.0014673	-0.001103	3.7903776	
13.1091249 C							
0.0002288	407.6527628	1782089.	6.6330828	0.0015173	-0.001170	3.8356121	
13.2133218 C							
0.0002388	414.1790376	1734781.	6.5645794	0.0015673	-0.001238	3.8753331	
13.3166523 C							
0.0002488	420.4676376	1690322.	6.5021381	0.0016174	-0.001305	3.9096578	
13.4239820 C							
0.0002588	426.4765732	1648219.	6.4447144	0.0016676	-0.001373	3.9384934	
13.5327465 C							
0.0002688	432.2572425	1608399.	6.3921977	0.0017179	-0.001440	3.9618734	
13.6464443 C							
0.0002788	437.7593859	1570437.	6.3436279	0.0017683	-0.001507	3.9797045	
13.7615952 C							
0.0002888	443.0481406	1534366.	6.2992163	0.0018189	-0.001574	3.9920039	
13.8833949 C							
0.0002988	448.0721920	1499823.	6.2580857	0.0018696	-0.001641	3.9986836	
14.0078610 C							
0.0003088	452.8513853	1466725.	6.2201978	0.0019205	-0.001707	3.9995412	
14.1375048 C							
0.0003188	457.3873670	1434941.	6.1854999	0.0019716	-0.001774	3.9999230	
14.2746609 C							
0.0003288	461.6502454	1404259.	6.1534560	0.0020229	-0.001840	3.9995362	
14.4169951 C							
0.0003388	465.6405943	1374585.	6.1238260	0.0020744	-0.001906	3.9989375	
14.5644566 C							
0.0003488	469.3980106	1345944.	6.0966491	0.0021262	-0.001972	3.9992151	
14.7195438 C							
0.0003588	472.9320597	1318278.	6.0717061	0.0021782	-0.002037	3.9993419	

14.8821088 C							
0.0003688	476.2497553	1291525.	6.0487527	0.0022305	-0.002102	3.9993480	
15.0514828 C							
0.0003788	479.3392914	1265582.	6.0273036	0.0022828	-0.002167	3.9992277	
15.2240670 C							
0.0003888	482.2404062	1240490.	6.0075714	0.0023354	-0.002232	3.9989578	
15.4035674 C							
0.0003988	484.9640048	1216211.	5.9894070	0.0023883	-0.002297	3.9984771	
15.5897515 C							
0.0004088	487.5208967	1192712.	5.9726745	0.0024413	-0.002361	3.9991421	
15.7823746 C							
0.0004188	489.9141595	1169944.	5.9572700	0.0024946	-0.002426	3.9999495	
15.9814189 C							
0.0004288	492.1554382	1147884.	5.9430778	0.0025481	-0.002490	3.9996243	
16.1866026 C							
0.0004388	494.2533625	1126503.	5.9299123	0.0026017	-0.002554	3.9988458	
16.3966186 C							
0.0004488	496.2128640	1105767.	5.9175846	0.0026555	-0.002617	3.9985304	
16.6099008 C							
0.0004588	498.0401466	1085646.	5.9062295	0.0027095	-0.002681	3.9998303	
16.8289723 C							
0.0004688	499.7491556	1066132.	5.8957541	0.0027636	-0.002744	3.9988898	
17.0534166 C							
0.0004788	501.3543760	1047215.	5.8860688	0.0028180	-0.002807	3.9989001	
17.2827540 C							
0.0004888	502.8428464	1028834.	5.8771623	0.0028725	-0.002870	3.9996026	
17.5175064 C							
0.0004988	504.2363304	1011000.	5.8689357	0.0029271	-0.002933	3.9978925	
-17.932362 C							
0.0005088	505.5362221	993683.	5.8613472	0.0029820	-0.002996	3.9998829	
-18.403868 C							
0.0005188	506.7402311	976849.	5.8543697	0.0030370	-0.003058	3.9983849	
-18.870583 C							
0.0005288	507.8675855	960506.	5.8479201	0.0030921	-0.003121	3.9999637	
-19.333249 C							
0.0005388	508.9022475	944598.	5.8420144	0.0031474	-0.003183	3.9984941	
-19.791159 C							
0.0005488	509.8716525	929151.	5.8365526	0.0032028	-0.003245	3.9999688	
-20.245430 C							
0.0006088	514.2164657	844709.	5.8121220	0.0035381	-0.003615	3.9990511	
-22.890345 C							
0.0006688	514.2164657	768922.	5.8028387	0.0038806	-0.003977	3.9999014	
-25.326516 C							

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Summary of Results for Nominal Moment Capacity for Section 2  
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Moment values interpolated at maximum compressive strain = 0.003  
or maximum developed moment if pile fails at smaller strains.

Load No.	Axial Thrust kips	Nominal Mom. Cap. in-kip	Max. Comp. Strain	Max. Tens. Strain
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1	154.000	505.931	0.00300000	-0.00301636

Note that the values of moment capacity in the table above are not

factored by a strength reduction factor (phi-factor).

In ACI 318, the value of the strength reduction factor depends on whether the transverse reinforcing steel bars are tied hoops (0.65) or spirals (0.75).

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to ACI 318, or the value required by the design standard being followed.

The following table presents factored moment capacities and corresponding bending stiffnesses computed for common resistance factor values used for reinforced concrete sections.

Axial Load No.	Resist. Factor	Nominal Ax. Thrust kips	Nominal Moment Cap in-kips	Ult. (Fac) Ax. Thrust kips	Ult. (Fac) Moment Cap in-kips	Bend. Stiff. at Ult Mom kip-in <sup>2</sup>
1	0.65	154.000000	505.931173	100.100000	328.855262	2431355.
1	0.75	154.000000	505.931173	115.500000	379.448380	1997532.
1	0.90	154.000000	505.931173	138.600000	455.338056	1449301.

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 Layering Correction Equivalent Depths of Soil & Rock Layers  
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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	-4.000	0.00	N.A.	No	0.00	3020.
2	-1.000	0.3096	No	No	3020.	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.

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 Computed Values of Pile Loading and Deflection  
 for Lateral Loading for Load Case Number 1  
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Pile-head conditions are Shear and Moment (Loading Type 1)

Shear force at pile head	=	21000.0 lbs
Applied moment at pile head	=	0.0 in-lbs
Axial thrust load on pile head	=	154000.0 lbs

Depth Distrib. X Lat. Load feet lb/inch	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch
0.00	0.3120	2.11E-08	21000.	-0.00476	0.00	1.34E+10	-319.845	4305.
0.7000	0.2721	171272.	18268.	-0.00470	0.00	1.34E+10	-330.570	10207.
1.4000	0.2330	319079.	15457.	-0.00455	0.00	1.34E+10	-338.687	12211.
2.1000	0.1956	442730.	12590.	-0.00431	0.00	1.34E+10	-343.995	14773.
2.8000	0.1605	541749.	9691.	-0.00400	0.00	1.30E+10	-346.269	18118.
3.5000	0.1284	615883.	6786.	-0.00362	0.00	1.29E+10	-345.297	22585.
4.2000	0.09968	665133.	3905.	-0.00320	0.00	1.28E+10	-340.833	28721.
4.9000	0.07462	689768.	1076.	-0.00276	0.00	1.27E+10	-332.590	37441.
5.6000	0.05338	690345.	-1665.	-0.00230	0.00	1.27E+10	-320.190	50383.
6.3000	0.03598	667740.	-4283.	-0.00185	0.00	1.28E+10	-303.086	70758.
7.0000	0.02227	623180.	-6734.	-0.00143	0.00	1.29E+10	-280.342	105728.
7.7000	0.01199	558311.	-8961.	-0.00104	0.00	1.30E+10	-249.968	175173.
8.4000	0.00473	475339.	-10863.	-7.14E-04	0.00	1.34E+10	-202.879	360164.
9.1000	-1.61E-05	377665.	-11683.	-4.47E-04	0.00	1.34E+10	7.5280	3937500.
9.8000	-0.00277	280216.	-10906.	-2.40E-04	0.00	1.34E+10	177.4956	537787.
10.5000	-0.00405	195063.	-9341.	-9.10E-05	0.00	1.34E+10	195.1565	404638.
11.2000	-0.00430	123522.	-7689.	8.95E-06	0.00	1.34E+10	198.1095	386846.
11.9000	-0.00390	65859.	-6045.	6.84E-05	0.00	1.34E+10	193.3297	416297.
12.6000	-0.00315	21784.	-4463.	9.59E-05	0.00	1.34E+10	183.3159	488379.
13.3000	-0.00229	-9373.	-2983.	9.98E-05	0.00	1.34E+10	169.2407	620759.
14.0000	-0.00148	-28582.	-1635.	8.79E-05	0.00	1.34E+10	151.6674	862737.
14.7000	-8.14E-04	-37065.	-448.871	6.73E-05	0.00	1.34E+10	130.6974	1348794.
15.4000	-3.47E-04	-36297.	543.5923	4.42E-05	0.00	1.34E+10	105.6035	2559173.
16.1000	-7.07E-05	-28047.	1126.	2.41E-05	0.00	1.34E+10	33.1193	3937500.
16.8000	5.74E-05	-17438.	1152.	9.78E-06	0.00	1.34E+10	-26.927	3937500.



37.8000 0.00	0.00	-3.89E-05	2.46E-07	0.00	0.00	3.43E+09	3.38E-07	3937500.
38.5000 0.00	0.00	-2.50E-05	1.69E-06	0.00	0.00	3.43E+09	5.56E-09	3937500.
39.2000 0.00	0.00	-1.07E-05	1.35E-06	0.00	0.00	3.43E+09	-8.52E-08	3937500.
39.9000 0.00	0.00	-2.31E-06	6.88E-07	0.00	0.00	3.43E+09	-7.31E-08	3937500.
40.6000 0.00	0.00	9.03E-07	2.18E-07	0.00	0.00	3.43E+09	-3.88E-08	3937500.
41.3000 0.00	0.00	1.37E-06	-1.19E-10	0.00	0.00	3.43E+09	-1.31E-08	3937500.
42.0000 0.00	0.00	9.13E-07	-5.81E-08	0.00	0.00	3.43E+09	-6.93E-10	3937500.
42.7000 0.00	0.00	4.02E-07	-4.88E-08	0.00	0.00	3.43E+09	2.91E-09	3937500.
43.4000 0.00	0.00	9.47E-08	-2.55E-08	0.00	0.00	3.43E+09	2.63E-09	3937500.
44.1000 0.00	0.00	-2.74E-08	-8.47E-09	0.00	0.00	3.43E+09	1.43E-09	3937500.
44.8000 0.00	0.00	-4.83E-08	-3.20E-10	0.00	0.00	3.43E+09	5.06E-10	3937500.
45.5000 0.00	0.00	-3.33E-08	1.99E-09	0.00	0.00	3.43E+09	4.32E-11	3937500.
46.2000 0.00	0.00	-1.51E-08	1.75E-09	0.00	0.00	3.43E+09	-9.84E-11	3937500.
46.9000 0.00	0.00	-3.84E-09	9.46E-10	0.00	0.00	3.43E+09	-9.42E-11	3937500.
47.6000 0.00	0.00	7.97E-10	3.28E-10	0.00	0.00	3.43E+09	-5.30E-11	3937500.
48.3000 0.00	0.00	1.69E-09	2.36E-11	0.00	0.00	3.43E+09	-1.94E-11	3937500.
49.0000 0.00	0.00	1.21E-09	-6.74E-11	0.00	0.00	3.43E+09	-2.23E-12	3937500.
49.7000 0.00	0.00	5.66E-10	-6.30E-11	0.00	0.00	3.43E+09	3.30E-12	3937500.
50.4000 0.00	0.00	1.54E-10	-3.50E-11	0.00	0.00	3.43E+09	3.37E-12	3937500.
51.1000 0.00	0.00	-2.15E-11	-1.26E-11	0.00	0.00	3.43E+09	1.95E-12	3937500.
51.8000 0.00	0.00	-5.90E-11	-1.29E-12	0.00	0.00	3.43E+09	0.00	3937500.
52.5000 0.00	0.00	-4.39E-11	2.27E-12	0.00	0.00	3.43E+09	0.00	3937500.
53.2000 0.00	0.00	-2.12E-11	2.25E-12	0.00	0.00	3.43E+09	0.00	3937500.
53.9000 0.00	0.00	-6.10E-12	1.29E-12	0.00	0.00	3.43E+09	0.00	3937500.
54.6000 0.00	0.00	0.00	0.00	0.00	0.00	3.43E+09	0.00	3937500.
55.3000 0.00	0.00	2.05E-12	0.00	0.00	0.00	3.43E+09	0.00	3937500.
56.0000 0.00	0.00	1.59E-12	0.00	0.00	0.00	3.43E+09	0.00	3937500.
56.7000 0.00	0.00	0.00	0.00	0.00	0.00	3.43E+09	0.00	3937500.
57.4000 0.00	0.00	0.00	0.00	0.00	0.00	3.43E+09	0.00	3937500.

58.1000	0.00	0.00	0.00	0.00	0.00	3.43E+09	0.00	3937500.
0.00								
58.8000	0.00	0.00	0.00	0.00	0.00	3.43E+09	0.00	3937500.
0.00								
59.5000	0.00	0.00	0.00	0.00	0.00	3.43E+09	0.00	3937500.
0.00								
60.2000	0.00	0.00	0.00	0.00	0.00	3.43E+09	0.00	3937500.
0.00								
60.9000	0.00	0.00	0.00	0.00	0.00	3.43E+09	0.00	3937500.
0.00								
61.6000	0.00	0.00	0.00	0.00	0.00	3.43E+09	0.00	3937500.
0.00								
62.3000	0.00	0.00	0.00	0.00	0.00	3.43E+09	0.00	3937500.
0.00								
63.0000	0.00	0.00	0.00	0.00	0.00	3.43E+09	0.00	3937500.
0.00								
63.7000	0.00	0.00	0.00	0.00	0.00	3.43E+09	0.00	3937500.
0.00								
64.4000	0.00	0.00	0.00	0.00	0.00	3.43E+09	0.00	3937500.
0.00								
65.1000	0.00	0.00	0.00	0.00	0.00	3.43E+09	0.00	3937500.
0.00								
65.8000	0.00	0.00	0.00	0.00	0.00	3.43E+09	0.00	3937500.
0.00								
66.5000	0.00	0.00	0.00	0.00	0.00	3.43E+09	0.00	3937500.
0.00								
67.2000	0.00	0.00	0.00	0.00	0.00	3.43E+09	0.00	3937500.
0.00								
67.9000	0.00	0.00	0.00	0.00	0.00	3.43E+09	0.00	3937500.
0.00								
68.6000	0.00	0.00	0.00	0.00	0.00	3.43E+09	0.00	3937500.
0.00								
69.3000	0.00	0.00	0.00	0.00	0.00	3.43E+09	0.00	3937500.
0.00								
70.0000	0.00	0.00	0.00	0.00	0.00	3.43E+09	0.00	1968750.
0.00								

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

Output Summary for Load Case No. 1:

Pile-head deflection = 0.31202573 inches  
 Computed slope at pile head = -0.0047586 radians  
 Maximum bending moment = 690345. inch-lbs  
 Maximum shear force = 21000. lbs  
 Depth of maximum bending moment = 5.60000000 feet below pile head  
 Depth of maximum shear force = 0.000000 feet below pile head  
 Number of iterations = 27  
 Number of zero deflection points = 17

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 Computed Values of Pile Loading and Deflection  
 for Lateral Loading for Load Case Number 2  
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Pile-head conditions are Shear and Pile-head Rotation (Loading Type 2)

Shear force at pile head = 21000.0 lbs  
 Rotation of pile head = 0.000E+00 radians  
 Axial load at pile head = 154000.0 lbs

(Zero slope for this load indicates fixed-head conditions)

Depth Distrib. X Lat. Load feet lb/inch	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in <sup>2</sup>	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch
0.00	0.07287	-676312.	21000.	0.00	0.00	1.27E+10	-222.361	12815.
0.00								
0.7000	0.07100	-507468.	19074.	-3.90E-04	0.00	1.27E+10	-236.287	27954.
0.00								
1.4000	0.06632	-354864.	17042.	-6.69E-04	0.00	1.34E+10	-247.398	31337.
0.00								
2.1000	0.05976	-219428.	14929.	-8.49E-04	0.00	1.34E+10	-255.765	35950.
0.00								
2.8000	0.05205	-101861.	12757.	-9.50E-04	0.00	1.34E+10	-261.303	42171.
0.00								
3.5000	0.04380	-2649.	10551.	-9.83E-04	0.00	1.34E+10	-263.893	50610.
0.00								
4.2000	0.03554	77945.	8337.	-9.59E-04	0.00	1.34E+10	-263.384	62259.
0.00								
4.9000	0.02768	139892.	6140.	-8.91E-04	0.00	1.34E+10	-259.593	78768.
0.00								
5.6000	0.02057	183408.	3990.	-7.89E-04	0.00	1.34E+10	-252.292	103035.
0.00								
6.3000	0.01442	208974.	1918.	-6.66E-04	0.00	1.34E+10	-241.185	140492.
0.00								
7.0000	0.00937	217352.	-43.677	-5.33E-04	0.00	1.34E+10	-225.839	202370.
0.00								
7.7000	0.00547	209618.	-1855.	-3.99E-04	0.00	1.34E+10	-205.533	315402.
0.00								
8.4000	0.00268	187211.	-3458.	-2.74E-04	0.00	1.34E+10	-176.040	552012.
0.00								
9.1000	8.71E-04	152231.	-4756.	-1.67E-04	0.00	1.34E+10	-132.974	1282743.
0.00								
9.8000	-1.35E-04	107745.	-5049.	-8.59E-05	0.00	1.34E+10	63.1212	3937500.
0.00								
10.5000	-5.72E-04	67626.	-4282.	-3.08E-05	0.00	1.34E+10	119.5936	1756171.
0.00								
11.2000	-6.53E-04	35889.	-3260.	1.64E-06	0.00	1.34E+10	123.6399	1590782.
0.00								
11.9000	-5.44E-04	12848.	-2245.	1.69E-05	0.00	1.34E+10	118.1679	1822998.
0.00								
12.6000	-3.68E-04	-1866.	-1298.	2.04E-05	0.00	1.34E+10	107.1803	2443995.

0.00									
13.3000	-2.02E-04	-9015.	-450.209	1.70E-05	0.00	1.34E+10	94.7335	3937500.	
0.00									
14.0000	-8.33E-05	-9473.	111.7616	1.12E-05	0.00	1.34E+10	39.0691	3937500.	
0.00									
14.7000	-1.45E-05	-7166.	304.4764	5.94E-06	0.00	1.34E+10	6.8154	3937500.	
0.00									
15.4000	1.65E-05	-4373.	300.6443	2.32E-06	0.00	1.34E+10	-7.728	3937500.	
0.00									
16.1000	2.45E-05	-2122.	220.0404	2.83E-07	0.00	1.34E+10	-11.464	3937500.	
0.00									
16.8000	2.12E-05	-677.150	130.0767	-5.95E-07	0.00	1.34E+10	-9.956	3937500.	
0.00									
17.5000	1.45E-05	65.2793	59.8024	-7.87E-07	0.00	1.34E+10	-6.776	3937500.	
0.00									
18.2000	8.01E-06	329.5676	15.5686	-6.63E-07	0.00	1.34E+10	-3.756	3937500.	
0.00									
18.9000	3.31E-06	328.5487	-6.723	-4.57E-07	0.00	1.34E+10	-1.551	3937500.	
0.00									
19.6000	3.38E-07	217.8024	-13.904	-2.85E-07	0.00	1.34E+10	-0.158	3937500.	
0.00									
20.3000	-1.49E-06	95.7065	-11.644	-9.98E-08	0.00	3.43E+09	0.6964	3937500.	
0.00									
21.0000	-1.34E-06	22.4423	-6.084	4.50E-08	0.00	3.43E+09	0.6274	3937500.	
0.00									
21.7000	-7.29E-07	-6.622	-2.013	6.44E-08	0.00	3.43E+09	0.3419	3937500.	
0.00									
22.4000	-2.57E-07	-11.541	-0.07175	4.21E-08	0.00	3.43E+09	0.1203	3937500.	
0.00									
23.1000	-2.15E-08	-7.937	0.4757	1.83E-08	0.00	3.43E+09	0.01006	3937500.	
0.00									
23.8000	5.03E-08	-3.597	0.4189	4.13E-09	0.00	3.43E+09	-0.02358	3937500.	
0.00									
24.5000	4.80E-08	-0.910	0.2254	-1.39E-09	0.00	3.43E+09	-0.02249	3937500.	
0.00									
25.2000	2.69E-08	0.1930	0.07790	-2.27E-09	0.00	3.43E+09	-0.01263	3937500.	
0.00									
25.9000	9.86E-09	0.4045	0.00545	-1.54E-09	0.00	3.43E+09	-0.00462	3937500.	
0.00									
26.6000	1.12E-09	0.2886	-0.01616	-6.87E-10	0.00	3.43E+09	-5.23E-04	3937500.	
0.00									
27.3000	-1.69E-09	0.1348	-0.01503	-1.69E-10	0.00	3.43E+09	7.91E-04	3937500.	
0.00									
28.0000	-1.72E-09	0.03648	-0.00833	4.14E-11	0.00	3.43E+09	8.04E-04	3937500.	
0.00									
28.7000	-9.93E-10	-0.00524	-0.00300	7.97E-11	0.00	3.43E+09	4.65E-04	3937500.	
0.00									
29.4000	-3.77E-10	-0.01412	-3.03E-04	5.59E-11	0.00	3.43E+09	1.77E-04	3937500.	
0.00									
30.1000	-5.29E-11	-0.01047	5.44E-04	2.58E-11	0.00	3.43E+09	2.48E-05	3937500.	
0.00									
30.8000	5.61E-11	-0.00504	5.38E-04	6.79E-12	0.00	3.43E+09	-2.63E-05	3937500.	
0.00									
31.5000	6.12E-11	-0.00145	3.07E-04	-1.16E-12	0.00	3.43E+09	-2.87E-05	3937500.	
0.00									
32.2000	3.65E-11	1.25E-04	1.15E-04	-2.79E-12	0.00	3.43E+09	-1.71E-05	3937500.	
0.00									
32.9000	1.44E-11	4.91E-04	1.48E-05	-2.03E-12	0.00	3.43E+09	-6.74E-06	3937500.	

0.00									
33.6000	2.37E-12	3.79E-04	-1.82E-05	0.00	0.00	3.43E+09	-1.11E-06	3937500.	
0.00									
34.3000	-1.84E-12	1.88E-04	-1.92E-05	0.00	0.00	3.43E+09	8.62E-07	3937500.	
0.00									
35.0000	-2.18E-12	5.70E-05	-1.13E-05	0.00	0.00	3.43E+09	1.02E-06	3937500.	
0.00									
35.7000	-1.34E-12	-2.12E-06	-4.39E-06	0.00	0.00	3.43E+09	6.28E-07	3937500.	
0.00									
36.4000	0.00	-1.70E-05	-6.78E-07	0.00	0.00	3.43E+09	2.56E-07	3937500.	
0.00									
37.1000	0.00	-1.37E-05	5.99E-07	0.00	0.00	3.43E+09	4.80E-08	3937500.	
0.00									
37.8000	0.00	-6.99E-06	6.84E-07	0.00	0.00	3.43E+09	-2.78E-08	3937500.	
0.00									
38.5000	0.00	-2.23E-06	4.15E-07	0.00	0.00	3.43E+09	-3.62E-08	3937500.	
0.00									
39.2000	0.00	-1.26E-08	1.67E-07	0.00	0.00	3.43E+09	-2.30E-08	3937500.	
0.00									
39.9000	0.00	5.83E-07	2.97E-08	0.00	0.00	3.43E+09	-9.69E-09	3937500.	
0.00									
40.6000	0.00	4.94E-07	-1.95E-08	0.00	0.00	3.43E+09	-2.02E-09	3937500.	
0.00									
41.3000	0.00	2.60E-07	-2.43E-08	0.00	0.00	3.43E+09	8.79E-10	3937500.	
0.00									
42.0000	0.00	8.67E-08	-1.52E-08	0.00	0.00	3.43E+09	1.28E-09	3937500.	
0.00									
42.7000	0.00	3.76E-09	-6.33E-09	0.00	0.00	3.43E+09	8.40E-10	3937500.	
0.00									
43.4000	0.00	-1.99E-08	-1.27E-09	0.00	0.00	3.43E+09	3.66E-10	3937500.	
0.00									
44.1000	0.00	-1.77E-08	6.22E-10	0.00	0.00	3.43E+09	8.37E-11	3937500.	
0.00									
44.8000	0.00	-9.61E-09	8.60E-10	0.00	0.00	3.43E+09	-2.71E-11	3937500.	
0.00									
45.5000	0.00	-3.35E-09	5.57E-10	0.00	0.00	3.43E+09	-4.50E-11	3937500.	
0.00									
46.2000	0.00	-2.58E-10	2.39E-10	0.00	0.00	3.43E+09	-3.06E-11	3937500.	
0.00									
46.9000	0.00	6.76E-10	5.27E-11	0.00	0.00	3.43E+09	-1.38E-11	3937500.	
0.00									
47.6000	0.00	6.37E-10	-1.94E-11	0.00	0.00	3.43E+09	-3.41E-12	3937500.	
0.00									
48.3000	0.00	3.55E-10	-3.03E-11	0.00	0.00	3.43E+09	0.00	3937500.	
0.00									
49.0000	0.00	1.29E-10	-2.03E-11	0.00	0.00	3.43E+09	1.58E-12	3937500.	
0.00									
49.7000	0.00	1.38E-11	-9.01E-12	0.00	0.00	3.43E+09	1.11E-12	3937500.	
0.00									
50.4000	0.00	-2.27E-11	-2.16E-12	0.00	0.00	3.43E+09	0.00	3937500.	
0.00									
51.1000	0.00	-2.28E-11	0.00	0.00	0.00	3.43E+09	0.00	3937500.	
0.00									
51.8000	0.00	-1.31E-11	1.07E-12	0.00	0.00	3.43E+09	0.00	3937500.	
0.00									
52.5000	0.00	-4.94E-12	0.00	0.00	0.00	3.43E+09	0.00	3937500.	
0.00									
53.2000	0.00	0.00	0.00	0.00	0.00	3.43E+09	0.00	3937500.	

0.00									
53.9000	0.00	0.00	0.00	0.00	0.00	3.43E+09	0.00	3937500.	
0.00									
54.6000	0.00	0.00	0.00	0.00	0.00	3.43E+09	0.00	3937500.	
0.00									
55.3000	0.00	0.00	0.00	0.00	0.00	3.43E+09	0.00	3937500.	
0.00									
56.0000	0.00	0.00	0.00	0.00	0.00	3.43E+09	0.00	3937500.	
0.00									
56.7000	0.00	0.00	0.00	0.00	0.00	3.43E+09	0.00	3937500.	
0.00									
57.4000	0.00	0.00	0.00	0.00	0.00	3.43E+09	0.00	3937500.	
0.00									
58.1000	0.00	0.00	0.00	0.00	0.00	3.43E+09	0.00	3937500.	
0.00									
58.8000	0.00	0.00	0.00	0.00	0.00	3.43E+09	0.00	3937500.	
0.00									
59.5000	0.00	0.00	0.00	0.00	0.00	3.43E+09	0.00	3937500.	
0.00									
60.2000	0.00	0.00	0.00	0.00	0.00	3.43E+09	0.00	3937500.	
0.00									
60.9000	0.00	0.00	0.00	0.00	0.00	3.43E+09	0.00	3937500.	
0.00									
61.6000	0.00	0.00	0.00	0.00	0.00	3.43E+09	0.00	3937500.	
0.00									
62.3000	0.00	0.00	0.00	0.00	0.00	3.43E+09	0.00	3937500.	
0.00									
63.0000	0.00	0.00	0.00	0.00	0.00	3.43E+09	0.00	3937500.	
0.00									
63.7000	0.00	0.00	0.00	0.00	0.00	3.43E+09	0.00	3937500.	
0.00									
64.4000	0.00	0.00	0.00	0.00	0.00	3.43E+09	0.00	3937500.	
0.00									
65.1000	0.00	0.00	0.00	0.00	0.00	3.43E+09	0.00	3937500.	
0.00									
65.8000	0.00	0.00	0.00	0.00	0.00	3.43E+09	0.00	3937500.	
0.00									
66.5000	0.00	0.00	0.00	0.00	0.00	3.43E+09	0.00	3937500.	
0.00									
67.2000	0.00	0.00	0.00	0.00	0.00	3.43E+09	0.00	3937500.	
0.00									
67.9000	0.00	0.00	0.00	0.00	0.00	3.43E+09	0.00	3937500.	
0.00									
68.6000	0.00	0.00	0.00	0.00	0.00	3.43E+09	0.00	3937500.	
0.00									
69.3000	0.00	0.00	0.00	0.00	0.00	3.43E+09	0.00	3937500.	
0.00									
70.0000	0.00	0.00	0.00	0.00	0.00	3.43E+09	0.00	1968750.	
0.00									

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

Output Summary for Load Case No. 2:

Pile-head deflection = 0.07287478 inches  
 Computed slope at pile head = 0.000000 radians  
 Maximum bending moment = -676312. inch-lbs  
 Maximum shear force = 21000. lbs  
 Depth of maximum bending moment = 0.000000 feet below pile head  
 Depth of maximum shear force = 0.000000 feet below pile head  
 Number of iterations = 24  
 Number of zero deflection points = 17

-----  
 Summary of Pile-head Responses for Conventional Analyses  
 -----

Definitions of Pile-head Loading Conditions:

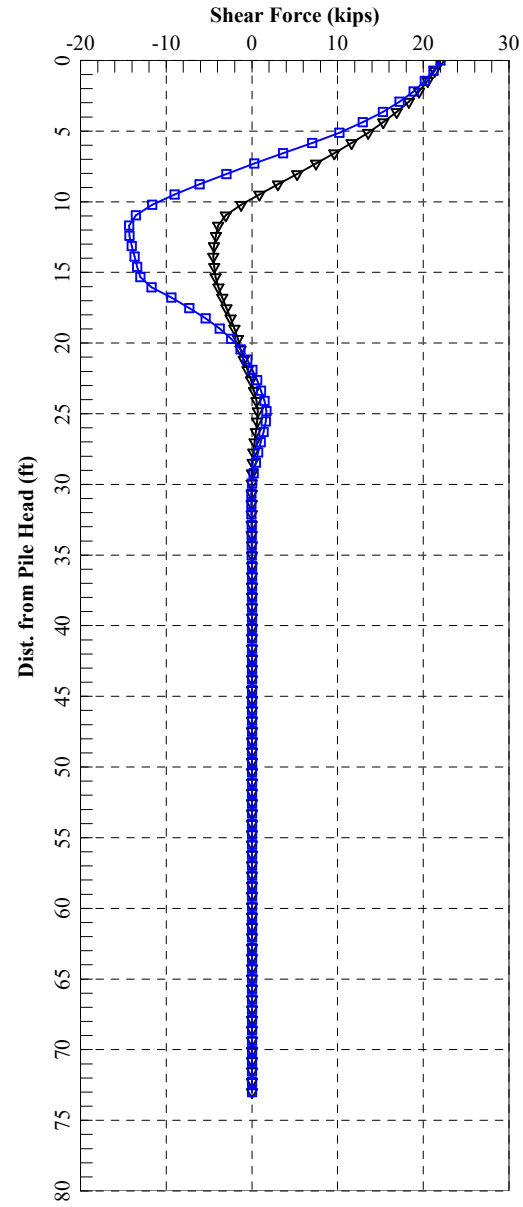
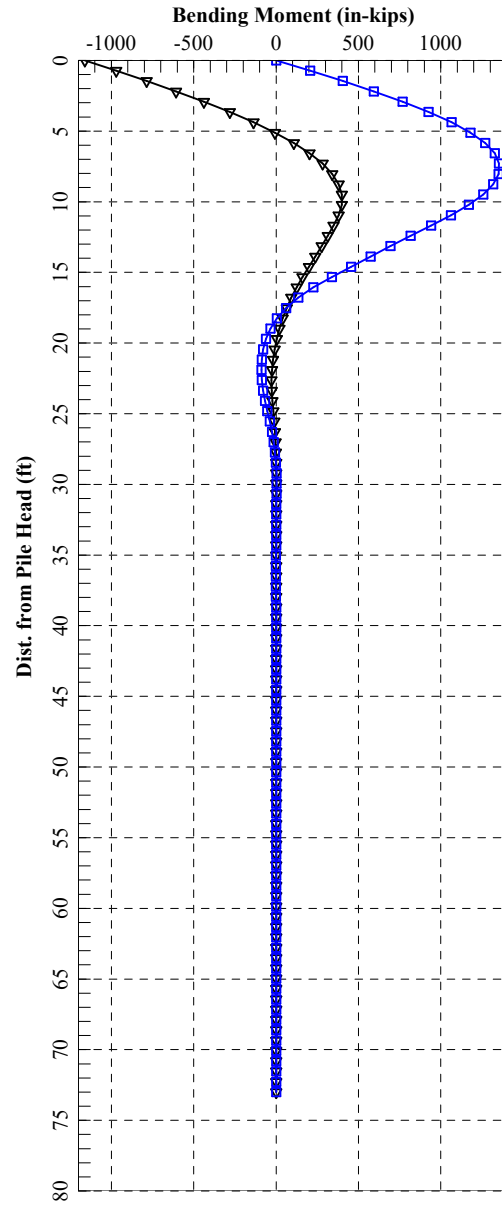
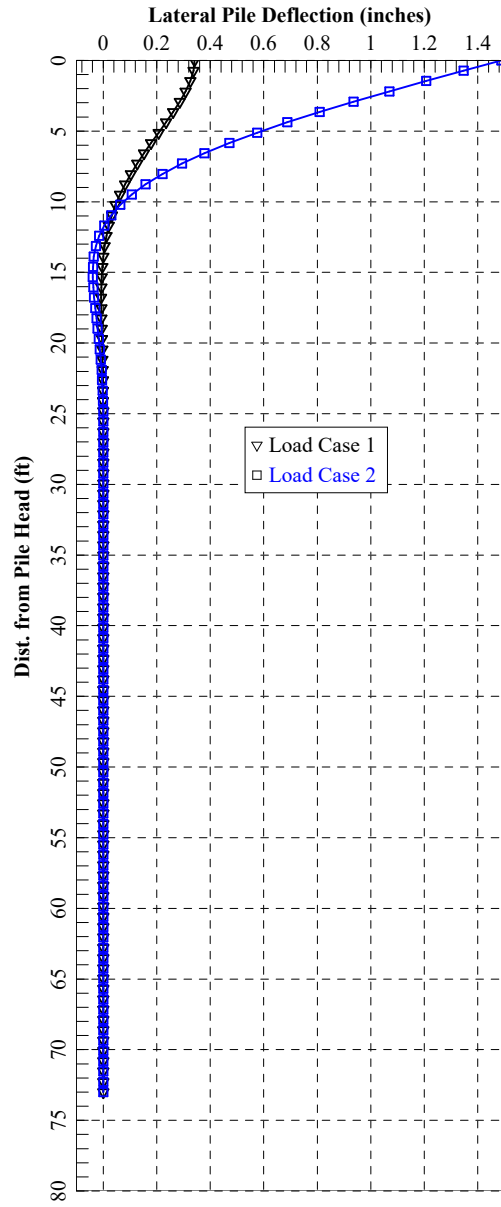
Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs  
 Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians  
 Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.  
 Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs  
 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	21000.	M, in-lb	0.00	154000.	0.3120	-0.00476	21000.	690345.
2	V, lb	21000.	S, rad	0.00	154000.	0.07287	0.00	21000.	-676312.

Maximum pile-head deflection = 0.3120257345 inches  
 Maximum pile-head rotation = -0.0047586487 radians = -0.272650 deg.

The analysis ended normally.

Commonwealth\_12.75-inch diameter Micropile



=====  
LPIle for Windows, Version 2022-12.007

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

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

Path to file locations:

\Users\smalla\OneDrive - HDR, Inc\AFtoRO\King&Common\Analysis\Commonwealth\90%\

Name of input data file:

Commonwealth Micropile\_Long.lp12d

Name of output report file:

Commonwealth Micropile\_Long.lp12o

Name of plot output file:

Commonwealth Micropile\_Long.lp12p

Name of runtime message file:

Commonwealth Micropile\_Long.lp12r  
-----

Date and Time of Analysis

-----  
Date: December 11, 2023

Time: 15:18:44

-----  
Problem Title  
-----

Project Name: Commonwealth Bridge

Job Number:

Client: CSX

Engineer: SM

Description: LPILE Analysis of 12.75-inch OD Micropile\_Embedment4feet

-----  
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:

- Cyclic loading specified

- Number of cycles of loading = 100 cycles
- Analysis uses p-y modification factors for p-y curves
- Analysis uses layering correction (Method of Georgiadis)
- No distributed lateral loads are entered
- 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 = 2  
 Total length of pile = 73.000 ft  
 Depth of ground surface below top of pile = -4.0000 ft

Pile diameters used for p-y curve computations are defined using 4 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	12.5300
2	30.000	12.5300
3	30.000	11.7500
4	73.000	11.7500

Input Structural Properties for Pile Sections:  
 -----

Pile Section No. 1:

Section 1 is a drilled shaft with permanent casing  
Length of section = 30.000000 ft  
Casing outside diameter = 12.530000 in

Pile Section No. 2:

Section 2 is a round drilled shaft, bored pile, or CIDH pile  
Length of section = 43.000000 ft  
Shaft Diameter = 11.750000 in

-----  
Soil and Rock Layering Information  
-----

The soil profile is modelled using 6 layers

Layer 1 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer = -4.000000 ft  
Distance from top of pile to bottom of layer = 11.000000 ft  
Effective unit weight at top of layer = 50.000000 pcf  
Effective unit weight at bottom of layer = 50.000000 pcf  
Friction angle at top of layer = 30.000000 deg.  
Friction angle at bottom of layer = 30.000000 deg.  
Subgrade k at top of layer = 60.000000 pci  
Subgrade k at bottom of layer = 60.000000 pci

Layer 2 is soft clay, p-y criteria by Matlock, 1970

Distance from top of pile to top of layer = 11.000000 ft  
Distance from top of pile to bottom of layer = 16.000000 ft  
Effective unit weight at top of layer = 50.000000 pcf  
Effective unit weight at bottom of layer = 50.000000 pcf  
Undrained cohesion at top of layer = 500.000000 psf  
Undrained cohesion at bottom of layer = 500.000000 psf  
Epsilon-50 at top of layer = 0.020000  
Epsilon-50 at bottom of layer = 0.020000

Layer 3 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer = 16.000000 ft  
Distance from top of pile to bottom of layer = 21.000000 ft  
Effective unit weight at top of layer = 50.000000 pcf  
Effective unit weight at bottom of layer = 50.000000 pcf  
Friction angle at top of layer = 32.000000 deg.  
Friction angle at bottom of layer = 32.000000 deg.

Subgrade k at top of layer = 60.000000 pci  
 Subgrade k at bottom of layer = 60.000000 pci

Layer 4 is stiff clay without free water

Distance from top of pile to top of layer = 21.000000 ft  
 Distance from top of pile to bottom of layer = 31.000000 ft  
 Effective unit weight at top of layer = 60.000000 pcf  
 Effective unit weight at bottom of layer = 60.000000 pcf  
 Undrained cohesion at top of layer = 1000.000000 psf  
 Undrained cohesion at bottom of layer = 1000.000000 psf  
 Epsilon-50 at top of layer = 0.007000  
 Epsilon-50 at bottom of layer = 0.007000

Layer 5 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer = 31.000000 ft  
 Distance from top of pile to bottom of layer = 46.000000 ft  
 Effective unit weight at top of layer = 60.000000 pcf  
 Effective unit weight at bottom of layer = 60.000000 pcf  
 Friction angle at top of layer = 32.000000 deg.  
 Friction angle at bottom of layer = 32.000000 deg.  
 Subgrade k at top of layer = 60.000000 pci  
 Subgrade k at bottom of layer = 60.000000 pci

Layer 6 is stiff clay without free water

Distance from top of pile to top of layer = 46.000000 ft  
 Distance from top of pile to bottom of layer = 100.000000 ft  
 Effective unit weight at top of layer = 65.000000 pcf  
 Effective unit weight at bottom of layer = 65.000000 pcf  
 Undrained cohesion at top of layer = 3000. psf  
 Undrained cohesion at bottom of layer = 3000. psf  
 Epsilon-50 at top of layer = 0.007000  
 Epsilon-50 at bottom of layer = 0.007000

(Depth of the lowest soil layer extends 27.000 ft below the pile tip)

-----  
 Summary of Input Soil Properties  
 -----

Layer	Soil Type	Layer	Effective	Cohesion	Angle of
E50					

Num. or krm	Name kpy (p-y Curve Type) pci	Depth	Unit Wt.		Friction
		ft	pcf	psf	deg.
1	Sand	-4.000	50.0000	--	30.0000
--	60.0000 (Reese, et al.)	11.0000	50.0000	--	30.0000
--	60.0000				
2	Soft	11.0000	50.0000	500.0000	--
0.02000	--				
	Clay	16.0000	50.0000	500.0000	--
0.02000	--				
3	Sand	16.0000	50.0000	--	32.0000
--	60.0000				
	(Reese, et al.)	21.0000	50.0000	--	32.0000
--	60.0000				
4	Stiff Clay	21.0000	60.0000	1000.0000	--
0.00700	--				
	w/o Free Water	31.0000	60.0000	1000.0000	--
0.00700	--				
5	Sand	31.0000	60.0000	--	32.0000
--	60.0000				
	(Reese, et al.)	46.0000	60.0000	--	32.0000
--	60.0000				
6	Stiff Clay	46.0000	65.0000	3000.	--
0.00700	--				
	w/o Free Water	100.0000	65.0000	3000.	--
0.00700	--				

Modification Factors for p-y Curves

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

Point No.	Depth X ft	p-mult	y-mult
1	0.000	0.5000	1.0000
2	30.000	0.5000	1.0000

Cyclic Loading Type

Cyclic loading criteria were used for computation of p-y curves for all analyses.

Number of cycles of loading = 100

-----  
 Pile-head Loading and Pile-head Fixity Conditions  
 -----

Number of loads specified = 2

Load Compute No.	Load Top y Type vs. Pile Length	Condition Run Analysis 1	Condition 2	Axial Thrust Force, lbs
1	2	V = 22000. lbs Yes	S = 0.0000 in/in	119000.
2	1	V = 22000. lbs Yes	M = 0.0000 in-lbs	119000.

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 = 2

Pile Section No. 1:  
 -----

Dimensions and Properties of Drilled Shaft (Bored Pile) with Permanent Casing:  
 -----

Length of Section = 30.000000 ft  
 Outer Diameter of Casing = 12.530000 in

Concrete Cover Thickness Inside Casing = 3.000000 in  
 Casing Wall Thickness = 0.390000 in  
 Moment of Inertia of Steel Casing = 274.301717 in<sup>4</sup>  
 Yield Stress of Casing = 45000. psi  
 Elastic Modulus of Casing = 29000000. psi  
 Number of Reinforcing Bars = 1 bar  
 Area of Single Reinforcing Bar = 4.908739 sq. in.  
 Edge-to-Edge Bar Spacing = -2.50000 in  
 Maximum Concrete Aggregate Size = 0.750000 in  
 Ratio of Bar Spacing to Aggregate Size = -3.33  
 Offset of Center of Rebar Cage from Center of Pile = 0.0000 in  
 Yield Stress of Reinforcing Bars = 75000. psi  
 Modulus of Elasticity of Reinforcing Bars = 29000000. psi  
 Gross Area of Pile = 123.308219 sq. in.  
 Area of Concrete = 103.525295 sq. in.  
 Cross-sectional Area of Steel Casing = 14.874185 sq. in.  
 Area of All Steel (Casing and Bars) = 19.782923 sq. in.  
 Area Ratio of All Steel to Gross Area of Pile = 16.04 percent

Axial Structural Capacities:  
 -----

Nom. Axial Structural Capacity =  $0.85 F_c A_c + F_y A_s$  = 1389.480 kips  
 Tensile Load for Cracking of Concrete = -109.246 kips  
 Nominal Axial Tensile Capacity = -1037.494 kips

Reinforcing Bar Dimensions and Positions Used in Computations:

Bar Number	Bar Diam. inches	Bar Area sq. in.	X inches	Y inches
1	2.500000	4.908739	0.00000	0.00000

NOTE: The positions of the above rebars were computed by LPILE

Concrete Properties:  
 -----

Compressive Strength of Concrete = 4000. psi  
 Modulus of Elasticity of Concrete = 3604997. psi  
 Modulus of Rupture of Concrete = -474.34165 psi  
 Compression Strain at Peak Stress = 0.001886  
 Tensile Strain at Fracture of Concrete = -0.0001154  
 Maximum Coarse Aggregate Size = 0.750000 in

Number of Axial Thrust Force Values Determined from Pile-head Loadings = 1

Number	Axial Thrust Force kips
1	119.000

Definitions of Run Messages and Notes:

- C = concrete in section has cracked in tension.
- Y = stress in reinforcing steel has reached yield stress.
- T = ACI 318 criteria for tension-controlled section met, tensile strain in reinforcement exceeds 0.005 while simultaneously compressive strain in concrete more than 0.003. See ACI 318-14, Section 21.2.3.
- Z = depth of tensile zone in concrete section is less than 10 percent of section depth.

Bending Stiffness (EI) = Computed Bending Moment / Curvature.  
 Position of neutral axis is measured from edge of compression side of pile.  
 Compressive stresses and strains are positive in sign.  
 Tensile stresses and strains are negative in sign.

Axial Thrust Force = 119.000 kips

Bending Max Conc Curvature Stress rad/in. ksi	Bending Max Steel Moment Stress in-kip ksi	Bending Max Casing Stiffness Stress kip-in2 ksi	Depth to Run N Axis Msg in	Max Comp Strain in/in	Max Tens Strain in/in
0.00000125	14.6514578	11721166.	101.5703660	0.0001270	0.0001113
0.5200400	3.4979697	3.6796547			
0.00000250	29.3028894	11721156.	53.9196814	0.0001348	0.0001035
0.5506618	3.5412648	3.9046348			
0.00000375	43.9542685	11721138.	38.0370081	0.0001426	0.00009565
0.5811613	3.5846565	4.1297115			
0.00000500	58.6055690	11721114.	30.0963376	0.0001505	0.00008783
0.6115384	3.6281447	4.3548847			
0.00000625	73.2567645	11721082.	25.3324683	0.0001583	0.00008002
0.6417929	3.6717296	4.5801546			
0.00000750	87.9078290	11721044.	22.1569995	0.0001662	0.00007220
0.6719246	3.7154110	4.8055210			
0.00000875	102.5587360	11720998.	19.8891881	0.0001740	0.00006439
0.7019333	3.7591891	5.0309841			
0.00001000	117.2094594	11720946.	18.1886627	0.0001819	0.00005659
0.7318189	3.8030637	5.2565437			

0.00001125	131.8599731	11720886.	16.8663279	0.0001897	0.00004878
0.7615812	3.8470350	5.4822000			
0.00001250	146.5102506	11720820.	15.8087266	0.0001976	0.00004098
0.7912200	3.8911028	5.7079528			
0.00001375	161.1602659	11720747.	14.9436587	0.0002055	0.00003319
0.8207351	3.9352673	5.9338023			
0.00001500	175.8099926	11720666.	14.2229908	0.0002133	0.00002539
0.8501264	3.9795283	6.1597483			
0.00001625	190.4594046	11720579.	13.6134000	0.0002212	0.00001761
0.8793937	4.0238860	6.3857910			
0.00001750	205.1084757	11720484.	13.0910839	0.0002291	0.00000982
0.9085368	4.0683402	6.6119302			
0.00001875	219.7571794	11720383.	12.6385876	0.0002370	0.00000204
0.9375556	4.1128911	6.8381661			
0.00002000	234.4054898	11720274.	12.2428199	0.0002449	-0.00000574
0.9664498	4.1575386	7.0644986			
0.00002125	249.0533310	11720157.	11.8937696	0.0002527	-0.00001352
0.9952193	4.2022825	7.2909275			
0.00002250	263.6999540	11719998.	11.5836445	0.0002606	-0.00002129
1.0238633	4.2471189	7.5174489			
0.00002375	278.3439217	11719744.	11.3062874	0.0002685	-0.00002906
1.0523809	4.2920403	7.7440553			
0.00002500	292.9837725	11719351.	11.0567717	0.0002764	-0.00003683
1.0807707	4.3370383	7.9707383			
0.00002625	307.6181966	11718788.	10.8311099	0.0002843	-0.00004460
1.1090318	4.3821052	8.1974902			
0.00002750	322.2460656	11718039.	10.6260402	0.0002922	-0.00005236
1.1371630	4.4272338	8.4243038			
0.00002875	336.8664329	11717093.	10.4388694	0.0003001	-0.00006012
1.1651635	4.4724180	8.6511730			
0.00003000	351.4784836	11715949.	10.2673535	0.0003080	-0.00006788
1.1930325	4.5176522	8.8780922			
0.00003125	366.0815509	11714610.	10.1096088	0.0003159	-0.00007564
1.2207694	4.5629315	9.1050565			
0.00003250	380.6750710	11713079.	9.9640418	0.0003238	-0.00008339
1.2483735	4.6082519	9.3320619			
0.00003375	395.2585637	11711365.	9.8292956	0.0003317	-0.00009115
1.2758443	4.6536095	9.5591045			
0.00003500	409.8316246	11709475.	9.7042076	0.0003396	-0.00009890
1.3031814	4.6990010	9.7861810			
0.00003625	424.3939120	11707418.	9.5877759	0.0003476	-0.000107
1.3303844	4.7444237	10.0132887			
0.00003750	438.9451370	11705204.	9.4791327	0.0003555	-0.000114
1.3574529	4.7898750	10.2404250			
0.00003875	438.9451370	11327616.	9.2754258	0.0003594	-0.000126
1.3708007	4.7206219	10.3528569 C			
0.00004000	448.1165076	11202913.	9.1709669	0.0003668	-0.000134
1.3959705	4.7517277	10.5656477 C			
0.00004125	460.5475955	11164790.	9.0724392	0.0003742	-0.000143
1.4209630	4.7823554	10.7779604 C			

0.00004250	472.9142077	11127393.	8.9792481	0.0003816	-0.000151
1.4457690	4.8124173	10.9897073 C			
0.00004375	485.2263599	11090888.	8.8909999	0.0003890	-0.000159
1.4703986	4.8419941	11.2009691 C			
0.00004500	497.5001595	11055559.	8.8074077	0.0003963	-0.000168
1.4948717	4.8712489	11.4119089 C			
0.00004625	509.7280608	11021147.	8.7280254	0.0004037	-0.000176
1.5191781	4.9000898	11.6224348 C			
0.00004750	521.9090610	10987559.	8.6524963	0.0004110	-0.000184
1.5433148	4.9284834	11.8325134 C			
0.00004875	534.0693694	10955269.	8.5807400	0.0004183	-0.000193
1.5673173	4.9567349	12.0424499 C			
0.00005125	558.2650599	10892977.	8.4469023	0.0004329	-0.000209
1.6148300	5.0120101	12.4610951 C			
0.00005375	582.3464009	10834352.	8.3248370	0.0004475	-0.000226
1.6617562	5.0662291	12.8786841 C			
0.00005625	606.3243096	10779099.	8.2130260	0.0004620	-0.000243
1.7081085	5.1194760	13.2953010 C			
0.00005875	630.2047514	10726889.	8.1101715	0.0004765	-0.000260
1.7538923	5.1717699	13.7109649 C			
0.00006125	654.0081929	10677685.	8.0153144	0.0004909	-0.000277
1.7991373	5.2233553	14.1259203 C			
0.00006375	677.7479281	10631340.	7.9276073	0.0005054	-0.000293
1.8438644	5.2744050	14.5403400 C			
0.00006625	701.4235837	10587526.	7.8462258	0.0005198	-0.000310
1.8880725	5.3248903	14.9541953 C			
0.00006875	725.0303787	10545896.	7.7704146	0.0005342	-0.000327
1.9317495	5.3746809	15.3673559 C			
0.00007125	748.6026718	10506704.	7.6998662	0.0005486	-0.000344
1.9749579	5.4243532	15.7803982 C			
0.00007375	772.1054435	10469226.	7.6337410	0.0005630	-0.000361
2.0176309	5.4732560	16.1926710 C			
0.00007625	795.5838278	10433886.	7.5719696	0.0005774	-0.000378
2.0598535	5.5221982	16.6049832 C			
0.00007875	819.0013436	10400017.	7.5138259	0.0005917	-0.000395
2.1015539	5.5704682	17.0166232 C			
0.00008125	842.4018439	10368023.	7.4593371	0.0006061	-0.000412
2.1428193	5.6189193	17.4284443 C			
0.00008375	865.7462390	10337269.	7.4078381	0.0006204	-0.000429
2.1835683	5.6667308	17.8396258 C			
0.00008625	889.0704282	10308063.	7.3593695	0.0006347	-0.000446
2.2238762	5.7146549	18.2509199 C			
0.00008875	912.3649107	10280168.	7.3135895	0.0006491	-0.000463
2.2637214	5.7624707	18.6621057 C			
0.00009125	935.6203167	10253373.	7.2701959	0.0006634	-0.000480
2.3030838	5.8099637	19.0729687 C			
0.00009375	958.8586980	10227826.	7.2291827	0.0006777	-0.000497
2.3420119	5.8576361	19.4840111 C			
0.00009625	982.0691841	10203316.	7.1902679	0.0006921	-0.000514
2.3804798	5.9052187	19.8949637 C			

0.00009875	1005.	10179693.	7.1532304	0.0007064	-0.000531
2.4184718	5.9525350	20.3056500 C			
0.0001013	1028.	10157069.	7.1180831	0.0007207	-0.000548
2.4560291	6.0000307	20.7165157 C			
0.0001038	1052.	10135370.	7.0846893	0.0007350	-0.000565
2.4931512	6.0477061	21.1275611 C			
0.0001063	1075.	10114345.	7.0527495	0.0007494	-0.000582
2.5297895	6.0950193	21.5382443 C			
0.0001088	1098.	10094095.	7.0223020	0.0007637	-0.000599
2.5659833	6.1424049	21.9489999 C			
0.0001113	1121.	10074601.	6.9932787	0.0007780	-0.000616
2.6017417	6.1899736	22.3599386 C			
0.0001138	1144.	10055814.	6.9655858	0.0007923	-0.000633
2.6370641	6.2377227	22.7710577 C			
0.0001163	1167.	10037593.	6.9390388	0.0008067	-0.000650
2.6719218	6.2853191	23.1820241 C			
0.0001188	1190.	10019927.	6.9135898	0.0008210	-0.000667
2.7063223	6.3328478	23.5929228 C			
0.0001213	1213.	10002847.	6.8892418	0.0008353	-0.000684
2.7402862	6.3805575	24.0040025 C			
0.0001238	1236.	9986319.	6.8659281	0.0008497	-0.000701
2.7738130	6.4284485	24.4152635 C			
0.0001263	1259.	9970309.	6.8435874	0.0008640	-0.000718
2.8069022	6.4765213	24.8267063 C			
0.0001288	1282.	9954750.	6.8221191	0.0008783	-0.000735
2.8395402	6.5246122	25.2381672 C			
0.0001313	1305.	9939574.	6.8014235	0.0008927	-0.000752
2.8717122	6.5725311	25.6494561 C			
0.0001338	1327.	9924836.	6.7815486	0.0009070	-0.000769
2.9034460	6.6206327	26.0609277 C			
0.0001363	1350.	9910512.	6.7624495	0.0009214	-0.000786
2.9347409	6.6689174	26.4725824 C			
0.0001388	1373.	9896579.	6.7440842	0.0009357	-0.000803
2.9655964	6.7173856	26.8844206 C			
0.0001413	1396.	9883017.	6.7264139	0.0009501	-0.000820
2.9960119	6.7660377	27.2964427 C			
0.0001438	1419.	9869805.	6.7094024	0.0009645	-0.000837
3.0259868	6.8148742	27.7086492 C			
0.0001463	1442.	9856875.	6.6929467	0.0009788	-0.000854
3.0554997	6.8636010	28.1207460 C			
0.0001488	1464.	9844236.	6.6770498	0.0009932	-0.000871
3.0845603	6.9123523	28.5328673 C			
0.0001588	1555.	9796559.	6.6188732	0.0010507	-0.000938
3.1963837	7.1092177	30.1832127 C			
0.0001688	1646.	9752825.	6.5681373	0.0011084	-0.001006
3.3010886	7.3087539	31.8362289 C			
0.0001788	1736.	9712254.	6.5234244	0.0011661	-0.001074
3.3985900	7.5100845	33.4910395 C			
0.0001888	1826.	9674471.	6.4840079	0.0012239	-0.001141
3.4889301	7.7144736	35.1489086 C			

0.0001988	1916.	9639030.	6.4490679	0.0012818	-0.001209
3.5720625	7.9218018	36.8097168 C			
0.0002088	2005.	9605506.	6.4178043	0.0013397	-0.001276
3.6479069	8.1311210	38.4725160 C			
0.0002188	2094.	9573712.	6.3898970	0.0013978	-0.001343
3.7164822	8.3435986	40.1384736 C			
0.0002288	2183.	9543410.	6.3649106	0.0014560	-0.001410
3.7777473	8.5592668	41.8076218 C			
0.0002388	2272.	9514402.	6.3424828	0.0015143	-0.001477
3.8316606	8.7781582	43.4799932 C			
0.0002488	2360.	9485748.	6.3224565	0.0015727	-0.001544
3.8782066	9.0013651	45.0000000 CY			
0.0002588	2441.	9434010.	6.3059286	0.0016317	-0.001610
3.9175442	9.2392078	45.0000000 CY			
0.0002688	2506.	9324326.	6.2905562	0.0016906	-0.001677
3.9492243	9.4764695	45.0000000 CY			
0.0002788	2558.	9177810.	6.2740623	0.0017489	-0.001744
3.9730464	9.6957502	45.0000000 CY			
0.0002888	2602.	9012871.	6.2577380	0.0018069	-0.001811
3.9893262	-10.028503	45.0000000 CY			
0.0002988	2641.	8840887.	6.2420230	0.0018648	-0.001879
3.9981847	-10.511961	45.0000000 CY			
0.0003088	2675.	8665048.	6.2270242	0.0019226	-0.001946
3.9994703	-10.998122	45.0000000 CY			
0.0003188	2706.	8488747.	6.2129853	0.0019804	-0.002014
3.9999631	-11.484108	45.0000000 CY			
0.0003288	2733.	8313330.	6.1994874	0.0020381	-0.002081
3.9987342	-11.973079	45.0000000 CY			
0.0003388	2758.	8140642.	6.1867699	0.0020958	-0.002149
3.9993550	-12.462213	45.0000000 CY			
0.0003488	2780.	7971329.	6.1748820	0.0021535	-0.002216
3.9996819	-12.950332	45.0000000 CY			
0.0003588	2800.	7805863.	6.1637633	0.0022113	-0.002284
3.9998339	-13.437344	45.0000000 CY			
0.0003688	2819.	7644590.	6.1533536	0.0022690	-0.002351
3.9998885	-13.923224	45.0000000 CY			
0.0003788	2836.	7487445.	6.1437747	0.0023270	-0.002419
3.9998839	-14.406014	45.0000000 CY			
0.0003888	2851.	7334808.	6.1348613	0.0023849	-0.002486
3.9998157	-14.886858	45.0000000 CY			
0.0003988	2866.	7186832.	6.1265318	0.0024430	-0.002553
3.9996400	-15.366120	45.0000000 CY			
0.0004088	2879.	7043562.	6.1187356	0.0025010	-0.002621
3.9992723	-15.843892	45.0000000 CY			
0.0004188	2891.	6904541.	6.1117527	0.0025593	-0.002688
3.9985982	-16.316309	45.0000000 CY			
0.0004288	2903.	6769969.	6.1051700	0.0026176	-0.002755
3.9980973	-16.787800	45.0000000 CY			
0.0004388	2913.	6639661.	6.0988969	0.0026759	-0.002822
3.9999364	-17.259169	45.0000000 CY			

0.0004488	2923.	6513383.	6.0934022	0.0027344	-0.002888
3.9993846	-17.724048	45.0000000 CY			
0.0004588	2932.	6391461.	6.0881779	0.0027930	-0.002955
3.9980393	-18.188515	45.0000000 CY			
0.0004688	2940.	6273008.	6.0833772	0.0028516	-0.003022
3.9999837	-18.650257	45.0000000 CY			
0.0004788	2948.	6158700.	6.0790053	0.0029103	-0.003088
3.9992560	-19.108825	45.0000000 CY			
0.0004888	2956.	6047708.	6.0749299	0.0029691	-0.003155
3.9971787	-19.565730	45.0000000 CY			
0.0004988	2963.	5940461.	6.0711355	0.0030280	-0.003221
3.9997663	-20.020931	45.0000000 CY			
0.0005088	2969.	5836354.	6.0677707	0.0030870	-0.003288
3.9979840	-20.471999	45.0000000 CY			
0.0005188	2975.	5735740.	6.0645160	0.0031460	-0.003354
3.9999318	-20.923358	45.0000000 CY			
0.0005288	2981.	5637910.	6.0617841	0.0032052	-0.003420
3.9982657	-21.368594	45.0000000 CY			
0.0005388	2986.	5543366.	6.0591511	0.0032644	-0.003486
3.9999627	-21.813862	45.0000000 CY			
0.0005488	2991.	5451423.	6.0568101	0.0033237	-0.003552
3.9981193	-22.256013	45.0000000 CY			
0.0006088	3016.	4954697.	6.0473017	0.0036813	-0.003946
3.9992071	-24.857337	45.0000000 CY			
0.0006688	3034.	4536130.	6.0434638	0.0040416	-0.004338
3.9952128	-27.381767	45.0000000 CY			

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Summary of Results for Nominal Moment Capacity for Section 1  
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Moment values interpolated at maximum compressive strain = 0.003  
or maximum developed moment if pile fails at smaller strains.

Load Tens. No. Strain	Axial Thrust kips	Nominal Mom. Cap. in-kip	Max. Comp. Strain	Max.
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1 -0.00318977	119.000	2959.483	0.00300000	

Note that the values of moment capacity in the table above are not factored by a strength reduction factor (phi-factor).

In ACI 318, the value of the strength reduction factor depends on whether the transverse reinforcing steel bars are tied hoops (0.65) or spirals (0.75).

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to ACI 318, or the value required by the design standard being followed.

The following table presents factored moment capacities and corresponding bending stiffnesses computed for common resistance factor values used for reinforced concrete sections.

Axial Stiff. Load Ult Mom No. kip-in <sup>2</sup>	Resist. Factor	Nominal Ax. Thrust kips	Nominal Moment Cap in-kips	Ult. (Fac) Ax. Thrust kips	Ult. (Fac) Moment Cap in-kips	Bend. at
1 9636065.	0.65	119.000000	2959.	77.350000	1924.	
1 9531429.	0.75	119.000000	2959.	89.250000	2220.	
1 8725856.	0.90	119.000000	2959.	107.100000	2664.	

Pile Section No. 2:  
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Dimensions and Properties of Drilled Shaft (Bored Pile):  
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Length of Section	=	43.000000 ft
Shaft Diameter	=	11.750000 in
Concrete Cover Thickness (to edge of long. rebar)	=	2.610000 in
Number of Reinforcing Bars	=	1 bar
Yield Stress of Reinforcing Bars	=	75000. psi
Modulus of Elasticity of Reinforcing Bars	=	29000000. psi
Gross Area of Shaft	=	108.434034 sq. in.
Total Area of Reinforcing Steel	=	4.908739 sq. in.
Area Ratio of Steel Reinforcement	=	4.53 percent
Edge-to-Edge Bar Spacing	=	-2.50000 in
Maximum Concrete Aggregate Size	=	0.750000 in
Ratio of Bar Spacing to Aggregate Size	=	-3.33
Offset of Center of Rebar Cage from Center of Pile	=	0.0000 in

Axial Structural Capacities:  
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Nom. Axial Structural Capacity =  $0.85 F_c A_c + F_y A_s$  = 720.141 kips

Tensile Load for Cracking of Concrete = -59.481 kips  
 Nominal Axial Tensile Capacity = -368.155 kips

Reinforcing Bar Dimensions and Positions Used in Computations:

Bar Number	Bar Diam. inches	Bar Area sq. in.	X inches	Y inches
1	2.500000	4.908739	0.00000	0.00000

NOTE: The positions of the above rebars were computed by LPILE

Concrete Properties:

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Compressive Strength of Concrete = 4000. psi  
 Modulus of Elasticity of Concrete = 3604997. psi  
 Modulus of Rupture of Concrete = -474.34165 psi  
 Compression Strain at Peak Stress = 0.001886  
 Tensile Strain at Fracture of Concrete = -0.0001154  
 Maximum Coarse Aggregate Size = 0.750000 in

Number of Axial Thrust Force Values Determined from Pile-head Loadings = 1

Number	Axial Thrust Force kips
1	119.000

Definitions of Run Messages and Notes:

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- C = concrete in section has cracked in tension.
- Y = stress in reinforcing steel has reached yield stress.
- T = ACI 318 criteria for tension-controlled section met, tensile strain in reinforcement exceeds 0.005 while simultaneously compressive strain in concrete more than 0.003. See ACI 318-14, Section 21.2.3.
- Z = depth of tensile zone in concrete section is less than 10 percent of section depth.

Bending Stiffness (EI) = Computed Bending Moment / Curvature.  
 Position of neutral axis is measured from edge of compression side of pile.  
 Compressive stresses and strains are positive in sign.  
 Tensile stresses and strains are negative in sign.

Axial Thrust Force = 119.000 kips

Bending Max Conc Curvature Stress rad/in. ksi	Bending Max Steel Moment Stress in-kip ksi	Run Msg Stiffness kip-in2	Depth to N Axis in	Max Comp Strain in/in	Max Tens Strain in/in
0.00000125	4.4593369	3567470.	176.9355153	0.0002212	0.0002065
0.8827503	6.2456671				
0.00000250	8.9186252	3567450.	91.4089603	0.0002285	0.0001991
0.9099458	6.2906590				
0.00000375	13.3778163	3567418.	62.9017542	0.0002359	0.0001918
0.9370450	6.3358298				
0.00000500	17.8368617	3567372.	48.6493854	0.0002432	0.0001845
0.9640477	6.3811797				
0.00000625	22.2957127	3567314.	40.0989516	0.0002506	0.0001772
0.9909536	6.4267084				
0.00000750	26.7543207	3567243.	34.3994852	0.0002580	0.0001699
1.0177623	6.4724162				
0.00000875	31.2126372	3567159.	30.3291432	0.0002654	0.0001626
1.0444735	6.5183029				
0.00001000	35.6706134	3567061.	27.2770039	0.0002728	0.0001553
1.0710870	6.5643687				
0.00001125	40.1282010	3566951.	24.9036664	0.0002802	0.0001480
1.0976024	6.6106134				
0.00001250	44.5853511	3566828.	23.0054903	0.0002876	0.0001407
1.1240195	6.6570372				
0.00001375	49.0420152	3566692.	21.4528861	0.0002950	0.0001334
1.1503378	6.7036399				
0.00001500	53.4981447	3566543.	20.1594609	0.0003024	0.0001261
1.1765572	6.7504218				
0.00001625	57.9536909	3566381.	19.0654041	0.0003098	0.0001189
1.2026773	6.7973827				
0.00001750	62.4086051	3566206.	18.1279941	0.0003172	0.0001116
1.2286979	6.8445227				
0.00001875	66.8628389	3566018.	17.3159014	0.0003247	0.0001044
1.2546185	6.8918417				
0.00002000	71.3163434	3565817.	16.6056291	0.0003321	0.00009711
1.2804390	6.9393399				
0.00002125	75.7690700	3565603.	15.9792090	0.0003396	0.00008987
1.3061589	6.9870173				
0.00002250	80.2209700	3565376.	15.4226657	0.0003470	0.00008263
1.3317781	7.0348738				
0.00002375	84.6719948	3565137.	14.9249661	0.0003545	0.00007541
1.3572961	7.0829095				
0.00002500	89.1220956	3564884.	14.4772836	0.0003619	0.00006818

1.3827128	7.1311245				
0.00002625	93.5712238	3564618.	14.0724731	0.0003694	0.00006096
1.4080277	7.1795186				
0.00002750	98.0193305	3564339.	13.7046883	0.0003769	0.00005375
1.4332406	7.2280921				
0.00002875	102.4663671	3564048.	13.3690998	0.0003844	0.00004655
1.4583512	7.2768449				
0.00003000	106.9122848	3563743.	13.0616832	0.0003919	0.00003935
1.4833592	7.3257770				
0.00003125	111.3570348	3563425.	12.7790579	0.0003993	0.00003216
1.5082642	7.3748885				
0.00003250	115.8005683	3563094.	12.5183633	0.0004068	0.00002497
1.5330660	7.4241794				
0.00003375	120.2428366	3562751.	12.2771628	0.0004144	0.00001779
1.5577643	7.4736497				
0.00003500	124.6837907	3562394.	12.0533677	0.0004219	0.00001062
1.5823587	7.5232996				
0.00003625	129.1233820	3562024.	11.8451776	0.0004294	0.00000345
1.6068489	7.5731289				
0.00003750	133.5615561	3561641.	11.6510318	0.0004369	-0.00000371
1.6312347	7.6231378				
0.00003875	137.9980399	3561240.	11.4695695	0.0004444	-0.00001087
1.6555154	7.6733241				
0.00004000	142.4321952	3560805.	11.2995964	0.0004520	-0.00001802
1.6796902	7.7236820				
0.00004125	146.8632313	3560321.	11.1400619	0.0004595	-0.00002516
1.7037578	7.7742038				
0.00004250	151.2903648	3559773.	10.9900385	0.0004671	-0.00003230
1.7277173	7.8248820				
0.00004375	155.7128236	3559150.	10.8487048	0.0004746	-0.00003943
1.7515673	7.8757084				
0.00004500	160.1298769	3558442.	10.7153308	0.0004822	-0.00004656
1.7753068	7.9266755				
0.00004625	164.5408578	3557640.	10.5892656	0.0004898	-0.00005368
1.7989348	7.9777761				
0.00004750	168.9451520	3556740.	10.4699273	0.0004973	-0.00006080
1.8224504	8.0290031				
0.00004875	173.3422024	3555737.	10.3567939	0.0005049	-0.00006792
1.8458524	8.0803490				
0.00005125	182.1125483	3553416.	10.1473097	0.0005200	-0.00008214
1.8923131	8.1833806				
0.00005375	190.8483442	3550667.	9.9575778	0.0005352	-0.00009634
1.9383108	8.2868256				
0.00005625	199.5467097	3547497.	9.7849422	0.0005504	-0.000111
1.9838401	8.3906477				
0.00005875	199.5467097	3396540.	9.5252283	0.0005596	-0.000131
2.0110199	8.3210782 C				
0.00006125	199.5467097	3257905.	9.3613155	0.0005734	-0.000146
2.0515639	8.3840165 C				
0.00006375	203.7144915	3195521.	9.2084056	0.0005870	-0.000162

2.0913441	8.4435275 C				
0.00006625	208.5744163	3148293.	9.0653110	0.0006006	-0.000178
2.1303830	8.4997266 C				
0.00006875	213.2340644	3101586.	8.9311946	0.0006140	-0.000194
2.1687365	8.5530758 C				
0.00007125	217.7075840	3055545.	8.8051680	0.0006274	-0.000210
2.2064252	8.6036955 C				
0.00007375	222.0091764	3010294.	8.6864722	0.0006406	-0.000226
2.2434703	8.6517186 C				
0.00007625	226.1530708	2965942.	8.5744557	0.0006538	-0.000242
2.2798949	8.6973007 C				
0.00007875	230.1533918	2922583.	8.4685585	0.0006669	-0.000258
2.3157226	8.7406153 C				
0.00008125	234.0240816	2880296.	8.3682975	0.0006799	-0.000275
2.3509784	8.7818553 C				
0.00008375	237.7788165	2839150.	8.2732557	0.0006929	-0.000291
2.3856884	8.8212335 C				
0.00008625	241.4073955	2798926.	8.1828520	0.0007058	-0.000308
2.4198288	8.8584318 C				
0.00008875	244.9246222	2759714.	8.0967839	0.0007186	-0.000324
2.4534270	8.8936804 C				
0.00009125	248.3579597	2721731.	8.0149166	0.0007314	-0.000341
2.4865415	8.9275653 C				
0.00009375	251.7114249	2684922.	7.9369382	0.0007441	-0.000357
2.5191822	8.9601525 C				
0.00009625	254.9501905	2648833.	7.8621970	0.0007567	-0.000374
2.5512672	8.9904686 C				
0.00009875	258.1351946	2614027.	7.7909752	0.0007694	-0.000391
2.5829347	9.0200255 C				
0.0001013	261.2372566	2580121.	7.7227396	0.0007819	-0.000408
2.6141181	9.0480240 C				
0.0001038	264.2683699	2547165.	7.6573541	0.0007945	-0.000425
2.6448422	9.0747035 C				
0.0001063	267.2481530	2515277.	7.5947938	0.0008069	-0.000441
2.6751567	9.1006070 C				
0.0001088	270.1475472	2484115.	7.5345727	0.0008194	-0.000458
2.7049873	9.1248167 C				
0.0001113	273.0110631	2454032.	7.4769381	0.0008318	-0.000475
2.7344464	9.1486390 C				
0.0001138	275.7999646	2424615.	7.4213421	0.0008442	-0.000492
2.7634338	9.1708292 C				
0.0001163	278.5531987	2396157.	7.3680100	0.0008565	-0.000509
2.7920509	9.1925900 C				
0.0001188	281.2517472	2368436.	7.3166052	0.0008688	-0.000526
2.8202459	9.2132548 C				
0.0001213	283.9006349	2341449.	7.2670529	0.0008811	-0.000544
2.8480342	9.2329798 C				
0.0001238	286.5277512	2315376.	7.2194903	0.0008934	-0.000561
2.8754879	9.2526602 C				
0.0001263	289.0781609	2289728.	7.1732763	0.0009056	-0.000578

2.9024604	9.2703817 C				
0.0001288	291.6179015	2264993.	7.1289458	0.0009179	-0.000595
2.9291306	9.2884344 C				
0.0001313	294.1103416	2240841.	7.0860366	0.0009300	-0.000612
2.9553966	9.3054694 C				
0.0001338	296.5597946	2217269.	7.0445080	0.0009422	-0.000629
2.9812725	9.3216372 C				
0.0001363	298.9986305	2194485.	7.0045859	0.0009544	-0.000647
3.0068477	9.3381315 C				
0.0001388	301.3879684	2172166.	6.9658047	0.0009665	-0.000664
3.0320116	9.3534272 C				
0.0001413	303.7464907	2150418.	6.9282806	0.0009786	-0.000681
3.0568189	9.3682497 C				
0.0001438	306.0944448	2129353.	6.8921393	0.0009907	-0.000698
3.0813269	9.3833952 C				
0.0001463	308.4070424	2108766.	6.8570651	0.0010028	-0.000716
3.1054628	9.3978261 C				
0.0001488	310.6819508	2088618.	6.8229797	0.0010149	-0.000733
3.1292215	9.4114371 C				
0.0001588	319.5879626	2013153.	6.6972066	0.0010632	-0.000802
3.2210088	9.4651109 C				
0.0001688	328.1529824	1944610.	6.5857397	0.0011113	-0.000871
3.3075066	9.5158469 C				
0.0001788	336.4173118	1882055.	6.4864509	0.0011595	-0.000941
3.3888285	9.5650606 C				
0.0001888	344.4153863	1824717.	6.3976730	0.0012076	-0.001010
3.4650697	9.6142211 C				
0.0001988	352.1327892	1771737.	6.3176098	0.0012556	-0.001080
3.5361708	9.6621195 C				
0.0002088	359.6211377	1722736.	6.2454631	0.0013037	-0.001149
3.6022722	9.7115027 C				
0.0002188	366.8949263	1677234.	6.1803097	0.0013519	-0.001218
3.6634017	9.7634094 C				
0.0002288	373.9271729	1634654.	6.1209206	0.0014002	-0.001288
3.7194510	9.8157651 C				
0.0002388	380.7689426	1594844.	6.0671257	0.0014485	-0.001357
3.7705496	9.8724076 C				
0.0002488	387.3874564	1557337.	6.0178935	0.0014970	-0.001426
3.8165691	9.9307626 C				
0.0002588	393.8064318	1521957.	5.9729811	0.0015455	-0.001495
3.8575498	9.9929780 C				
0.0002688	400.0418847	1488528.	5.9321186	0.0015943	-0.001564
3.8934882	10.0607079 C				
0.0002788	406.0445253	1456662.	5.8943137	0.0016430	-0.001632
3.9242319	10.1294548 C				
0.0002888	411.8615812	1426360.	5.8598381	0.0016920	-0.001701
3.9498504	-10.458075 C				
0.0002988	417.4894879	1397454.	5.8283716	0.0017412	-0.001769
3.9702783	-11.092877 C				
0.0003088	422.9037324	1369729.	5.7993487	0.0017905	-0.001837

3.9854252	-11.724051 C				
0.0003188	428.1087847	1343086.	5.7726403	0.0018400	-0.001905
3.9952548	-12.350663 C				
0.0003288	433.1157508	1317462.	5.7482387	0.0018897	-0.001973
3.9997175	-12.970774 C				
0.0003388	437.9121685	1292730.	5.7259738	0.0019397	-0.002041
3.9999554	-13.584046 C				
0.0003488	442.4833901	1268770.	5.7057016	0.0019899	-0.002108
3.9996403	-14.190080 C				
0.0003588	446.8124424	1245470.	5.6870631	0.0020402	-0.002175
3.9985651	-14.790874 C				
0.0003688	450.9144158	1222819.	5.6700071	0.0020908	-0.002242
3.9987187	-15.385555 C				
0.0003788	454.8039419	1200802.	5.6545164	0.0021416	-0.002309
3.9987086	-15.972937 C				
0.0003888	458.4894251	1179394.	5.6404584	0.0021927	-0.002375
3.9985326	-16.553151 C				
0.0003988	461.9800600	1158571.	5.6277113	0.0022440	-0.002441
3.9981585	-17.126361 C				
0.0004088	465.2854956	1138313.	5.6161629	0.0022956	-0.002507
3.9996562	-17.692753 C				
0.0004188	468.4089656	1118589.	5.6057268	0.0023474	-0.002573
3.9999553	-18.252338 C				
0.0004288	471.3628514	1099389.	5.5963028	0.0023994	-0.002638
3.9997184	-18.805391 C				
0.0004388	474.1579114	1080702.	5.5878019	0.0024516	-0.002704
3.9991508	-19.352163 C				
0.0004488	476.8030573	1062514.	5.5801223	0.0025041	-0.002769
3.9980831	-19.893180 C				
0.0004588	479.3013144	1044799.	5.5731031	0.0025567	-0.002834
3.9999870	-20.429863 C				
0.0004688	481.6544430	1027529.	5.5668378	0.0026095	-0.002898
3.9995335	-20.960370 C				
0.0004788	483.8834550	1010723.	5.5612329	0.0026624	-0.002963
3.9982458	-21.485342 C				
0.0004888	485.9939867	994361.	5.5562369	0.0027156	-0.003027
3.9999872	-22.004934 C				
0.0004988	487.9761014	978398.	5.5518425	0.0027690	-0.003091
3.9992610	-22.518724 C				
0.0005088	489.8562933	962862.	5.5479530	0.0028225	-0.003155
3.9971794	-23.027611 C				
0.0005188	491.6257078	947712.	5.5445636	0.0028762	-0.003219
3.9997209	-23.531233 C				
0.0005288	493.2945460	932945.	5.5416249	0.0029301	-0.003283
3.9978845	-24.029910 C				
0.0005388	494.8715303	918555.	5.5390924	0.0029842	-0.003346
3.9998900	-24.523942 C				
0.0005488	496.3497570	904510.	5.5369645	0.0030384	-0.003409
3.9981371	-25.013007 C				
0.0006088	503.5434752	827176.	5.5307835	0.0033669	-0.003786

3.9963138	-27.857036 C				
0.0006688	508.3220503	760108.	5.5329351	0.0037002	-0.004158
3.9987974	-30.560958 C				
0.0007288	508.3220503	697526.	5.5632897	0.0040542	-0.004509
3.9997285	-32.661370 C				

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Summary of Results for Nominal Moment Capacity for Section 2  
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Moment values interpolated at maximum compressive strain = 0.003  
or maximum developed moment if pile fails at smaller strains.

Load Tens. No. Strain	Axial Thrust kips	Nominal Mom. Cap. in-kip	Max. Comp. Strain	Max.
----- ----- ----- -----	----- ----- ----- -----	----- ----- ----- -----	----- ----- ----- -----	----- ----- ----- -----
1 -0.00336458	119.000	495.303	0.00300000	

Note that the values of moment capacity in the table above are not factored by a strength reduction factor (phi-factor).

In ACI 318, the value of the strength reduction factor depends on whether the transverse reinforcing steel bars are tied hoops (0.65) or spirals (0.75).

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to ACI 318, or the value required by the design standard being followed.

The following table presents factored moment capacities and corresponding bending stiffnesses computed for common resistance factor values used for reinforced concrete sections.

Axial Stiff. Load Ult Mom No. kip-in^2	Resist. Factor	Nominal Ax. Thrust kips	Nominal Moment Cap in-kips	Ult. (Fac) Ax. Thrust kips	Ult. (Fac) Moment Cap in-kips	Bend. at
----- ----- ----- ----- ----- -----	----- ----- ----- ----- ----- -----	----- ----- ----- ----- ----- -----	----- ----- ----- ----- ----- -----	----- ----- ----- ----- ----- -----	----- ----- ----- ----- ----- -----	----- ----- ----- ----- ----- -----
1 1994276.	0.65	119.000000	495.302649	77.350000	321.946722	
1 1649490.	0.75	119.000000	495.302649	89.250000	371.476987	



lb/inch	lb/inch	lb/inch				
0.00	0.3417	-1161226.	22000.	0.00	0.00	1.00E+10
-64.675	829.1049	0.00				
0.7300	0.3372	-970459.	21351.	-9.30E-04	0.00	1.00E+10
-83.555	2170.	0.00				
1.4600	0.3254	-785222.	20525.	-0.00168	0.00	1.04E+10
-104.882	2824.	0.00				
2.1900	0.3078	-607347.	19509.	-0.00226	0.00	1.08E+10
-127.256	3622.	0.00				
2.9200	0.2858	-438723.	18297.	-0.00267	0.00	1.17E+10
-149.441	4580.	0.00				
3.6500	0.2610	-281224.	16894.	-0.00294	0.00	1.17E+10
-170.897	5736.	0.00				
4.3800	0.2343	-136620.	15308.	-0.00309	0.00	1.17E+10
-191.147	7146.	0.00				
5.1100	0.2068	-6578.	13551.	-0.00315	0.00	1.17E+10
-209.862	8891.	0.00				
5.8400	0.1792	107364.	11641.	-0.00311	0.00	1.17E+10
-226.235	11061.	0.00				
6.5700	0.1523	203863.	9602.	-0.00299	0.00	1.17E+10
-239.292	13765.	0.00				
7.3000	0.1267	281840.	7466.	-0.00281	0.00	1.17E+10
-248.439	17175.	0.00				
8.0300	0.1030	340532.	5269.	-0.00258	0.00	1.17E+10
-253.151	21530.	0.00				
8.7600	0.08152	379533.	3052.	-0.00231	0.00	1.17E+10
-252.982	27186.	0.00				
9.4900	0.06252	398825.	859.8576	-0.00202	0.00	1.17E+10
-247.561	34689.	0.00				
10.2200	0.04613	398809.	-1259.	-0.00172	0.00	1.17E+10
-236.153	44844.	0.00				
10.9500	0.03236	380360.	-3056.	-0.00143	0.00	1.17E+10
-174.151	47146.	0.00				
11.6800	0.02108	348250.	-3957.	-0.00116	0.00	1.17E+10
-31.604	13135.	0.00				
12.4100	0.01208	313444.	-4211.	-9.10E-04	0.00	1.17E+10
-26.251	19040.	0.00				
13.1400	0.00513	276379.	-4412.	-6.90E-04	0.00	1.17E+10
-19.736	33700.	0.00				
13.8700	-7.55E-06	237585.	-4490.	-4.98E-04	0.00	1.17E+10
1.9610	2275540.	0.00				
14.6000	-0.00359	198755.	-4405.	-3.35E-04	0.00	1.17E+10
17.5121	42736.	0.00				
15.3300	-0.00587	161115.	-4237.	-2.00E-04	0.00	1.17E+10
20.6349	30792.	0.00				
16.0600	-0.00710	124932.	-3923.	-9.33E-05	0.00	1.17E+10
51.2468	63261.	0.00				
16.7900	-0.00750	92585.	-3452.	-1.20E-05	0.00	1.17E+10

56.1652	65563.	0.00					
17.5200	-0.00731	64476.	-2958.	4.67E-05	0.00	1.17E+10	
56.6021	67865.	0.00					
18.2500	-0.00669	40660.	-2476.	8.60E-05	0.00	1.17E+10	
53.5536	70168.	0.00					
18.9800	-0.00580	20921.	-2031.	1.09E-04	0.00	1.17E+10	
47.9769	72470.	0.00					
19.7100	-0.00478	4849.	-1642.	1.19E-04	0.00	1.17E+10	
40.7651	74772.	0.00					
20.4400	-0.00372	-8100.	-1320.	1.17E-04	0.00	1.17E+10	
32.7361	77074.	0.00					
21.1700	-0.00272	-18530.	-942.066	1.07E-04	0.00	1.17E+10	
53.6444	172861.	0.00					
21.9000	-0.00184	-24829.	-494.046	9.13E-05	0.00	1.17E+10	
48.6432	231880.	0.00					
22.6300	-0.00112	-27376.	-92.757	7.18E-05	0.00	1.17E+10	
42.9753	336325.	0.00					
23.3600	-5.80E-04	-26604.	255.2075	5.16E-05	0.00	1.17E+10	
36.4687	550554.	0.00					
24.0900	-2.15E-04	-23012.	550.4326	3.31E-05	0.00	1.17E+10	
30.9343	1258323.	0.00					
24.8200	-1.10E-06	-17029.	686.6195	1.81E-05	0.00	1.17E+10	
0.1586	1258323.	0.00					
25.5500	1.02E-04	-11020.	623.3546	7.61E-06	0.00	1.17E+10	
-14.603	1258323.	0.00					
26.2800	1.32E-04	-6124.	476.1747	1.21E-06	0.00	1.17E+10	
-19.000	1258323.	0.00					
27.0100	1.23E-04	-2680.	315.6971	-2.08E-06	0.00	1.17E+10	
-17.639	1258323.	0.00					
27.7400	9.58E-05	-588.295	178.1856	-3.30E-06	0.00	1.17E+10	
-13.757	1258323.	0.00					
28.4700	6.49E-05	448.4589	77.1038	-3.36E-06	0.00	1.17E+10	
-9.321	1258323.	0.00					
29.2000	3.70E-05	769.5617	13.0274	-2.90E-06	0.00	1.17E+10	
-5.308	1258323.	0.00					
29.9300	1.40E-05	682.7496	-19.060	-2.36E-06	0.00	1.17E+10	
-2.018	1258323.	0.00					
30.6600	-4.38E-06	440.5406	-22.385	-1.56E-06	0.00	3.57E+09	
1.2592	2516646.	0.00					
31.3900	-1.33E-05	293.8321	-15.380	-6.62E-07	0.00	3.57E+09	
0.3399	223212.	0.00					
32.1200	-1.60E-05	172.4542	-12.072	-8.92E-08	0.00	3.57E+09	
0.4155	227816.	0.00					
32.8500	-1.49E-05	82.5159	-8.521	2.24E-07	0.00	3.57E+09	
0.3954	232420.	0.00					
33.5800	-1.21E-05	22.7055	-5.361	3.53E-07	0.00	3.57E+09	
0.3261	237025.	0.00					
34.3100	-8.72E-06	-12.138	-2.879	3.66E-07	0.00	3.57E+09	
0.2404	241629.	0.00					
35.0400	-5.64E-06	-28.502	-1.132	3.16E-07	0.00	3.57E+09	

0.1585	246233.	0.00					
35.7700	-3.18E-06	-32.629	-0.03925	2.41E-07	0.00	3.57E+09	
0.09096	250837.	0.00					
36.5000	-1.42E-06	-29.692	0.5399	1.65E-07	0.00	3.57E+09	
0.04128	255442.	0.00					
37.2300	-2.93E-07	-23.512	0.7588	9.93E-08	0.00	3.57E+09	
0.00870	260046.	0.00					
37.9600	3.23E-07	-16.604	0.7542	5.00E-08	0.00	3.57E+09	
-0.00977	264650.	0.00					
38.6900	5.83E-07	-10.404	0.6329	1.68E-08	0.00	3.57E+09	
-0.01792	269254.	0.00					
39.4200	6.19E-07	-5.552	0.4697	-2.74E-09	0.00	3.57E+09	
-0.01934	273859.	0.00					
40.1500	5.35E-07	-2.169	0.3105	-1.22E-08	0.00	3.57E+09	
-0.01700	278463.	0.00					
40.8800	4.04E-07	-0.08604	0.1788	-1.50E-08	0.00	3.57E+09	
-0.01307	283067.	0.00					
41.6100	2.72E-07	0.9945	0.08241	-1.39E-08	0.00	3.57E+09	
-0.00894	287671.	0.00					
42.3400	1.61E-07	1.3867	0.01969	-1.10E-08	0.00	3.57E+09	
-0.00538	292276.	0.00					
43.0700	8.03E-08	1.3623	-0.01580	-7.58E-09	0.00	3.57E+09	
-0.00272	296880.	0.00					
43.8000	2.85E-08	1.1257	-0.03201	-4.52E-09	0.00	3.57E+09	
-9.81E-04	301484.	0.00					
44.5300	9.86E-10	0.8109	-0.03646	-2.15E-09	0.00	3.57E+09	
-3.45E-05	306088.	0.00					
45.2600	-9.10E-09	0.4914	-0.03520	-5.48E-10	0.00	3.57E+09	
3.23E-04	310693.	0.00					
45.9900	-8.61E-09	0.1954	-0.03242	2.96E-10	0.00	3.57E+09	
3.10E-04	315297.	0.00					
46.7200	-3.92E-09	-0.07726	-0.01628	4.41E-10	0.00	3.57E+09	
0.00338	7549938.	0.00					
47.4500	-8.89E-10	-0.09061	0.00187	2.35E-10	0.00	3.57E+09	
7.66E-04	7549938.	0.00					
48.1800	1.92E-10	-0.04494	0.00451	6.82E-11	0.00	3.57E+09	
-1.65E-04	7549938.	0.00					
48.9100	3.06E-10	-0.01182	0.00263	-1.50E-12	0.00	3.57E+09	
-2.63E-04	7549938.	0.00					
49.6400	1.65E-10	0.00111	8.50E-04	-1.46E-11	0.00	3.57E+09	
-1.43E-04	7549938.	0.00					
50.3700	4.91E-11	0.00311	4.08E-05	-9.46E-12	0.00	3.57E+09	
-4.23E-05	7549938.	0.00					
51.1000	0.00	0.00185	-1.43E-04	-3.38E-12	0.00	3.57E+09	
3.34E-07	7549938.	0.00					
51.8300	-1.01E-11	6.10E-04	-1.03E-04	0.00	0.00	3.57E+09	
8.68E-06	7549938.	0.00					
52.5600	-6.64E-12	3.69E-05	-4.03E-05	0.00	0.00	3.57E+09	
5.72E-06	7549938.	0.00					
53.2900	-2.41E-12	-9.76E-05	-6.19E-06	0.00	0.00	3.57E+09	

2.08E-06	7549938.	0.00					
54.0200	0.00	-7.24E-05	3.95E-06	0.00	0.00	3.57E+09	
2.39E-07	7549938.	0.00					
54.7500	0.00	-2.87E-05	3.87E-06	0.00	0.00	3.57E+09	
-2.56E-07	7549938.	0.00					
55.4800	0.00	-4.67E-06	1.79E-06	0.00	0.00	3.57E+09	
-2.19E-07	7549938.	0.00					
56.2100	0.00	2.64E-06	4.19E-07	0.00	0.00	3.57E+09	
-9.44E-08	7549938.	0.00					
56.9400	0.00	2.69E-06	-7.92E-08	0.00	0.00	3.57E+09	
-1.92E-08	7549938.	0.00					
57.6700	0.00	1.27E-06	-1.37E-07	0.00	0.00	3.57E+09	
6.10E-09	7549938.	0.00					
58.4000	0.00	3.06E-07	-7.52E-08	0.00	0.00	3.57E+09	
7.91E-09	7549938.	0.00					
59.1300	0.00	-4.99E-08	-2.28E-08	0.00	0.00	3.57E+09	
4.05E-09	7549938.	0.00					
59.8600	0.00	-9.44E-08	-1.41E-10	0.00	0.00	3.57E+09	
1.12E-09	7549938.	0.00					
60.5900	0.00	-5.29E-08	4.46E-09	0.00	0.00	3.57E+09	
-6.59E-11	7549938.	0.00					
61.3200	0.00	-1.64E-08	3.00E-09	0.00	0.00	3.57E+09	
-2.67E-10	7549938.	0.00					
62.0500	0.00	-3.35E-10	1.11E-09	0.00	0.00	3.57E+09	
-1.65E-10	7549938.	0.00					
62.7800	0.00	3.06E-09	1.38E-10	0.00	0.00	3.57E+09	
-5.65E-11	7549938.	0.00					
63.5100	0.00	2.11E-09	-1.30E-10	0.00	0.00	3.57E+09	
-4.64E-12	7549938.	0.00					
64.2400	0.00	7.91E-10	-1.14E-10	0.00	0.00	3.57E+09	
8.22E-12	7549938.	0.00					
64.9700	0.00	1.06E-10	-5.01E-11	0.00	0.00	3.57E+09	
6.41E-12	7549938.	0.00					
65.7000	0.00	-8.76E-11	-1.06E-11	0.00	0.00	3.57E+09	
2.63E-12	7549938.	0.00					
66.4300	0.00	-7.96E-11	2.99E-12	0.00	0.00	3.57E+09	
0.00	7549938.	0.00					
67.1600	0.00	-3.55E-11	4.11E-12	0.00	0.00	3.57E+09	
0.00	7549938.	0.00					
67.8900	0.00	-7.76E-12	2.14E-12	0.00	0.00	3.57E+09	
0.00	7549938.	0.00					
68.6200	0.00	1.94E-12	0.00	0.00	0.00	3.57E+09	
0.00	7549938.	0.00					
69.3500	0.00	2.84E-12	0.00	0.00	0.00	3.57E+09	
0.00	7549938.	0.00					
70.0800	0.00	1.51E-12	0.00	0.00	0.00	3.57E+09	
0.00	7549938.	0.00					
70.8100	0.00	0.00	0.00	0.00	0.00	3.57E+09	
0.00	7549938.	0.00					
71.5400	0.00	0.00	0.00	0.00	0.00	3.57E+09	

```

0.00 7549938. 0.00
    72.2700 0.00 0.00 0.00 0.00 0.00 3.57E+09
0.00 7549938. 0.00
    73.0000 0.00 0.00 0.00 0.00 0.00 3.57E+09
0.00 3774969. 0.00

```

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

Output Summary for Load Case No. 1:

```

Pile-head deflection          = 0.34166585 inches
Computed slope at pile head  = 0.000000 radians
Maximum bending moment       = -1161226. inch-lbs
Maximum shear force          = 22000. lbs
Depth of maximum bending moment = 0.000000 feet below pile head
Depth of maximum shear force  = 0.000000 feet below pile head
Number of iterations         = 13
Number of zero deflection points = 14

```

-----  
Computed Values of Pile Loading and Deflection  
for Lateral Loading for Load Case Number 2  
-----

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

```

Shear force at pile head      = 22000.0 lbs
Applied moment at pile head   = 0.0 in-lbs
Axial thrust load on pile head = 119000.0 lbs

```

Depth Res.	Deflect. Soil	Bending Distrib.	Shear Force	Slope S	Total Stress	Bending Stiffness	Soil p
X	y	Moment	Force	S	Stress	Stiffness	p
Es*H	Lat. Load						
feet	inches	in-lbs	lbs	radians	psi*	lb-in <sup>2</sup>	
lb/inch	lb/inch	lb/inch					
0.00	1.4883	2.71E-07	22000.	-0.01615	0.00	1.17E+10	
-78.823	231.9700	0.00					
0.7300	1.3469	206527.	21201.	-0.01607	0.00	1.17E+10	
-103.654	674.1594	0.00					

1.4600	1.2068	404939.	20167.	-0.01584	0.00	1.17E+10
-132.356	960.7632	0.00				
2.1900	1.0694	592878.	18861.	-0.01545	0.00	1.08E+10
-165.890	1359.	0.00				
2.9200	0.9361	767587.	17244.	-0.01489	0.00	1.05E+10
-203.158	1901.	0.00				
3.6500	0.8085	926036.	15285.	-0.01417	0.00	1.03E+10
-244.163	2645.	0.00				
4.3800	0.6879	1064925.	12950.	-0.01332	0.00	1.01E+10
-288.902	3679.	0.00				
5.1100	0.5752	1180684.	10207.	-0.01234	0.00	1.00E+10
-337.377	5138.	0.00				
5.8400	0.4717	1269478.	7023.	-0.01126	0.00	9.96E+09
-389.588	7235.	0.00				
6.5700	0.3779	1327213.	3623.	-0.01012	0.00	9.92E+09
-386.656	8963.	0.00				
7.3000	0.2944	1354055.	274.5914	-0.00894	0.00	9.91E+09
-377.827	11244.	0.00				
8.0300	0.2213	1350656.	-2982.	-0.00774	0.00	9.91E+09
-365.587	14471.	0.00				
8.7600	0.1587	1317958.	-6109.	-0.00656	0.00	9.93E+09
-348.334	19224.	0.00				
9.4900	0.1063	1257318.	-9033.	-0.00543	0.00	9.97E+09
-319.432	26318.	0.00				
10.2200	0.06360	1171014.	-11641.	-0.00437	0.00	1.00E+10
-275.962	38010.	0.00				
10.9500	0.02983	1062468.	-13553.	-0.00340	0.00	1.01E+10
-160.543	47146.	0.00				
11.6800	0.00411	940643.	-14337.	-0.00253	0.00	1.02E+10
-18.331	39049.	0.00				
12.4100	-0.01456	816574.	-14294.	-0.00179	0.00	1.04E+10
27.9356	16806.	0.00				
13.1400	-0.02721	693932.	-14021.	-0.00116	0.00	1.06E+10
34.4099	11077.	0.00				
13.8700	-0.03484	573332.	-13707.	-6.39E-04	0.00	1.09E+10
37.3642	9395.	0.00				
14.6000	-0.03841	455118.	-13374.	-2.30E-04	0.00	1.12E+10
38.6008	8803.	0.00				
15.3300	-0.03887	339494.	-13035.	7.54E-05	0.00	1.17E+10
38.7513	8734.	0.00				
16.0600	-0.03709	226579.	-11692.	2.87E-04	0.00	1.17E+10
267.8691	63261.	0.00				
16.7900	-0.03384	134043.	-9410.	4.22E-04	0.00	1.17E+10
253.2485	65563.	0.00				
17.5200	-0.02970	60836.	-7293.	4.95E-04	0.00	1.17E+10
230.1178	67865.	0.00				
18.2500	-0.02517	5241.	-5402.	5.19E-04	0.00	1.17E+10
201.6242	70168.	0.00				
18.9800	-0.02061	-34886.	-3772.	5.08E-04	0.00	1.17E+10
170.4649	72470.	0.00				

19.7100	-0.01627	-61905.	-2417.	4.72E-04	0.00	1.17E+10
138.8551	74772.	0.00				
20.4400	-0.01234	-78221.	-1334.	4.20E-04	0.00	1.17E+10
108.5314	77074.	0.00				
21.1700	-0.00892	-86147.	-542.159	3.58E-04	0.00	1.17E+10
72.1858	70930.	0.00				
21.9000	-0.00606	-88466.	61.0877	2.93E-04	0.00	1.17E+10
65.5417	94763.	0.00				
22.6300	-0.00378	-85687.	603.3232	2.28E-04	0.00	1.17E+10
58.2564	134948.	0.00				
23.3600	-0.00207	-78371.	1078.	1.67E-04	0.00	1.17E+10
50.0822	212401.	0.00				
24.0900	-8.63E-04	-67151.	1474.	1.12E-04	0.00	1.17E+10
40.2600	408894.	0.00				
24.8200	-9.91E-05	-52789.	1712.	6.74E-05	0.00	1.17E+10
14.2400	1258323.	0.00				
25.5500	3.19E-04	-37293.	1637.	3.38E-05	0.00	1.17E+10
-31.385	862829.	0.00				
26.2800	4.92E-04	-24176.	1346.	1.08E-05	0.00	1.17E+10
-34.991	622678.	0.00				
27.0100	5.08E-04	-13726.	1039.	-3.38E-06	0.00	1.17E+10
-35.261	608513.	0.00				
27.7400	4.33E-04	-5971.	735.8502	-1.07E-05	0.00	1.17E+10
-33.889	685464.	0.00				
28.4700	3.19E-04	-811.325	449.8536	-1.33E-05	0.00	1.17E+10
-31.407	861160.	0.00				
29.2000	2.01E-04	1938.	186.1043	-1.29E-05	0.00	1.17E+10
-28.810	1258323.	0.00				
29.9300	9.43E-05	2476.	0.5659	-1.12E-05	0.00	1.17E+10
-13.551	1258323.	0.00				
30.6600	4.32E-06	1972.	-64.218	-7.86E-06	0.00	3.57E+09
-1.240	2516646.	0.00				
31.3900	-4.33E-05	1367.	-64.819	-3.76E-06	0.00	3.57E+09
1.1030	223212.	0.00				
32.1200	-6.15E-05	843.9627	-52.985	-1.04E-06	0.00	3.57E+09
1.5989	227816.	0.00				
32.8500	-6.15E-05	441.1701	-38.832	5.37E-07	0.00	3.57E+09
1.6323	232420.	0.00				
33.5800	-5.21E-05	162.5051	-25.512	1.28E-06	0.00	3.57E+09
1.4089	237025.	0.00				
34.3100	-3.91E-05	-8.459	-14.614	1.47E-06	0.00	3.57E+09
1.0792	241629.	0.00				
35.0400	-2.64E-05	-96.587	-6.641	1.34E-06	0.00	3.57E+09
0.7410	246233.	0.00				
35.7700	-1.57E-05	-127.604	-1.430	1.06E-06	0.00	3.57E+09
0.4489	250837.	0.00				
36.5000	-7.73E-06	-123.851	1.5242	7.54E-07	0.00	3.57E+09
0.2255	255442.	0.00				
37.2300	-2.46E-06	-102.473	2.8316	4.77E-07	0.00	3.57E+09
0.07295	260046.	0.00				

37.9600	6.16E-07	-75.235	3.0697	2.58E-07	0.00	3.57E+09
-0.01860	264650.	0.00				
38.6900	2.07E-06	-49.231	2.7095	1.06E-07	0.00	3.57E+09
-0.06363	269254.	0.00				
39.4200	2.47E-06	-27.984	2.0932	1.08E-08	0.00	3.57E+09
-0.07708	273859.	0.00				
40.1500	2.26E-06	-12.581	1.4410	-3.90E-08	0.00	3.57E+09
-0.07182	278463.	0.00				
40.8800	1.78E-06	-2.657	0.8742	-5.77E-08	0.00	3.57E+09
-0.05759	283067.	0.00				
41.6100	1.25E-06	2.8548	0.4424	-5.75E-08	0.00	3.57E+09
-0.04099	287671.	0.00				
42.3400	7.76E-07	5.2134	0.1495	-4.76E-08	0.00	3.57E+09
-0.02587	292276.	0.00				
43.0700	4.15E-07	5.5731	-0.02543	-3.43E-08	0.00	3.57E+09
-0.01406	296880.	0.00				
43.8000	1.74E-07	4.8393	-0.113	-2.15E-08	0.00	3.57E+09
-0.00600	301484.	0.00				
44.5300	3.76E-08	3.6330	-0.145	-1.11E-08	0.00	3.57E+09
-0.00132	306088.	0.00				
45.2600	-2.08E-08	2.3165	-0.148	-3.83E-09	0.00	3.57E+09
7.38E-04	310693.	0.00				
45.9900	-2.94E-08	1.0507	-0.140	3.06E-10	0.00	3.57E+09
0.00106	315297.	0.00				
46.7200	-1.55E-08	-0.136	-0.07700	1.43E-09	0.00	3.57E+09
0.01332	7549938.	0.00				
47.4500	-4.41E-09	-0.301	-0.00201	8.91E-10	0.00	3.57E+09
0.00380	7549938.	0.00				
48.1800	1.52E-10	-0.173	0.01407	3.08E-10	0.00	3.57E+09
-1.31E-04	7549938.	0.00				
48.9100	9.84E-10	-0.05535	0.00978	2.70E-11	0.00	3.57E+09
-8.48E-04	7549938.	0.00				
49.6400	6.26E-10	-0.00218	0.00370	-4.36E-11	0.00	3.57E+09
-5.39E-04	7549938.	0.00				
50.3700	2.20E-10	0.00962	5.11E-04	-3.45E-11	0.00	3.57E+09
-1.90E-04	7549938.	0.00				
51.1000	2.15E-11	0.00685	-4.00E-04	-1.43E-11	0.00	3.57E+09
-1.85E-05	7549938.	0.00				
51.8300	-2.97E-11	0.00264	-3.69E-04	-2.60E-12	0.00	3.57E+09
2.56E-05	7549938.	0.00				
52.5600	-2.41E-11	3.89E-04	-1.66E-04	1.12E-12	0.00	3.57E+09
2.08E-05	7549938.	0.00				
53.2900	-1.01E-11	-2.69E-04	-3.67E-05	1.27E-12	0.00	3.57E+09
8.72E-06	7549938.	0.00				
54.0200	-1.92E-12	-2.57E-04	8.72E-06	0.00	0.00	3.57E+09
1.66E-06	7549938.	0.00				
54.7500	0.00	-1.18E-04	1.32E-05	0.00	0.00	3.57E+09
-6.41E-07	7549938.	0.00				
55.4800	0.00	-2.69E-05	7.03E-06	0.00	0.00	3.57E+09
-7.59E-07	7549938.	0.00				

56.2100	0.00	5.59E-06	2.05E-06	0.00	0.00	3.57E+09
-3.78E-07	7549938.	0.00				
56.9400	0.00	9.11E-06	-3.93E-08	0.00	0.00	3.57E+09
-9.98E-08	7549938.	0.00				
57.6700	0.00	4.96E-06	-4.37E-07	0.00	0.00	3.57E+09
9.05E-09	7549938.	0.00				
58.4000	0.00	1.48E-06	-2.83E-07	0.00	0.00	3.57E+09
2.60E-08	7549938.	0.00				
59.1300	0.00	-5.52E-09	-1.01E-07	0.00	0.00	3.57E+09
1.55E-08	7549938.	0.00				
59.8600	0.00	-3.00E-07	-1.09E-08	0.00	0.00	3.57E+09
5.14E-09	7549938.	0.00				
60.5900	0.00	-1.99E-07	1.30E-08	0.00	0.00	3.57E+09
3.22E-10	7549938.	0.00				
61.3200	0.00	-7.25E-08	1.09E-08	0.00	0.00	3.57E+09
-8.14E-10	7549938.	0.00				
62.0500	0.00	-8.53E-09	4.63E-09	0.00	0.00	3.57E+09
-6.07E-10	7549938.	0.00				
62.7800	0.00	8.81E-09	9.15E-10	0.00	0.00	3.57E+09
-2.42E-10	7549938.	0.00				
63.5100	0.00	7.58E-09	-3.17E-10	0.00	0.00	3.57E+09
-3.96E-11	7549938.	0.00				
64.2400	0.00	3.29E-09	-3.95E-10	0.00	0.00	3.57E+09
2.20E-11	7549938.	0.00				
64.9700	0.00	6.76E-10	-2.00E-10	0.00	0.00	3.57E+09
2.26E-11	7549938.	0.00				
65.7000	0.00	-2.08E-10	-5.40E-11	0.00	0.00	3.57E+09
1.06E-11	7549938.	0.00				
66.4300	0.00	-2.74E-10	3.91E-12	0.00	0.00	3.57E+09
2.58E-12	7549938.	0.00				
67.1600	0.00	-1.41E-10	1.34E-11	0.00	0.00	3.57E+09
0.00	7549938.	0.00				
67.8900	0.00	-3.91E-11	8.16E-12	0.00	0.00	3.57E+09
0.00	7549938.	0.00				
68.6200	0.00	2.11E-12	2.76E-12	0.00	0.00	3.57E+09
0.00	7549938.	0.00				
69.3500	0.00	9.23E-12	0.00	0.00	0.00	3.57E+09
0.00	7549938.	0.00				
70.0800	0.00	5.73E-12	0.00	0.00	0.00	3.57E+09
0.00	7549938.	0.00				
70.8100	0.00	1.98E-12	0.00	0.00	0.00	3.57E+09
0.00	7549938.	0.00				
71.5400	0.00	0.00	0.00	0.00	0.00	3.57E+09
0.00	7549938.	0.00				
72.2700	0.00	0.00	0.00	0.00	0.00	3.57E+09
0.00	7549938.	0.00				
73.0000	0.00	0.00	0.00	0.00	0.00	3.57E+09
0.00	3774969.	0.00				

\* This analysis computed pile response using nonlinear moment-curvature rela-

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

Output Summary for Load Case No. 2:

Pile-head deflection = 1.48831966 inches  
 Computed slope at pile head = -0.0161460 radians  
 Maximum bending moment = 1354055. inch-lbs  
 Maximum shear force = 22000. lbs  
 Depth of maximum bending moment = 7.30000000 feet below pile head  
 Depth of maximum shear force = 0.000000 feet below pile head  
 Number of iterations = 25  
 Number of zero deflection points = 14

-----  
 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	Load 1	Load 2	Axial Loading	Pile-head Deflection	Pile-head Rotation	Max in lbs
1	V, lb	22000.	S, rad	0.00	119000.	0.3417	0.00
		-1161226.					
2	V, lb	22000.	M, in-lb	0.00	119000.	1.4883	-0.01615
		1354055.					

Maximum pile-head deflection = 1.4883196649 inches  
 Maximum pile-head rotation = -0.0161460339 radians = -0.925100 deg.

The analysis ended normally.



## **CALCULATIONS**

Seismic Consideration



**Project Information**

Project Number: 10331846  
 Project Name: AF-RO  
 Location: Alexandria, VA  
 Calculations By: ES  
 Date: 9/27/2022  
 Checker: HNP

Boring No. 22-Cmwth-BR-01

**Site Classification Results**

<b>Method</b>			<b>Site Class</b>
N-value	<b>12</b>	bpf	<b>E</b>
Su	<b>1609</b>	psf	<b>D</b>

Top of Layer ft	Bottom of Layer ft	Midpoint of Layer ft	Thickness of Layer ft	N-value bpf	Material	Su psf	Sand Layers	N-value		Su
								Di	Di/Ni	Di/Su
0	2	1	2	10	Sand		1	2	0.20	0.000
2	4	3	2	10	Sand		1	2	0.20	0.000
4	6	5	2	10	Sand		1	2	0.20	0.000
6	8	7	2	3	Clay	750	0	0	0.00	0.003
8	13	10.5	5	7	Clay	750	0	0	0.00	0.007
13	18	15.5	5	13	Clay	750	0	0	0.00	0.007
18	23	20.5	5	7	Sand		1	5	0.71	0.000
23	28	25.5	5	4	Sand		1	5	1.25	0.000
28	33	30.5	5	32	Sand		1	5	0.16	0.000
33	38	35.5	5	19	Sand		1	5	0.26	0.000
38	43	40.5	5	28	Sand		1	5	0.18	0.000
43	48	45.5	5	20	Sand		1	5	0.25	0.000
48	53	50.5	5	7	Clay	750	0	0	0.00	0.007
53	58	55.5	5	35	Clay	3000	0	0	0.00	0.002
58	63	60.5	5	24	Clay	3000	0	0	0.00	0.002
63	68	65.5	5	43	Clay	3000	0	0	0.00	0.002
68	73	70.5	5	37	Clay	3000	0	0	0.00	0.002
73	78	75.5	5	40	Clay	3000	0	0	0.00	0.002
78	83	80.5	5	70	Sand		1	5	0.07	0.000
83	88	85.5	5	53	Clay	3000	0	0	0.00	0.002
88	93	90.5	5	45	Clay	3000	0	0	0.00	0.002
93	98	95.5	5	63	Clay	3000	0	0	0.00	0.002
98	100	99	2	73	Clay	3000	0	0	0.00	0.001
								<b>41</b>	<b>3.48</b>	<b>0.037</b>



**Project Information**

Project Number: 10331846  
 Project Name: AF-RO  
 Location: Alexandria, VA  
 Calculations By: ES  
 Date: 9/27/2022  
 Checker: HNP

Boring No. 22-Cmwth-BR-02

**Site Classification Results**

Method			Site Class
N-value	6	bpf	E
Su	914	psf	E

Top of Layer ft	Bottom of Layer ft	Midpoint of Layer ft	Thickness of Layer ft	N-value bpf	Material	Su psf	Sand Layers	N-value		Su
								Di	Di/Ni	Di/Su
0	2	1	2	31	Sand		1	2	0.06	0.000
2	4	3	2	9	Sand		1	2	0.22	0.000
4	6	5	2	4	Sand		1	2	0.50	0.000
6	8	7	2	3	Clay	500	0	0	0.00	0.004
8	13	10.5	5	8	Clay	500	0	0	0.00	0.010
13	18	15.5	5	4	Clay	500	0	0	0.00	0.010
18	23	20.5	5	8	Clay	500	0	0	0.00	0.010
23	28	25.5	5	3	Sand		1	5	1.67	0.000
28	33	30.5	5	9	Sand		1	5	0.56	0.000
33	38	35.5	5	13	Clay	500	0	0	0.00	0.010
38	43	40.5	5	3	Sand		1	5	1.67	0.000
43	48	45.5	5	11	Sand		1	5	0.45	0.000
48	53	50.5	5	15	Clay	1000	0	0	0.00	0.005
53	58	55.5	5	8	Clay	1000	0	0	0.00	0.005
58	63	60.5	5	13	Sand		1	5	0.38	0.000
63	68	65.5	5	20	Sand		1	5	0.25	0.000
68	73	70.5	5	4	Sand		1	5	1.25	0.000
73	78	75.5	5	69	Clay	3000	0	0	0.00	0.002
78	83	80.5	5	70	Clay	3000	0	0	0.00	0.002
83	88	85.5	5	66	Clay	3000	0	0	0.00	0.002
88	93	90.5	5	51	Clay	3000	0	0	0.00	0.002
93	98	95.5	5	68	Clay	3000	0	0	0.00	0.002
98	100	99	2	78	Sand		1	2	0.03	0.000
								<b>43</b>	<b>7.04</b>	<b>0.062</b>



**Project Information**

Project Number: 10331846  
 Project Name: AF-RO  
 Location: Alexandria, VA  
 Calculations By: ES  
 Date: 9/27/2022  
 Checker: HNP

Boring No.: 22-King-BR-01

**Site Classification Results**

<u>Method</u>			<u>Site Class</u>
N-value	<b>15</b>	bpf	<b>D</b>
Su	<b>1935</b>	psf	<b>D</b>

Top of Layer ft	Bottom of Layer ft	Midpoint of Layer ft	Thickness of Layer ft	N-value bpf	Material	Su psf	Sand Layers	N-value		Su
								Di	Di/Ni	Di/Su
0	2	1	2	10	Sand		1	2	0.20	0.000
2	4	3	2	10	Sand		1	2	0.20	0.000
4	6	5	2	10	Sand		1	2	0.20	0.000
6	8	7	2	8	Clay	1000	0	0	0.00	0.002
8	13	10.5	5	11	Clay	1000	0	0	0.00	0.005
13	18	15.5	5	9	Clay	1000	0	0	0.00	0.005
18	23	20.5	5	3	Clay	500	0	0	0.00	0.010
23	28	25.5	5	36	Sand		1	5	0.14	0.000
28	33	30.5	5	20	Clay	3000	0	0	0.00	0.002
33	38	35.5	5	24	Clay	3000	0	0	0.00	0.002
38	43	40.5	5	25	Clay	3000	0	0	0.00	0.002
43	48	45.5	5	28	Clay	3000	0	0	0.00	0.002
48	53	50.5	5	39	Clay	3000	0	0	0.00	0.002
53	58	55.5	5	41	Clay	3000	0	0	0.00	0.002
58	63	60.5	5	59	Clay	3000	0	0	0.00	0.002
63	68	65.5	5	68	Clay	3000	0	0	0.00	0.002
68	73	70.5	5	37	Clay	3000	0	0	0.00	0.002
73	78	75.5	5	41	Clay	3000	0	0	0.00	0.002
78	83	80.5	5	39	Clay	3000	0	0	0.00	0.002
83	88	85.5	5	29	Clay	3000	0	0	0.00	0.002
88	93	90.5	5	55	Clay	3000	0	0	0.00	0.002
93	98	95.5	5	57	Clay	3000	0	0	0.00	0.002
98	100	99	2	64	Clay	3000	0	0	0.00	0.001
								<b>11</b>	<b>0.74</b>	<b>0.046</b>